Australian Government

Department of Health and Aged Care

Guidance Note for medical practitioners and hospitals

Prevention and management of tick bites in Australia

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Contents

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List of abbreviations

Abbreviations	Description
A&AA	Allergy & Anaphylaxis Australia
AAN	American Academy of Neurology
ACR	American College of Rheumatology
ASCIA	Australasian Society of Clinical Immunology and Allergy
CDC	Centers for Disease Control and Prevention
DEET	N,N-Diethyl-meta-toluamide
DIY	Do it yourself
DSCATT	Debilitating Symptom Complexes Attributed to Ticks
ED	Emergency departments
EPA	Environmental Protection Agency
IDSA	Infectious Diseases Society of America
LLPI	Long-lasting permethrin-impregnated
MMA	Mammalian meat allergy
MVH ED	Mona Vale Hospital Emergency Department
RCT	Randomised-controlled trial
TBE	Tick-borne encephalitis
TCFF	Thai China Flavours and Fragrances
TGA	Therapeutic Goods Administration
TiARA	Tick-induced Allergies Research and Awareness
US	United States

About this Guidance Note

Purpose and objective

This Guidance Note is part of a series of Guidance Notes on ticks, tick-borne diseases, tick-induced allergies, and Debilitating Symptom Complexes Attributed to Ticks (DSCATT).

In response to the 2016 Senate Community Affairs References Committee's Final Report *Inquiry into the growing evidence of an emerging tick-borne disease that causes a Lyme-like illness for many Australian patients,* the Australian Government commissioned the development of educational and awareness materials related to DSCATT, as well as a clinical pathway and multidisciplinary care model to support clinicians' decision-making on differential diagnosis and referral pathways for patients presenting with DSCATT. The purpose of the Guidance Notes is to provide evidence-based guidance for clinicians in community and hospital settings, as well as providing a reference source on DSCATT topics.

Topics covered in this Guidance Note

This Guidance Note covers prevention and management of tick bites for people living in Australia. It provides high-level information about tick-induced allergy, anaphylaxis and paralysis as these medical illnesses associated with tick bites in Australia have informed the advice and recommendations on management of tick bites in Australia. Greater detail on tick-induced allergy, anaphylaxis and paralysis is provided in the *Tick-induced allergies: tick anaphylaxis and mammalian meat allergy/anaphylaxis, and tick-associated toxicosis and paralysis* Guidance Note.

This Guidance Note does not cover Australian endemic tick-borne diseases in detail; these are covered in the *Australian endemic tick-borne diseases* Guidance Note. While focussed on Australia, this Guidance Note also provides an overview of ticks and tick-borne illnesses, both globally and in Australia, to raise awareness about tick-borne illnesses generally and therefore the need to prevent and manage tick bites. Detailed information about ticks, Australian ticks, and some important concepts about ticks, such as how they bite and the effect of tick saliva on the host, is covered in the *Introduction to ticks, Australian ticks and tick-borne diseases and illnesses* Guidance Note. Detailed information on serious tick-induced allergies and the ticks that cause these in Australia and overseas is covered in the *Tick-induced allergies: tick anaphylaxis and mammalian meat allergy/anaphylaxis, and tick-associated toxicosis and paralysis* Guidance Note. See *Overseas- acquired tick-borne diseases: Lyme disease* Guidance Note for more detail about preventing and managing tick bites when travelling overseas, including using the Australian-developed technique to remove ticks safely to prevent tick-induced allergies.

This Guidance Note is based on information freely available to the public, from published peer-reviewed literature, and Australian and international guidance and guidelines, with a focus on literature published in the past 10 years. In this Guidance Note, where published peer-reviewed papers were not freely available to the public but are of high importance as they relate to the Australian situation, this literature was included. Studies and publications cited by the authors of articles included in this Guidance Note are provided as in-text citations. This approach allows for articles published outside of the past 10 years and articles

that are not freely available to the public to be acknowledged and provides easy access for readers who may wish to explore an article further.

In this Guidance Note and in the series of Guidance Notes on ticks, tick-borne diseases, tick-induced allergies and DSCATT, there is some repetition of content between the Guidance Notes and also within the Guidance Notes, where appropriate. This approach enables each Guidance Note to be read as a stand-alone document, rather than requiring the reader to read from start to finish. The repetition between sections within a Guidance Note allows the reader to read each section as a standalone section, rather than being referred to other sections within the Guidance Note. The Contents page of each Guidance Note is hyperlinked to sections within the Guidance Note to enable the reader to easily access information. Additionally, readers are also referred to other Guidance Notes in this series where additional information can be found.

A short video on how to remove a tick by killing the tick *in situ* with ether-containing sprays is available here:

Important! Watch this video about how to safely remove a tick[1]
https://www.allergy.org.au/patients/insect-allergy-bites-and-stings

[1] An allergy project supported by the National Allergy Strategy, Australasian Society of Clinical Immunology and Allergy (ASCIA), Allergy & Anaphylaxis Australia (A&AA), and Tick-induced Allergies Research and Awareness (TiARA).

Overview and summary

Ticks are parasites that feed off human blood, and they can significantly affect human health.

In Australia, most tick bites pose no medical problems if the tick is safely removed. Tick bites can lead to a variety of illnesses in patients, with the most common being allergic reactions. The Australian paralysis tick (*Ixodes holocyclus*) can cause several illnesses, severe allergic reactions (anaphylaxis), paralysis and death. Tick bite prevention avoids the risk of being affected by tick-borne illness.

Of the many tick-borne illnesses worldwide, very few are vaccine-preventable. While there is a Q fever vaccine available in Australia, there are no vaccines available for other tick-borne illnesses known to be acquired in Australia, including Queensland tick typhus, Flinders Island spotted fever, and Australian spotted fever.

In the absence of vaccines, prevention of tick-borne illnesses is important and is guided by a suite of international and Australian recommendations aimed at reducing exposure to ticks. This includes personal protective strategies to prevent tick bites on people and pets and preventing tick bites around the home. Using strategies to prevent tick bites and appropriate techniques to safely remove ticks, whether in Australia or when people are travelling overseas, will help prevent tick-borne illnesses, including allergic reactions and infection.

Personal protective strategies to prevent tick bites on people in Australia

Personal protective strategies include:

- avoiding tick infested/endemic areas and contact with ticks
- wearing appropriate light-coloured protective clothing
- treating clothing and gear with the insecticide permethrin
- using insect repellent
- using camp beds when camping
- checking clothing for ticks, then placing in a hot dryer for 20 minutes, if available, to kill ticks
- checking the body for ticks.

Women should try to avoid exposure to ticks during pregnancy and during breastfeeding. There are limited data regarding permethrin use in pregnancy and it is not known whether it can be present in breast milk.

Managing a tick bite when bitten in Australia

Australia has specific challenges, particularly around allergies, anaphylaxis and mammalian meat allergy (MMA) from bites from one particular tick (the Australian paralysis tick), and therefore has different recommendations for the safe management and removal of ticks than the rest of the world.

To safely manage a tick bite, it is recommended that, if bitten by any tick in Australia, people should not disturb the tick, including from the time it is found attached to the skin to when

killing the tick using the methods recommended in this Guidance Note. Attached adult ticks should be killed *in situ* (where they are) by freezing them with ether-containing sprays to prevent allergic reactions to ticks. The dead tick should then be left to drop off. For ticks that can hardly be seen (nymph and larval ticks) it is recommended that a generous amount of permethrin cream is carefully dabbed or dropped onto the tick to kill the tick where it is. If the person cannot freeze the tick, leave the tick in place without disturbing it and seek urgent medical assistance to safely remove the tick. Safely managing the tick using the recommended methods in this Guidance Note should not be overly delayed, as a delay of several hours may increase the risk of contracting a tick-borne illness.

Current advice[2] stresses the importance of establishing whether a person who has been bitten by a tick in Australia has an allergy to tick bites. The subsequent medical management of the patient with tick bite is highly dependent on the whether the person has an allergy or not.

People who are allergic to tick bites should carry an adrenaline (epinephrine) autoinjector (such as EpiPen® or an Anapen®) and a mobile telephone and manage tick bites in accordance with the Australasian Society of Clinical Immunology and Allergy (ASCIA) Action Plan for Anaphylaxis available at this link: https://www.allergy.org.au/hp/anaphylaxis/ascia-action-plan-for-anaphylaxis.

It is vital that anyone with a known tick allergy summon urgent medical attention as soon as they are aware of an attached tick and not attempt to remove it without medical help. For patients with known tick allergies, managing and removing the tick must occur in a hospital or emergency department with capacity to initiate advanced life support in the event of anaphylaxis occurring when the tick is removed.

However, all bites from adult ticks need to be treated as if an anaphylaxis could result, as first adult tick bite anaphylaxis is not uncommon.

Anaphylaxis, including tick anaphylaxis, is a medical emergency. In Australia, anaphylactic reactions to tick bites have been fatal, but fatalities are uncommon. Tick anaphylaxis is **only seen with bites from adult ticks**. **Crucially, people who have an anaphylactic reaction to a tick bite react only when the tick is disturbed.** As such, tick anaphylaxis is very unlikely to occur when the tick is killed *in-situ* (where it is) using ether-containing sprays, before it is removed (that is freezing it where it is).

A range of short videos including on 'Signs and symptoms of allergic reaction' and 'EpiPen® administration', and 'Anapen® administration'[3] are available at https://allergyfacts.org.au/resources/videos-from-a-aa.

[2] Advice from the Australian Government Department of Health, Australasian Society of Clinical Immunology and Allergy (ASCIA), Tick-induced Allergies Research and Awareness (TiARA), and Healthdirect.

[3] Video from Allergy & Anaphylaxis Australia (A&AA).

Advice[7F4] on first aid and immediate actions for anaphylaxis, including tick anaphylaxis, is as follows:

Lie the person down if possible and elevate the legs, as this maximises blood flow to the head and therefore oxygen to the brain. Do NOT allow them to stand or walk.

GIVE ADRENALINE INJECTOR. If there is an adrenaline autoinjector (EpiPen®, Anapen®) available, use it while waiting for emergency services if there is any closing over of the throat, breathing difficulty or impending loss of consciousness.

- Call 000 and explain that the reaction is life-threatening.
- If a person is living alone or is alone and suffering tick-induced anaphylaxis symptoms, s/he should open the front door, chock it open, and then lie down and put their feet up on a chair/lounge. As above, the person who is alone should call 000 and explain that the reaction is life-threatening. They should also use an adrenaline autoinjector (EpiPen®, Anapen®) if available, while waiting for emergency services if there is any closing over of their throat, breathing difficulty or impending loss of consciousness. The person should leave a note beside them noting they have been bitten by a tick, if time permits.

[4] Advice from ASCIA and TiARA.

Tick-borne illnesses and need to prevent and manage tick bites in the absence of vaccines

Human health

Worldwide, ticks (and mosquitoes) are recognised as the most important vectors in the transmission of bacterial and viral pathogens to humans and animals (Collwell et al. (2011) in Dehhaghi et al., 2019). Ticks feed off a range of hosts including mammals, reptiles, birds and amphibians and have the potential to pose public health and biosecurity risks as they can carry and transmit human and animal diseases (New Zealand Ministry of Health, 2015). Ticks are the major vectors of disease-causing agents to humans, companion animals and wildlife, and transmit the most diverse array of infectious agents of any blood-feeding arthropod (Wikel, 2018; Sonenshine, 2018), including the agents for Lyme disease, Rocky Mountain spotted fever, human granulocytic anaplasmosis, human monocytic anaplasmosis, tick-borne encephalitis (TBE), babesiosis, theileriosis, ehrlichiosis and many others. It is important to note that not all species of ticks are capable of transmitting these pathogens and often only a limited number of species are capable of doing so.

The remarkable success of ticks as vectors of disease is mainly related to their longevity, high reproductive potential and broad host spectrum for several species, along with their capacity to imbibe a very large quantity of blood over a relatively long period of time (Šimo et al., 2017).

Worldwide, there are almost 900 valid species of ticks, distributed in two main families:

- Argasidae (soft ticks)
- Ixodidae (hard ticks) (Guglielmone et al. (2010), and Barker et al. (2014) in Dehhaghi et al., 2019).

Hard ticks have a hard flat body and elongated mouthparts with rows of backward pointing teeth, and this group includes the most important species that bite humans (Australian Government Department of Health, 2015). Hard ticks are more readily identifiable than soft ticks and also spend more time attached to their hosts than soft ticks that feed for a shorter period of time (New Zealand Ministry of Health, 2015). Hard ticks favour habitats with areas of vegetation, such as forests and fields where females lay eggs on the ground, however, they may also be found in urban areas if there are unoccupied patches of grass (New Zealand Ministry of Health, 2015).

Soft ticks have a wrinkled leathery appearance (Australian Government Department of Health, 2015). Soft ticks generally favour sheltered habitats and will hide in the nests of hosts (New Zealand Ministry of Health, 2015), or areas where hosts rest.

Of the almost 900 species of tick dispersed globally, only 28 species have been recognised to transmit human pathogens which include organisms such as bacteria, viruses and protozoa (Rodríguez et al., 2018).

While ticks and tick-borne illnesses are often limited to specific geographical regions, they may be potentially found anywhere in the world, with international travel, from endemic regions to non-endemic regions by people, animals and cargo, potentially transporting ticks (Dehhaghi et al., 2019). Tick-borne infections of humans are zoonoses of wildlife origins

similar to tick transmitted diseases of companion and domestic animals (Baneth (2014) in Wikel, 2018). Zoonotic tick-borne infections occur when humans encroach into natural environments where ticks, their wildlife reservoir hosts, and their microbial communities co-exist within well defined (and long evolved) ecologies (Irwin et al., 2018).

In recent decades, ticks have been expanding their geographic ranges largely, [but not entirely] due to climate change, while tick populations in many areas of their past and even newly established localities have increased in abundance (Molaei et al., 2019; Semenza & Suk, 2017; Sonenshine, 2018). Such dynamic changes present new and increasingly severe public health threats to humans, livestock and companion animals in areas where ticks were previously unknown or were considered to be of minor importance (Molaei et al., 2019; Sonenshine, 2018).

In addition to the transmission of disease, tick bites can cause substantial blood loss [in animals], severe toxic reactions and death due to tick paralysis (Sonenshine & Roe (2014) in Sonenshine, 2018). Ticks are like bees, wasps and scorpions in that their venom can cause local or systemic allergic reactions and/or paralysis (Cabezas & Valdés (2014) in Taylor et al., 2019). Nearly 70 species of tick globally are capable of inducing paralysis (Gothe & Neitz (1991) in Hall-Mendelin et al., 2011).

Tick bite prevention avoids the risk of being affected by tick-borne illness.

In Australia, most tick bites pose no medical problems if the tick is safely removed. Tick bites in Australia can lead to a variety of illnesses in patients, with the most common being allergic reactions. In some cases people can experience more severe conditions such as allergic reactions including anaphylactic shock and, rarely, tick-induced paralysis (Australasian Society of Clinical Immunology and Allergy, 2019; Australian Government Department of Health, 2015; Graves & Stenos, 2017; Rappo et al., 2013; Taylor et al., 2019; van Nunen, 2018). In Australia, tick-related medical illnesses include allergies, infection, paralysis, and post-infection fatigue (Graves & Stenos, 2017).

In Australia, the situation is different to the rest of the world. Australia has the endemic tick, *I. holocyclus,* (the Australian paralysis tick), which is a notorious biter, including of humans (Graves & Stenos, 2017). The Australian paralysis tick is the most important and medically significant tick in Australia; it is responsible for over 95% of tick bites in humans in eastern Australia (Australian Government Department of Health, 2015; Geary et al., 2021; Taylor et al., 2019; van Nunen (2018) in van Nunen & Ratchford, 2021) and for most tick-borne illnesses in Australia (Australian Government Department of Health, 2015).

The saliva of *I. holocyclus* is the most toxic of all tick salivas globally (Sutherland & Tibballs (2001) in Barker & Barker, 2018). It is capable of inducing allergic reactions, including fatal anaphylaxis, paralysis, and death (Australian Government Department of Health, 2015; Brown & Hamilton (1998) in Graves & Stenos, 2017; Taylor et al., 2019; van Nunen, 2015, 2018), although allergic reactions in humans from the bite of *I. holocyclus* are now considered far more common than paralysis (Rappo et al. (2013), and van Nunen (2018) in Sukkanon et al., 2019).

Tick-related allergies are the reason many people present to hospital emergency departments (ED) in regions where ticks are hyper-endemic (van Nunen & Ratchford, 2021). A two-year survey of a New South Wales hospital ED found over 550 presentations of tick bite, with 34 tick bites resulting in anaphylaxis, and over 75% of these requiring adrenaline use (Rappo et al., 2013). Tick anaphylaxis was responsible for four deaths in Australia between 1997 and 2013 (Mullins et al. (2016), and McGain et al. (2016) in van Nunen & Ratchford, 2021).

I. holocyclus is also the tick responsible for the development of MMA (van Nunen et al. (2009) in Graves & Stenos, 2017; van Nunen, 2015, 2018; van Nunen & Ratchford, 2021). MMA is an emergent allergy, increasingly prevalent in tick-endemic areas in Australia and the United States (US) and occurring on every continent where humans are bitten by ticks (van Nunen, 2015; van Nunen & Ratchford, 2021). Australia is the most affected country globally for MMA (van Nunen, 2018).

With Australia having specific challenges, particularly around allergies, anaphylaxis and MMA following bites from *I. holocyclus* and removal of attached *I. holocyclus* ticks, medical professional organisations such as the ASCIA, researchers such as the Tick-induced Allergies Research and Awareness (TiARA) and the Australian Government Department of Health advise leaving ticks undisturbed and killing them *in situ* with ether-containing sprays to freeze attached adult ticks to prevent allergic reactions to ticks (Australasian Society of Clinical Immunology and Allergy, 2019; Australian Government Department of Health, 2020a; Taylor et al., 2019; Tick-induced Allergies Research and Awareness, n.d.).

Preventing and managing tick bites is vital in the nearly total absence of vaccines for tick-borne illnesses globally

Of the tick-borne diseases and illnesses worldwide, including Australia, only a small number have currently available vaccines. A vaccine is available for Q fever in Australia, and recommended for those at risk (Communicable Diseases Network Australia, 2018). TBE, found in Europe, Russia, and Asia, is vaccine-preventable, but the vaccine is not available in the US (Centers for Disease Control and Prevention, 2014) and it is not widely available in Australia (Australian Government Department of Health, 2020b). There are no vaccines available for other tick-borne diseases known to be acquired in Australia, including Queensland tick typhus, Flinders Island spotted fever, and Australian spotted fever.

Thus, in the absence of vaccines, prevention of tick-borne illnesses relies on a suite of international and Australian recommendations aimed at reducing exposure to ticks. This includes personal protective strategies to prevent tick bites on people and on pets, and preventing tick bites around the home.

Tick-borne diseases are preventable and an integrated approach to avoiding tick bites and preventing infection is necessary (World Health Organization, 2014). In the absence of vaccines for most tick-borne diseases, the risk of tick-borne diseases can be reduced by preventing exposure to ticks and avoiding tick bites (Lantos et al., 2020; World Health Organization, 2014).

This includes avoiding tick risk areas, being informed about how to recognise early symptoms of tick-borne diseases, wearing protective clothing (long trousers and long-sleeved shirts), using tick repellents on one's skin and clothes, checking the entire body daily

for ticks, and removing attached ticks before transmission of infection can occur (European Centre for Disease Prevention and Control, 2015a; World Health Organization, 2014).

Using strategies to prevent tick bites and appropriate techniques to remove ticks, whether in Australia or when people are travelling overseas, will help prevent tick-borne illnesses, including allergic reactions and infection. This Guidance Note focuses on Australian-specific advice and provides brief advice for Australian's travelling overseas.

How do people know if they have been bitten by a tick?

The following information is generic and not specific to any particular species of tick.

A tick bite usually looks like a small dark freckle with a scab, [or dark mole], on the skin. A magnifying glass may be helpful (European Centre for Disease Prevention and Control, 2015b) to confirm a tick is present.

As ticks are very small and their bites do not usually hurt, ticks can easily be overlooked on the body, especially if the tick is in a sheltered spot (Centers for Disease Control and Prevention, 2020a; European Centre for Disease Prevention and Control, 2015b). Ticks prefer soft skin and hairy areas (European Centre for Disease Prevention and Control, n.d.). Many people are probably unaware when they are bitten by a tick, as the tick can secrete and inject small amounts of saliva with anaesthetic properties so that the animal or person can't feel that the tick has attached itself (Centers for Disease Control and Prevention, 2020a; Graves & Stenos, 2017). Additionally to the bite being painless, often the person will not sense a tick moving on their skin (European Centre for Disease Prevention and Control, n.d.). However, once it starts to feed, it becomes noticeable, enlarging [as it becomes filled with blood and eggs] (Graves & Stenos, 2017), and some people have a reaction to the salivary compounds (Australian Government Department of Health, 2015; Graves & Stenos, 2017; Tick-induced Allergies Research and Awareness, n.d.; van Nunen, 2015, 2018; van Nunen & Ratchford, 2021). See *Tick-induced allergies: tick anaphylaxis and mammalian meat allergy/anaphylaxis, and tick-associated toxicosis and paralysis* Guidance Note for more detail.

Preventing tick bites in Australia

There is consistent advice about strategies and actions for preventing tick bites issued by Australian authorities and health professional organisations (Australasian Society of Clinical Immunology and Allergy, 2019; Australian Government Department of Health, 2015; Healthdirect Australia, 2020; Tick-induced Allergies Research and Awareness, n.d.) and international authorities (Centers for Disease Control and Prevention, 2019a; European Centre for Disease Prevention and Control, 2015b; Public Health England, 2018; World Health Organization, 2014).

In Australia, ASCIA, the peak professional body of clinical immunologists and allergy specialists in Australia and New Zealand, and TiARA have published several information resources on preventing and managing tick bites. Prevention of tick bites involves **'dressing for the occasion'** and ensuring a person's property is unfriendly to ticks (www.tiara.org.au in van Nunen, 2018).

Personal protective strategies to prevent tick bites on people

Avoid tick infested/endemic areas and contact with ticks

Figure 1: Questing female Australian paralysis tick (Ixodes holocyclus) (Public domain)

Public domain: S.L. Doggett, Department of Medical Entomology, New South Wales Health Pathology

https://www1.health.gov.au/internet/main/publishing.nsf/650f3eec0dfb990fca25692100069854/ea2fa455f96f36f1ca257c3700786bcb/WebPageBody/0.5510?OpenElement&FieldElemFormat=gif

The best way to prevent tick bites is to avoid tick-infested areas (Australian Government Department of Health, 2015). Over 95% of tick bites in humans in eastern Australia are due to the Australian paralysis tick (see Figure 1) (Australian Government Department of Health, 2015; Geary et al., 2021; Taylor et al., 2019; van Nunen (2018) in van Nunen & Ratchford, 2021), and most tick-borne illnesses in Australia are due to this species (Australian Government Department of Health, 2015). Australian paralysis ticks are found most commonly in wet sclerophyll forests and temperate rain forests (Tick-induced Allergies Research and Awareness, n.d.) in moist, humid coastal areas with abundant native animals that serve as hosts for the tick (Australian Government Department of Health, 2015). Long grasses and bushland provide ideal environments for ticks, and if people live close to these areas, it is not uncommon for there to be Australian paralysis ticks in people's gardens

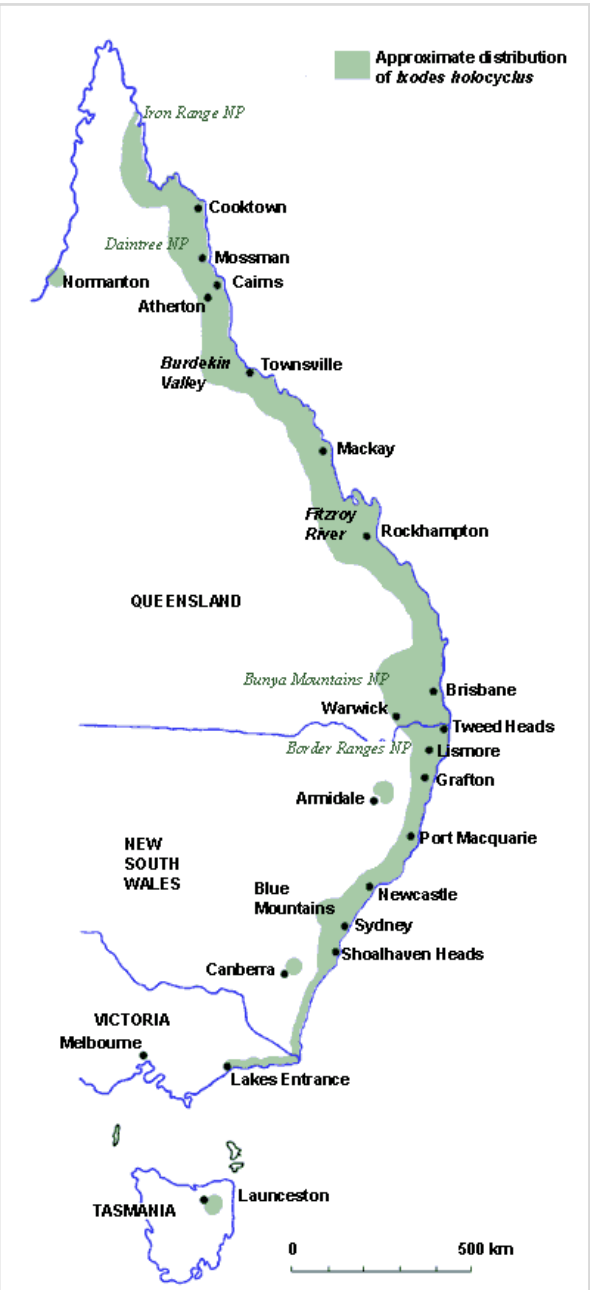
(Australian Government Department of Health, 2015). Avoid bush and long grass, especially after rain (Healthdirect Australia, 2020).

The main distribution of the *I. holocyclus* tick (see Figure 2 overleaf) is within 20 km of the coast along virtually the entire eastern seaboard of Australia (Barker & Walker (2014), and Hardy et al. (2014) in Stewart et al., 2017a; Tick-induced Allergies Research and Awareness, n.d.). However, it has been isolated in areas more than 100 km inland including the Bunya Mountains, Barcaldine, and Thargomindah in Queensland and the Lower Blue Mountains in New South Wales (Stewart et al., 2017a; Tick-induced Allergies Research and Awareness, n.d.). It can also be found in the Australian Capital Territory, probably having travelled from the coast (Tick-induced Allergies Research and Awareness, n.d.).[5] It is not known to occur in South Australia, Western Australia or the Northern Territory (Australian Government Department of Health, 2015).

People with recurrent severe allergic reactions to tick bites may consider relocating to an area where ticks are not endemic (Australasian Society of Clinical Immunology and Allergy, 2019).

[5] Probably travellers from the south coast on people and their companion animals.

Figure 2: Approximate geographic distribution of Australian paralysis tick (Ixodes holocyclus) (Public domain)



Public domain: Distribution map of the Paralysis Tick of Australia (Ixodes holocyclus)

Roberts FHS (1970) Australian Ticks. Yeerongpilly, Queensland.

Adapted from Roberts, F. H. S. (1970) Australian Ticks. Yeerongpilly, Queensland, by TAGS Inc., Bill Conroy & Norbert Fischer.

https://en.wikipedia.org/wiki/File:Ixodes_holocyclus_distribution_map.png#/media/File:Ixodes_holocyclus_distribution_map.png

During pregnancy, try to avoid exposure to ticks (Tick-induced Allergies Research and Awareness, n.d.). See precautionary advice in section on 'First aid for tick bites' on the use of permethrin creams during pregnancy and breastfeeding, to kill ticks that can hardly be seen (larval and nymph ticks).

See *Introduction to ticks, Australian ticks and tick-borne diseases and illnesses* Guidance Note and *Australian endemic tick-borne diseases* Guidance Note for more information on the geographic distribution of other Australian ticks that bite humans, and the risk areas, risk seasons and risk activities for tick bites.

If avoiding tick-infested areas is not possible, the following measures may reduce the risk of tick bites.

Wear appropriate light-coloured protective clothing

Wear light-coloured clothing, which makes it easier to see ticks before they attach to the skin (Australasian Society of Clinical Immunology and Allergy, 2019; Australian Government Department of Health, 2015, 2020a; Tick-induced Allergies Research and Awareness, n.d.).

Wear long-sleeved shirts and long trousers when walking in areas where ticks live. Tuck shirts into trousers. Tuck trouser legs into long socks (Australasian Society of Clinical Immunology and Allergy, 2019; Australian Government Department of Health, 2015, 2020a; Healthdirect Australia, 2020; Tick-induced Allergies Research and Awareness, n.d.).

Wear a wide-brimmed hat (Australasian Society of Clinical Immunology and Allergy, 2019; Healthdirect Australia, 2020; Tick-induced Allergies Research and Awareness, n.d.) if bending over into bushes when gardening or doing bush regeneration work.

Treat clothing and gear with the insecticide permethrin

Clothing treated with permethrin is also recommended. Permethrin-treated clothing is considered the most effective means of preventing tick bites in tick infested areas (Australian Government Department of Health, 2015, 2020a).

Consider using permethrin-treated clothing when exposed to tick habitats or gardening in tick endemic areas (Australasian Society of Clinical Immunology and Allergy, 2019; Australian Government Department of Health, 2015; Tick-induced Allergies Research and Awareness, n.d.).

Permethrin wash kits for treating clothing can be purchased from outdoor recreational stores and it is important to follow the label directions (Australian Government Department of Health, 2015). This method does not give as long-lasting protection as factory-bonded permethrin-treated clothing (Panthawong et al., 2020).

In addition to applying permethrin products to clothing, clothing commercially treated with permethrin is available in Australia. These products provide a greater duration of protection when the clothing is laundered (Panthawong et al., 2020).

Van Nunen & Ratchford advise people to obtain factory-bonded permethrin-treated clothing [especially] if they have tick-induced allergies, have a high-risk occupation, or engage in high-risk recreational pursuits (e.g. council workers, horticulturalists, [bushwalkers, bush regenerators, gardeners]) (van Nunen & Ratchford, 2021).

In 2020, Panthawong et al. reported findings on the first study to investigate the efficacy of permethrin-impregnated fabrics against *I. holocyclus,* the Australian paralysis tick (Panthawong et al., 2020). The study tested and compared the contact toxicity of a DIY product versus two pre-impregnated fabrics (shirt and trousers) against *I. holocyclus* and tested the efficacy of the fabrics after repeated washing. The study found the pre-impregnated product was more effective in repelling *I. holocyclus* ticks than clothing treated with a DIY impregnation pack (Panthawong et al., 2020).

All of the unwashed treated fabrics caused 100% knockdown of *I. holocyclus* ticks (Panthawong et al., 2020). After 10 washes, the pre-impregnated shirts fabric caused the

highest knockdown at 95%, the pre-impregnated trouser fabric caused 90% knockdown, while the DIY product produced only 15% knockdown. After 30 washes, again the pre-impregnated shirts fabric caused the highest knockdown at 70%, while the pre-impregnated trouser fabric caused 20% knockdown, and the DIY product produced only 10% knockdown. After 50 washes, the pre-impregnated shirts fabric still caused the highest knockdown at 45%, the pre-impregnated trouser fabric caused 20% knockdown, while the DIY product produced only 5% knockdown. While none of the permethrin-treated fabric caused significant tick mortality at 24 hours, Panthawong et al. noted that all ticks were moribund and did not survive for much longer and therefore were unlikely to bite (Panthawong et al., 2020).

Panthawong et al. commented that their investigations demonstrated that the pre-impregnated shirt fabric was the most effective at repelling *I. holocyclus* ticks as demonstrated by percentage knockdown and that, where possible it is preferable to use anti-tick clothing that is pre-impregnated at the factory; also, that the clothing should be composed of a mix of natural and synthetic fibres to provide the best protection from tick bite. Furthermore, as the study found that the efficacy of the pre-impregnated product degraded notably after 10 washes, the authors recommended that pre-impregnated shirts be replaced after 10 washes, and for clothing impregnated with the DIY permethrin kit, laundering would not be advisable, unless re-impregnation is undertaken. Panthawong et al. stressed that permethrin-impregnated clothing should be used in conjunction with topical repellents to minimise risk of tick bite (Panthawong et al., 2020).

While not specifically related to Australian ticks, but of relevance to Australians travelling overseas to Lyme disease endemic areas, a two-year randomised-controlled trial (RCT) investigated the protective effectiveness of long-lasting permethrin-impregnated (LLPI) (clothes treated with permethrin at the Insect Shield facility) against tick-bites in a Lyme disease endemic setting among outdoor workers frequently exposed to bites from the black-legged (deer) tick (*I. scapularis*) (Mitchell et al., 2020). This study found the factory-impregnated clothing to significantly reduce risk of tick bites by 65% in the first year of the study, and by 50% in the second year, compared to the control group, who wore untreated clothing (Mitchell et al., 2020). The two-year protective effect was 58%. No treatment-related adverse outcomes were reported in the treatment cohort of the study (Mitchell et al., 2020). In this RCT, participants in both cohorts were asked to wash their clothes as they normally would and to maintain their routine tick bite prevention methods (e.g. protective clothing, tick checks, use of insect repellents on clothing and/or skin). The authors noted prior studies had shown factory permethrin impregnation of uniforms to be highly effective at preventing tick bites from the lone star tick among outdoor workers (Vaughn & Meshnick (2011), and Vaughn et al. (2014) in Mitchell et al., 2020), but that their study was the first RCT to field test LLPI clothing among outdoor workers where *I. scapularis* – the vector of the three most frequently reported tick-borne diseases in the US – was the predominant human biting tick. While the authors noted a number of limitations of the study, they commented their study showed that LLPI clothing provides significant levels of protection from bites of black-legged (deer) ticks among outdoor workers, retains moderate protective effectiveness through two years of routine fieldwork and laundering, and that factory permethrin impregnation of clothing is safe (Mitchell et al., 2020).

An earlier pilot study that assessed the effectiveness of LLPI clothing in the field for the prevention of tick bites in outdoor workers in North California, US, found the participants wearing Insect-Shield-treated clothing had a 93% reduction ($P < 0.0001$) in the total

incidence of tick bites compared to participants using standard tick-bite prevention measures (Vaughn & Meshnick, 2011). The authors noted that the factory-based method for long-lasting permethrin impregnation of clothing developed by Insect Shield allows clothing to retain effective repellent activity for over 70 washes, that clothing treated with Insect Shield had undergone extensive safety testing, and had been registered by the US Environmental Protection Agency (US EPA) for use among people of all ages, with no exclusion for pregnant women and children (Insect Shield, US EPA (2009) in Vaughn & Meshnick, 2011).

Use insect repellent

Insecticides containing either N,N-Diethyl-meta-toluamide (DEET) or picaridin should be applied to the skin prior to entering a tick infested area (Australian Government Department of Health, 2015, 2020a; Healthdirect Australia, 2020). The repellent should be applied and re-applied according to the manufacturer's instructions (Australian Government Department of Health, 2015). Higher concentrations of DEET are not necessarily more effective, but are longer lasting (Australian Government Department of Health, 2020a).

Use insect repellent that contains DEET (such as Tropical RID®, Tropical Aerogard®, BushMan®) (Australasian Society of Clinical Immunology and Allergy, 2019; Tick-induced Allergies Research and Awareness, n.d.).

TiARA also recommends using picaridin (OFF!®).

A very recent study by Sukkanon et al. (2019) that investigated the use of repellents for the prevention of bites from adult female *I. holocyclus* ticks tested five personal repellents along with coconut oil, and a citronella patch and wristband (Sukkanon et al., 2019). The authors noted this study provided the first published data on the effectiveness of topical repellents as part of a personal protection strategy for the prevention of tick bites from *I. holocyclus.* The active ingredients and concentrations of personal repellents products used in the tick bioassay were:

- picaridin (92.8 g/lL), Aerogard® repellent spray
- DEET (115 g/L), Aerogard® repellent roll-on
- lemon eucalyptus (360 g/L), Bug-grrr Off® natural repellent spray
- citronellal (28.35 g/L), tea tree oil (18.9 g/L), lemon-scented tea tree oil (9.45 g/L) Walkabout Insect Repellent, Thursday Plantation
- citronella patch (120mg/patch) Mozzigear™ Mosquito patch insect repellent
- citronella band (750 mg/band) Mozzigear™ Mosquito band insect repellent
- a crude extract of *Andrographis paniculata* (100%) Thai China Flavours and Fragrances (TCFF) Industry Co., Ltd.
- coconut oil (100%) Redwin Sensitive Skin (Sukkanon et al., 2019).

Solutions of the *A. paniculata* extract were prepared by dissolving in absolute ethanol to the concentrations of 30%, 15% and 10%. Coconut oil was diluted two-fold and three-fold to match the *A. paniculata* dilution (Sukkanon et al., 2019).

These repellents were all tested for repellency in a laboratory assay over the time intervals of 15 minutes, and one, two, three and four hours post application.

For the personal repellents at four hours, Sukkanon et al. found there was no statistical difference in repellency between the formulations of picaridin, DEET and lemon eucalyptus, with over 84% repellency recorded for all. Picaridin and DEET provided high repellency with 85% to 94% and 98% to 100%, respectively, for up to four hours. There was no significant difference found between both products for up to three hours ($P > 0.05$), while DEET was significantly more effective at repelling ticks than picaridin at four hours after treatment ($P = 0.012$). Lemon eucalyptus (360 g/L) remained effective (98% to 100% repellency) in repelling female ticks for up to four hours after treatment and was not significantly different to DEET at this time point ($P > 0.05$) (Sukkanon et al., 2019).

For citronella in combination with tea tree oil (Walkabout Insect Repellent), the repellent at 28.35 g/L exhibited high repellency (89% to 100%) over four hours; however, the level of repellency was found to be significantly lower after two hours ($P = 0.029$). Coconut oil also exhibited a relatively high repellency (70% to 95%) at 15% to 30% concentration, although repellency was significantly lower after one hour with the 30% concentration ($P = 0.005$). For *A. paniculata* crude extract at 15% to 30% w/v, the authors reported high repellency (74% to 79%) was observed only at the first 15 minutes, which then decreased to 36% to 69% repellency the following hour, being significantly lower. The citronella-impregnated patch exhibited complete repellency (100%) for four hours, while the wristband provided only 57% to 69% repellency. No significant differences were found between the time frames tested for both citronella-impregnated products (Sukkanon et al., 2019).

Thus, Sukkanon et al. advised **picaridin, DEET and lemon eucalyptus would be the personal repellents recommended for preventing tick bites**. While the citronella patch produced 100% repellency over four hours, as this type of product is known to only provide protection close to the patch, Sukkanon et al. advised it is not recommended for routine use.

Internationally, the Infectious Diseases Society of America (IDSA)/ American Academy of Neurology (AAN)/American College of Rheumatology (ACR) (IDSA/AAN/ACR) advise **commercially available products not recommended as repellents** to prevent tick bites due to insufficient evidence include botanical agents and essential oils (for example essential oils of rosemary, cinnamon leaf, lemongrass, nootkatone [from grapefruit], geraniol (Bissinger et al. (2014) in Lantos et al., 2020) and carvacrol (Jordan et al. (2012) in Lantos et al., 2020). See *Overseas-acquired Lyme disease* Guidance Note for more information from the IDSA/AAN/ACR on the use of repellents.

Use camp beds when camping

Use camp beds when camping to elevate the body above the ground or floor to help prevent tick bites (Tasmanian Department of Health, 2020; Victorian Department of Health and Human Services, n.d.).

Check clothing for ticks then place in a hot dryer for 20 minutes, if available, to kill ticks

- Brush clothing to remove ticks before coming inside (Australasian Society of Clinical Immunology and Allergy, 2019; Healthdirect Australia, 2020).
- All clothing should be removed after being outdoors or visiting tick infested areas and placed into a hot dryer for 20 minutes to kill any tick that could be still on the clothing

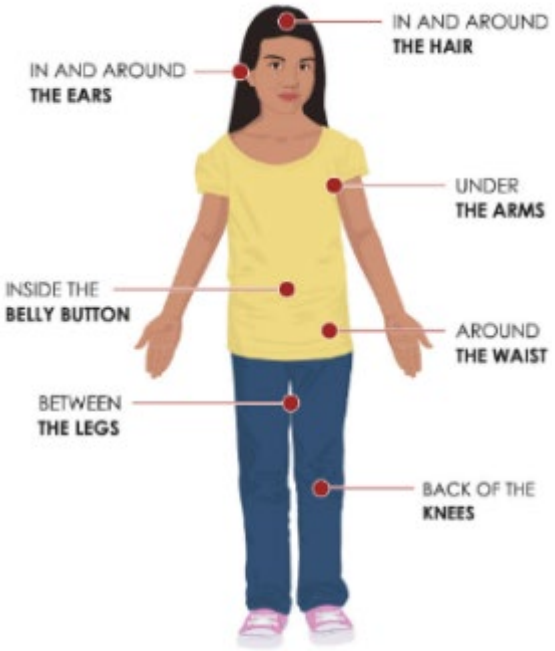
(Australian Government Department of Health, 2015; Healthdirect Australia, 2020; Tick-induced Allergies Research and Awareness, n.d.).

Check body for ticks

Undress and check for ticks daily, checking carefully on the neck and scalp (Australasian Society of Clinical Immunology and Allergy, 2019; Tick-induced Allergies Research and Awareness, n.d.). Ticks can take two hours to attach (Tick-induced Allergies Research and Awareness, n.d.).

The entire body should be checked for ticks of all sizes and stages, paying particular attention to areas behind the ears and the back of the head or neck, especially on children (see Figure 3) (Australian Government Department of Health, 2015).

Figure 3: Where to check for ticks (Public domain)



Public domain: Photo courtesy of CDC

Preventing tick bites on pets

- Regularly treat pets to prevent tick bites. People should ask their vet for advice, noting many dogs and cats die every year from tick paralysis (Tick-induced Allergies Research and Awareness, n.d.).

Preventing tick bites around the home

Advice to manage ticks around people's homes in Australia (Tick-induced Allergies Research and Awareness, n.d.) includes:

- keeping overhanging foliage and leaf litter to a minimum and mowing lawns regularly, as ticks do not like dry conditions
- installing animal proof fencing to prevent host animals (e.g. bandicoots) coming into people's yards, where hosts can drop ticks

- installing fencing to prevent children entering tick-prone areas around the home
- applying insecticides to areas where ticks occur. People may need the services of a professional pest controller. Ensure that ticks are mentioned on the insecticide label (Tick-induced Allergies Research and Awareness, n.d.).

The study by Sukkanon et al. (2019), mentioned above under insect repellents, tested two spatial repellents in the laboratory for repellency and toxicity against *I. holocyclus* (Sukkanon et al., 2019). The repellents were also tested for toxicity in the field. The authors noted this was the first published study investigating spatial repellents for the prevention of tick bite from *I. holocyclus.* The repellents tested were OFF!® Clip-On™ (metofluthrin 312 g/kg) and Thermacell® (allethrin 219.7 g/kg). Both spatial repellents produced significant repellency and toxicity (OFF!® Clip-On™(P = 0.004); Thermacell® (P = 0.002)) in the laboratory compared to controls, but failed to produce any tick mortality in the field. Sukkanon et al. advised **spatial repellents are not recommended** for the prevention of bites from *I. holocyclus* (Sukkanon et al., 2019).

A recent Australian study by Panthawong and colleagues demonstrated that ultrasonic pest repellent devices marketed as insect or tick repellers do not provide adequate protection against bites of *I. holocyclus* (Panthawong et al., 2021). The authors advised **ultrasonic devices are not recommended** for use in the prevention of tick bites from *I. holocyclus* on humans or pets. Panthawong et al. noted ultrasonic pest repellers are often promoted as products to protect people and pets from the bites of hematophagous arthropods such as ticks, yet, prior to their study there had been no published reports that have demonstrated the ultrasonic sound effectively repelled any arthropod pest, and no research on the effectiveness of these devices against *I. holocyclus* (Panthawong et al., 2021). In this study nine commercial ultrasonic sound pest repellent devices purchased online were evaluated. All nine devices demonstrated low-level repellency against *I. holocyclus* in the confined test arena, with the authors noting the small amount of repellency observed would be insufficient to offer adequate protection against tick bites, and that repellency would be expected to be even lower in an open field situation, where sound waves would be more dispersed (Panthawong et al., 2021).

Managing tick bites in Australia

Australia has specific challenges, particularly around allergies, anaphylaxis and MMA following bites from one particular tick (I. holocyclus), and therefore has different recommendations for the safe management and removal of ticks than the rest of the world. Medical professional organisations such as ASCIA, researchers such as TiARA, and the Australian Government Department of Health advise leaving ticks undisturbed and killing them in situ with ether-containing sprays to freeze attached adult ticks to prevent allergic reactions to ticks (Australasian Society of Clinical Immunology and Allergy, 2019; Australian Government Department of Health, 2020a; Taylor et al., 2019; Tick-induced Allergies Research and Awareness, n.d.).

Current advice from the Australian Government Department of Health, ASCIA, TiARA and Healthdirect, all highlight and stress the importance of establishing whether a person who has been bitten by a tick in Australia has an allergy to ticks bites, with the subsequent medical management of the patient with tick bite being highly dependent on the whether the person has an allergy or not.

All bites from adult ticks need to be treated as if an anaphylaxis could result as first adult tick bite anaphylaxis is not uncommon.

To safely manage a tick bite, it is recommended that if bitten by any tick in Australia, people should not disturb the tick, from the time it is found attached to the skin to when it is killed using the methods recommended in this Guidance Note. Attached adult ticks should be killed *in situ* (where they are) by freezing them with ether-containing sprays to prevent allergic reactions to ticks. The dead tick should then be left to drop off. For ticks that can hardly be seen (nymph and larval ticks) it is recommended that a generous amount of permethrin cream is carefully dabbed or dropped onto the tick to kill the tick where it is. If the person cannot freeze the tick, leave the tick in place without disturbing it and seek urgent medical assistance to safely remove the tick. Safely managing the tick using the recommended methods in this Guidance Note should not be overly delayed, as a delay of several hours may increase the risk of contracting a tick-borne illness.

The Australian Immunisation Handbook (https://immunisationhandbook.health.gov.au/) notes that bite wounds can lead to tetanus, however, ‘bite wounds’ are not intended to extend to tick bites. Therefore, clinicians do not need to check the tetanus immunisation status of patients who present with a tick bite.

Background and development of Australian advice

This section discusses the development of the Australian advice on freezing ticks *in situ* with ether-containing sprays to prevent tick-induced allergies. It also discusses the background, major considerations and research that underpins this Australian advice in the context of other international advice and published reviews on tick removal. Current advice on managing a tick bite in Australia is in subsequent sections.

Guidance from international authorities and medical professional associations provide advice about removing attached ticks, including ticks involved in the transmission of Lyme disease. The focus of international advice about removing attached ticks is prompt tick removal to prevent infection with a tick-borne disease. The attached tick is removed using fine-tipped

tweezers to grasp the tick as close to the skin's surface as possible, and pulling upward with steady, even pressure (Centers for Disease Control and Prevention, 2019b; European Centre for Disease Prevention and Control, 2015a; Lantos et al., 2020; World Health Organization, 2014).

The Australian Government Department of Health advice in 2015 regarding removal of attached ticks in non-allergic individuals, or for larval or nymphal stage ticks, was to use fine-tipped forceps (Australian Government Department of Health, 2015), with the technique described consistent with international advice. At that time, the Department of Health stressed that people who suffer allergic reactions to ticks should only attempt to remove a tick whilst at a medical facility such as an ED (Australian Government Department of Health, 2015).

Of note is the emphasis on allergic reactions to ticks in the Australian Government Department of Health's advice in 2015. Although tick allergy has been documented in Japan and occasionally in Spain and France, it is much more prominent in Australia (van Nunen (2018) in Taylor et al., 2019). International authority and medical professional association advice on removal of ticks does not therefore consider issues with allergic reactions to ticks in their tick removal advice. Furthermore, the Centers for Disease Control and Prevention (CDC) has only recently advised on its webpage on Alpha-gal syndrome (Centers for Disease Control and Prevention, 2020b) that preventing tick bites is important in reducing exposure to tick-borne disease and may reduce the likelihood of developing Alpha-gal syndrome (MMA after tick bite).

In 2017, an Australian systematic review examined the current scientific literature to determine what method of tick removal should be promoted in terms of preventing future health complications, including tick bite allergy and transmission of infection (Coleman & Coleman, 2017). This systematic review was a 'thematic synthesis' of the included medical and scientific studies; the quality of the studies was not assessed. Based on the 13 included studies published between 1985 and 2016, (Akin Belli et al. (2016), van Nunen et al. (2014), Sheele et al. (2014), Izutani (2014), Duscher et al. (2012), Ghirga & Ghirga (2009), Samsoen & Molet (20014), Stewart et al. (1998), Kahl et al. (1998), Oteo et al. (1996), Lee et al. (1995), De Boer & van den Bogaard (1993), and Needham (1985) in Coleman & Coleman, 2017), Coleman & Coleman concluded, in 2017, that the best method is to remove the tick as soon as possible after it is detected, using either fine-tipped forceps or a reputable commercially produced tick removal tool to pull the tick away from the site of attachment (Coleman & Coleman, 2017). They also noted that other methods of removal, such as freezing, while promising had not, [at that time] been scientifically validated, and recommended more research (Coleman & Coleman, 2017). Additionally, Coleman & Coleman concluded that some methods of tick removal, such as applying chemicals such as petroleum jelly, alcohol, or nail polish to the tick had been discredited (Coleman & Coleman, 2017).

Also in 2017, a systematic review out of Belgium, conducted using a Cochrane Review methodology, was considered by the authors to be the first systematic review to investigate the most effective method of tick removal using chemical or mechanical techniques that can be performed by lay people (Huygelen et al., 2017). Of 2,046 articles returned in the search, six experimental animal studies were included (Bowles et al. (1992), De Boer & van den Bogaard (1993), Duscher et al. (2012), Needham (1985), Stewart et al. (1998), and Zenner

et al. (2006) in Huygelen et al., 2017). Of note, four of the studies included in Huygelen et al.'s systematic review (Huygelen et al., 2017) were included in Coleman & Coleman's systematic review (Coleman & Coleman, 2017). Huygelen et al. found the available studies were all of very low quality (assessed by GRADE) and suggested that there was limited evidence in favour of pulling ticks with commercial tick removal devices or pulling with forceps, compared to rotation with forceps to remove ticks (Huygelen et al., 2017). Additionally, an effect of applying chemical treatment (with either gasoline, methylated spirit, or petroleum jelly) or heat on nymphs or female ticks could not be demonstrated in the included studies (Huygelen et al., 2017). Huygelen et al. noted that in addition to the included studies being determined to be very low-quality, results of studies were imprecise due to limited sample size, large variability of results, and/or lack of data. The authors noted that since large high-quality studies are lacking, more rigorous studies are warranted to enable strong evidence-based recommendations (Huygelen et al., 2017).

In Australia, Taylor et al. conducted research on freezing ticks *in situ* with the aim of preventing tick-induced allergies, during the peak tick season of 2016, at the Mona Vale Hospital Emergency Department (MVH ED) in Sydney (New South Wales). The results of this study were published in 2019 (Taylor et al., 2019). The study by Taylor et al. was a prospective cross-sectional study involving 121 patients. The authors concluded the results supported the use of ether-containing spray and permethrin cream to kill ticks *in situ*, before careful removal by the mouthparts in order to reduce allergic and anaphylactic reactions. More detail about this study is provided in the sections on 'First aid for tick bites: DO kill the tick in situ' and 'Management of tick bites in people who are allergic to ticks'.

ASCIA, the main professional body of clinical immunology and allergy specialists in Australia and New Zealand, recommend killing ticks *in situ* with ether-containing spray and allowing them to drop off (Australasian Society of Clinical Immunology and Allergy (c2019) in Taylor et al., 2019). Taylor et al. noted, in their 2019 article on freezing ticks *in situ* before removal to prevent allergic and anaphylactic reactions in humans, that the ASCIA recommendation was contrary to worldwide consensus on tick management to prevent tick-transmitted diseases (Taylor et al., 2019). Earlier, van Nunen had noted that the use of fine-tipped forceps coupled with gentle upwards traction is often advised for tick removal in countries where severe infectious diseases not found in Australia are the main concern (Due at al. (2013) in van Nunen, 2018), and where tick allergy/anaphylaxis is very rarely seen. Moreover, the tick-borne diseases that do exist in Australia are associated with less morbidity and mortality, and usually respond quickly to oral antibiotics (Graves & Stenos (2017) in Taylor et al., 2019).

Taylor et al. noted that a tick must be attached for four or five days to cause host paralysis (Hall-Mendelin et al. (2011) in Taylor et al., 2019), whereas transmission time for tick-borne disease varies by pathogen but is generally at least 24 hours post attachment (Eisen (2018) in Taylor et al., 2019). As such, while advice from international health authorities centred on ticks being removed as soon as possible because of concerns regarding infectious disease transmission, Taylor et al. noted both paralysis and tick-borne disease may be avoided by removing ticks within a critical time period (Taylor et al., 2019).

Tick anaphylaxis was first described in Australia in 1940 (McKay (1940) in Taylor et al., 2019). Killing ticks *in situ* to prevent anaphylaxis was first suggested 30 years ago (in 1988) by the entomologist Bernard Stone (Stone (1988) in Taylor et al., 2019), Australia's leading expert in tick paralysis for many years. Taylor et al. noted Stone's main aim was to create a

vaccine for tick paralysis due to the large numbers of domestic and farm yard animals that were affected each year due to bites by ticks (Stone & Aylward (1987) in Taylor et al., 2019).

The Australian paralysis tick appears to be the most potently toxic tick species globally (Hall-Mendelin et al., 2011). In Australia, between 1914 and 1942, 20 human fatalities were attributed to tick bite, with all but three fatalities being children (Murray & Koch (1969) in Hall-Mendelin et al., 2011). Paralysis caused by the holocyclotoxin (a neurotoxin) in the saliva of *I. holocyclus* has resulted in higher human mortality than either red-back or funnel-web spiders (Sutherland & Tibballs (2001) in Barker & Barker, 2018; Nicholson et al. (2006), and Miller (2002) in Taylor et al., 2019). While there has not been a death from tick paralysis in Australia for many decades (since 1945) (Dehhaghi et al., 2019; Doggett, 2004; Grattan-Smith et al. (1997) in Graves & Stenos, 2017; Grattan-Smith et al. (1997) in Hall-Mendelin et al., 2011; Barker & Walker (2014) in Taylor et al., 2019) between 1979 and 2013 there were four recorded fatalities from tick anaphylaxis, with all fatalities occurring shortly after removal of a live adult tick and despite resuscitation with adrenaline (McGain et al. (2016) in Taylor et al., 2019). Taylor et al. noted that three of the four patients who died had known tick allergies but one had not previously reacted to a tick bite and that this finding was consistent with findings from the US where 50% of fatal reactions to insect sting occurred in individuals with no history of reaction to insect sting (Lieberman et al. (2015) in Taylor et al., 2019). As such, Taylor et al.'s advice was that every tick bite should be managed with care given the potential for severe reaction and the inability to predict severity based on previous reactions (Taylor et al., 2019).

I. holocyclus has a much more deeply embedded hypostome than other ticks, which led Stone to hypothesise that *I. holocyclus* may have a more complex bite-site with accumulated proteins that are somehow dispersed during forceful tick removal (Stone et al. (1989), and Stone (1990) in Taylor et al., 2019). Stone had observed, during his research on *I. holocyclus* ticks, that shortly after forceful tick removal paralysis tended to worsen in cats and dogs, but in humans, anaphylactic-like symptoms were more common immediately post tick removal (Taylor et al., 2019). To mitigate this, Stone suggested killing ticks *in situ* and leaving them to fall off, with the ideal tickicidal agent needing to be rapidly penetrating, rapidly acting and suitable for use on human or animal skin (Taylor et al., 2019). Taylor et al. reported Stone used household insect repellent containing pyrethrins and noted the ticks were killed instantly, that their mouthparts lost turgidity and the ticks would fall off within 24 hours, without causing an allergic reaction (Stone (1989) in Taylor et al., 2019). Stone's observations reinforce the validity of killing the tick *in situ* as is currently advocated.

Since Stone's suggestion to kill ticks *in situ* 30 years ago, Taylor et al. noted only one small study has examined the technique of tick removal in preventing allergic reactions (van Nunen et al. (2014) in Taylor et al., 2019). In this study Taylor noted that 78 patients who had experienced an anaphylactic tick bite were counselled on how to kill ticks *in situ* by freezing with ether-containing spray. Taylor et al. reported that the study found, at follow-up, that six of the patients had experienced another tick bite, but none of these six patients had experienced another allergic reaction when they killed the attached ticks *in situ* and left them to fall out (van Nunen et al. (2014) in Taylor et al., 2019).

In 2018, van Nunen noted that overall, data are limited regarding the relative efficacy of tick removal methods in preventing tick-induced allergies, principally because the allergies are emergent, however, such studies are in progress (van Nunen (2014) in van Nunen, 2018).

In 2021, van Nunen & Ratchford noted that the research published by Taylor et al. in 2019 had verified the advice given since 2013 by ASCIA, TiARA and the Emergency Care Institute of New South Wales (Taylor et al. (2019) in van Nunen & Ratchford, 2021).

Establish whether the person is allergic to ticks or not

Current advice from the Australian Government Department of Health, ASCIA, TiARA and Healthdirect, all highlight and stress the importance of establishing whether a person who has been bitten by a tick in Australia has an allergy to ticks bites, with the subsequent medical management of the patient being highly dependent on the whether the person has an allergy.

All bites from adult ticks need to be treated as if an anaphylaxis could result as first adult tick bite anaphylaxis is not uncommon.

The Australian Government Department of Health advised medical practitioners in the DSCATT Clinical Pathway that if a tick has embedded in the patient's skin and remains *in situ*, enquire whether the patient suffers from allergies to ticks before attempting to remove the tick. It is vital that anyone with a known tick allergy summon urgent medical attention as soon as they are aware of an attached tick and not attempt to remove it without medical help. For patients with known tick allergies, removing the tick must occur in a medical facility with capacity to initiate advanced life support in the event of anaphylaxis (Australian Government Department of Health, 2020a).

First aid for tick bites

People who are not allergic to ticks should safely manage the tick bite by not disturbing the tick and killing the tick where it is without delay, as described in more detail below.

A short video on how to safely remove the tick by freezing it where it is with ether-containing sprays, thus killing the tick so that it then drops off, is available at the beginning of this Guidance Note. Alternatively, if the person cannot freeze the tick, they should leave the tick in place without disturbing it and seek urgent medical assistance to safely manage the tick bite.

DO NOT scratch or disturb a tick

- Do not scratch anything that itches until you have had a look at it, or scratch anything you cannot see if you live, work, volunteer or play in a tick-endemic area (Australasian Society of Clinical Immunology and Allergy, 2019; Tick-induced Allergies Research and Awareness, n.d.; van Nunen & Ratchford, 2021).
- Do not disturb (Tick-induced Allergies Research and Awareness, n.d.; van Nunen & Ratchford, 2021), squeeze, agitate, jerk or twist a tick, as this will make more likely that the tick will inject its saliva into the person (Healthdirect Australia, 2020; van Nunen & Ratchford, 2021), with tick saliva containing multiple salivary protein allergens as well as alpha-gal (van Nunen & Ratchford, 2021).
- Do not use irritant chemicals such as methylated spirits or kerosene (Australian Government Department of Health, 2015; Healthdirect Australia, 2020), or petroleum jelly, nail polish, oil or alcohol, or use a lighted match as these do not work and may cause the tick to burrow deeper into the skin (Healthdirect Australia, 2020).

DO NOT try pulling the tick out with household tweezers or fingernails

- Do not try 'picking' a tick out of your skin with household tweezers or other tick-removal gadgets (Tick-induced Allergies Research and Awareness, n.d.). This does not prevent tick allergy or anaphylaxis, and therefore ASCIA advises against this method (Australasian Society of Clinical Immunology and Allergy, 2019).
- Remember, 'Household tweezers are tick squeezers!' (Tick-induced Allergies Research and Awareness, 2019; van Nunen & Ratchford, 2021).

DO kill the tick in situ

See: https://www.allergy.org.au/patients/insect-allergy-bites-and-stings

For ticks that can be seen (adult ticks), freeze the tick to kill it in situ

Current advice from ASCIA, TiARA, the Australian Government Department of Health and published articles supports the killing of adult ticks *in situ* by freezing them. Published studies show that safe removal of the tick can reduce the possibility of becoming allergic to ticks. It can also reduce the risk of getting a tick-borne infectious disease, or developing tick paralysis (Australasian Society of Clinical Immunology and Allergy, 2019).

The Australian Government Department of Health noted in the DSCATT Clinical Pathway that several years of experience at Sydney hospital emergency departments using ether-containing sprays to freeze attached adult ticks has proven highly successful in killing ticks *in situ* and substantially reducing the risk of allergy/anaphylaxis (Australian Government Department of Health, 2020a). Figure 4 below shows an image of an adult female *I. holocyclus* tick attached to the skin of a human.

Figure 4: Adult female Australian paralysis tick (Ixodes holocyclus) in early attachment on human skin (Public domain)

Public domain: Broady, K. (2010)

https://commons.wikimedia.org/wiki/File:Ixodholfem7.jpg#/media/File:Ixodholfem7.jpg

TiARA, in its submission to the Parliamentary Inquiry into Allergies and Anaphylaxis in 2019, advised its tick removal mantra for the community was:

> *For ticks you can see (adult ticks)*
> ***"Freeze it, don't squeeze it!"*** *(Use an ether-containing spray) e.g. Tick Off®*
> *and remember:* ***"Household tweezers are tick squeezers"*** *(Tick-induced Allergies Research and Awareness, 2019)*

People should freeze the tick, using a product that rapidly freezes and kills the tick, and then allow it to drop off (Australasian Society of Clinical Immunology and Allergy, 2019; Tick-induced Allergies Research and Awareness, n.d.). People should ask their pharmacist for suitable ether-containing products (Tick-induced Allergies Research and Awareness, n.d.) and people should read the instructions on the packaging and any enclosed instructions to make sure they use the product safely and as directed.

In most cases ether-containing sprays will kill the tick within five minutes, and it will drop off the skin later (Australasian Society of Clinical Immunology and Allergy, 2019).

If the tick does not drop off, or the person can't freeze the tick, advice is to leave the tick in place and seek urgent medical assistance to remove the tick (Australasian Society of Clinical Immunology and Allergy, 2019; Tick-induced Allergies Research and Awareness, n.d.). People should seek medical attention for it to be removed, taking care to not squeeze the tick because this would cause tick saliva to enter their body, increasing the risk of tick-induced allergies (Tick-induced Allergies Research and Awareness, n.d.).

A study by Taylor et al. at MVH ED, Sydney, New South Wales, found that freezing a tick with Wart-Off Freeze® was effective in killing ticks *in situ* and reducing allergic/anaphylactic reactions, but that people need to do this carefully if using this technique in the community (Taylor et al., 2019). Taylor et al. explained that at MVH ED, the nozzle was held about one cm above the tick when the cold sprays were administered. Those attempting to replicate this method in the community need to be careful not to disturb ticks with the device. Since the device has a rounded aperture slightly larger than the tick and instructions for use on warts state to hold this flush with the skin, some may be tempted to try to fit the tick inside the device before spraying. This increases the chances of disturbing the tick. A new ether-containing spray – Medi Freeze Tick Off® (dimethylether, Pharmacare Laboratories Pty Ltd.), sold by the same company, has both a wider aperture as well as instructions for use on ticks that advise holding above the skin for exactly this reason.

For ticks that can hardly be seen (nymph and larval ticks) – use permethrin cream to kill the tick in situ

The Australian Government Department of Health and TiARA recommend the use of permethrin cream to kill larval and nymphal ticks *in situ* (Australian Government Department of Health, 2015; Tick-induced Allergies Research and Awareness, n.d.; van Nunen & Ratchford, 2021).

In its submission to the Parliamentary Inquiry into Allergies and Anaphylaxis in 2019, TiARA advised its tick removal mantra for the community was:

> *For ticks you can hardly see (larval and nymph stage ticks)*
> ***"Dab it, don't grab it"*** *(Apply the tickicide permethrin cream) Lyclear® (Tick-induced Allergies Research and Awareness, 2019).*

Permethrin based creams are available from chemists. Apply at least twice with a one minute interval between applications (Australian Government Department of Health, 2015). Scrape the tick off after 60 to 90 minutes using a sharp-edged scraper (van Nunen & Ratchford, 2021).

While TiARA currently recommends permethrin cream to kill larval and nymph ticks where they are (*in situ*), it is understood through experience reported by clinicians and patients that

permethrin cream is slow to kill these stages of the tick and that freezing larval and nymph ticks where they are may be more efficient. As more evidence emerges, current guidance may be updated and will be available at TiARA's website; https://www.tiara.org.au/. TiARA cautioned there are limited data regarding permethrin use in pregnancy and it is not known whether it can be present in breast milk (Tick-induced Allergies Research and Awareness, n.d.). As such, TiARA's advice was to try to avoid exposure to ticks during pregnancy and during breastfeeding (Tick-induced Allergies Research and Awareness, n.d.).

Management of tick bites in people who are allergic to tick bites

It is vital that anyone with a known tick allergy summon urgent medical attention as soon as they are aware of an attached tick and not attempt to remove it without medical help. For patients with known tick allergies, removing the tick must occur in a medical facility with capacity and capability to initiate advanced life support in the event of anaphylaxis (Australian Government Department of Health, 2020a).

ASCIA has provided the following advice and recommendations, based on the clinical experience and published studies of medical specialists who treat patients with tick allergy, for people who are allergic to tick bites and who find a tick lodged in their skin.

- If the person is allergic to ticks, they should carry an adrenaline (epinephrine) autoinjector (such as EpiPen® or an Anapen®) and a mobile telephone. Symptoms of a severe allergic reaction (anaphylaxis) include any acute onset illness with skin reactions such as swellings, and difficulty breathing.
- If the person is having symptoms of anaphylaxis as a reaction to a tick bite, use an adrenaline autoinjector, and follow the ASCIA Action Plan for Anaphylaxis available at this link: https://www.allergy.org.au/hp/anaphylaxis/ascia-action-plan-for-anaphylaxis.
- Do not forcibly remove the tick.
- ASCIA advises that in a tick allergic person, the tick should be killed and removed from the patient [and both these steps should occur] in a hospital emergency department (Australasian Society of Clinical Immunology and Allergy, 2019).

In 2021, van Nunen & Ratchford advised that, for self-management of tick anaphylaxis, any person who has had tick anaphylaxis previously should be supplied with an epinephrine autoinjector, and instructed in its use (van Nunen & Ratchford, 2021), and any further tick bite should be managed by the person as follows:

- Leave the tick undisturbed.
- Locate their epinephrine autoinjector.
- Telephone 000 for transport to the nearest ED.
- Not attempt to kill the tick or remove it at home.
- Have the tick killed *in situ* in the ED and leave it to drop off.
- If the tick is removed, this should be done by an expert in the ED using fine-tipped forceps.
- Avoid the use of plastic tweezers at the scene by ambulance officers, as these are inappropriate as they may compress the tick.

- Use their epinephrine autoinjector as instructed if indicated (van Nunen & Ratchford, 2021).

Additional advice from ASCIA, following consultation with a medical specialist, includes:

- A person with tick allergy may be able to kill and remove the tick safely without going to hospital. Some people with tick allergy are so highly allergic that medical support should always be sought. A medical specialist will advise as to which approach will be safest.
- If available, liquid nitrogen applied by a doctor is effective in killing a tick.
- If killing the tick and removing it can be safely performed by the person with tick allergy, kill the tick first by using a product to rapidly freeze the tick, to prevent it from injecting more allergen containing saliva. If the tick does not drop off, or the person can't freeze the tick, leave the tick in place and summon urgent medical assistance to remove the tick.
- Tick allergy should be confirmed by a clinical immunology/allergy specialist.

ASCIA also notes in its advice a link between tick allergy and the development of allergic reactions to mammalian meats and/or mammalian meat-derived gelatine.

Allergen immunotherapy, also known as desensitization, is currently not available to switch off tick bite allergy (Australasian Society of Clinical Immunology and Allergy, 2019).

Killing the tick *in situ* is aimed at ensuring the tick does not regurgitate allergen into the host and it is crucial to preventing allergic reactions. Preventing a recurrence of tick anaphylaxis is achievable by killing the tick *in situ* (van Nunen et al. (2014), Van Wye et al. (1991), and Stone (2000) in van Nunen, 2015). Research in 2014 by van Nunen et al. investigated tick removal techniques in tick anaphylaxis sufferers (van Nunen et al. (2014) in van Nunen, 2015). van Nunen noted freezing ticks *in situ* with ether-containing agents is the most practicable method of killing a tick on a human host (van Nunen et al. (2014), and Australasian Society of Clinical Immunology and Allergy (2016) in van Nunen, 2018). It has the advantage of being easy to use and the sprays are readily available, whereas using fine-tipped forceps coupled with gentle upwards traction to remove ticks requires a great deal of skill and good eyesight (van Nunen, 2015). Many patients with tick anaphylaxis report difficultly in visualising the tick (van Nunen, 2018), or being able to remove a tick with fine-tipped forceps (van Nunen, 2015). As such, the use of fine-tipped forceps should be restricted to health professionals in an appropriate facility and the use of household tweezers discouraged in the population at large (van Nunen, 2018). People almost invariably translate advice to use fine-tipped forceps to use household tweezers. This compresses the tick and its feeding chamber into the host's skin and thereby squeezes tick allergen into the host's vascular bed (van Nunen, 2018).

> *The tick must not be disturbed, scratched or pulled out as this is well recognised to result in an immediate anaphylaxis in those sensitised (Gauci et al. (1989), van Nunen et al. (2014), and Stone (2000) in van Nunen, 2015).*

The most recent study by Taylor et al. was a prospective cross-sectional study involving 121 patients, conducted in 2016 at MVH ED in Sydney, New South Wales (Taylor et al., 2019). Taylor et al. concluded the results supported the use of ether-containing spray and permethrin cream to kill ticks *in situ*, before careful removal by the mouthparts in order to reduce allergic and anaphylactic reactions (Taylor et al., 2019). That study also investigated the incidence of allergic/anaphylactic reactions when ticks were killed and removed from

patients presenting to the MVH ED over a six-month period during peak tick season. Taylor et al. explained that the MVH ED sees an average of 20 tick bite presentations per month, and during peak tick season, more than 50 per month. It had been common practice at MVH ED for many years to kill nymph ticks with Lyclear® Scabies Cream (5% w/w permethrin, made in Belgium for Johnson & Johnson Pacific, Sydney, Australia) and adult ticks with Wart-Off Freeze® (dimethylether, Koninklijke Utermohlen NV, Wolvega, The Netherlands, distributed in Australia by Pharmacare Laboratories, Sydney, Australia). The authors noted both agents are well tolerated and approved by the Australian Therapeutic Goods Administration (TGA) for use on human skin and that it is believed that killing ticks quickly with these agents immediately prevents further salivation and transmission of allergens (Taylor et al., 2019).

Unless contraindicated for medical reasons or patient refusal, the following methods were used to kill the ticks:

- Nymphs/Larvae: careful dab of Lyclear® Scabies Cream, covering the whole tick.
- Adult ticks: five sprays of Wart-Off Freeze®, held one cm above the tick.

Once the ticks have been killed, fine-tipped forceps were used to remove them by the mouthparts, avoiding compressing the abdomen, with Taylor et al. noting that, therefore, tick removal methods at MVH ED combine ASCIA recommendations (killing *in situ*) with the worldwide [other than Australia] consensus on early removal with fine-tipped forceps.

Of the 121 patients, 61 patients (28 were known to be tick hypersensitive) had ticks killed with either Wart-Off Freeze® or Lyclear® Scabies Cream (5% w/w permethrin) before removal with fine-tipped forceps or Tick Twister®, three (5%) of whom had allergic reactions although none was anaphylactic.

Forty four of the 61 patients had ticks killed with either ether-containing spray or permethrin cream in ED, before being removed with either fine-tipped forceps or Tick Twister®. Only one patient suffered an allergic reaction after removal; the datasheet in this case stated that the tick was particularly “embedded” making removal by mouthparts difficult. Taylor et al. noted that this patient had an allergic reaction despite the tick having been killed beforehand highlights the importance of still removing ticks by the mouthparts even after killing (Taylor et al., 2019).

Seventeen of the 61 patients presented to the ED having already killed ticks themselves with ether-containing spray or permethrin cream. All 17 patients had ticks then removed by the mouthparts; only two of the 17 patients suffered allergic reactions. These two patients had suffered reactions whilst attempting to use the ether-containing spray themselves prior to presentation, which Taylor et al. noted highlighted the importance of taking care when using this method (Taylor et al., 2019).

Taylor et al. explained that at MVH ED, the nozzle was held about one cm above the tick when the cold sprays are administered. Those attempting to replicate this method in the community need to be careful not to disturb ticks with the device. Since the device has a rounded aperture slightly larger than the tick and instructions for use on warts state to hold this flush with the skin, some may be tempted to try to fit the tick inside the device before spraying. This increases the chances of disturbing the tick. A new ether-containing spray – Medi Freeze Tick Off® (dimethylether, Pharmacare Laboratories Pty Ltd.) has both a wider

aperture as well as instructions for use on ticks that advise holding at one cm above the skin for exactly this reason.

Nine patients who killed the tick with ether-containing spray in the community before self-removing ticks with either fingers or household tweezers, had allergic reactions, likely due to squeezing the abdomen of the tick during its removal. Taylor et al. concluded that within the limitation of their study, results supported the use of ether-containing spray and permethrin cream to kill ticks *in situ*, before careful removal by the mouthparts in order to reduce allergic and anaphylactic reactions. The authors commented their study supports the hypothesis that accidental tick disturbance, live tick removal with fingers or household tweezers and even dead tick removal with fingers or household tweezers all increase the chance of risk of allergic reaction (Taylor et al., 2019).

First aid for tick-induced anaphylaxis

Anaphylaxis, including tick anaphylaxis, is a medical emergency.

Anaphylaxis, including tick anaphylaxis, is a potentially life threatening severe allergic reaction, that requires immediate treatment with adrenaline (epinephrine). Anaphylaxis should always be treated as a medical emergency. Call an ambulance (000 in Australia), immediately after giving an adrenaline autoinjector (EpiPen®, Anapen®) (Australasian Society of Clinical Immunology and Allergy, 2021b). When an anaphylaxis to a tick occurs, the treatment is the same as for anaphylaxis to any agent (Tick-induced Allergies Research and Awareness, n.d.; van Nunen, 2018; van Nunen & Ratchford, 2021).

While the severity of the anaphylactic reaction can range from Mueller grade I to IV, Australian research found 74% of reactions in tick anaphylaxis to be grade IV (van Nunen et al. (2014) in Taylor et al., 2019), the most severe grade of reaction.

In Australia, anaphylactic reactions to tick bites have been fatal, but fatalities are uncommon. (Tick-induced Allergies Research and Awareness, n.d.), with four deaths due to tick anaphylaxis having occurred in Australia between 1997 and 2013 (McGain et al. (2016), and Mullins et al. (2016) in van Nunen, 2018; Mullins et al. (2016), and McGain et al. (2016) in van Nunen & Ratchford, 2021).

Tick anaphylaxis is **only seen with bites from adult ticks**. **Crucially, people who have an anaphylactic reaction to a tick bite react only when the tick is disturbed.** Tick anaphylaxis is only seen with bites from adult ticks, and only when the adult tick is disturbed by inappropriate handling (van Nunen (2015), van Nunen (2014), Rappo et al. (2013), Gauci et al. (1988), Broady (2013), Dorey (1998), Padula (2008), Commins & Plats-Mills (2011), Kemp (1986), Brown & Hamilton (1998), and van Nunen (2014) in van Nunen, 2018). As such, tick anaphylaxis is very unlikely to occur when the tick is killed *in-situ* (where it is) using ether-containing sprays, before it is removed (that is freezing it where it is).

For information by A&AA on ‘Signs and symptoms of allergic reaction’, ‘EpiPen® administration’, and ‘Anapen® administration’, go to https://allergyfacts.org.au/resources/videos-from-a-aa.

Collective advice from TiARA and ASCIA on first aid and immediate actions for anaphylaxis, including tick anaphylaxis, is as follows (Australasian Society of Clinical Immunology and Allergy, 2021a; Tick-induced Allergies Research and Awareness, n.d.):

Lie the person down if possible and elevate the legs as this maximises blood flow to the head and therefore oxygen to the brain. **Do NOT allow them to stand or walk**.

GIVE ADRENALINE INJECTOR. If there is an adrenaline autoinjector (EpiPen®, Anapen®) available, use it while waiting for emergency services if there is any closing over of the throat, breathing difficulty or impending loss of consciousness.

- Call 000 and explain that the reaction is life-threatening.
- If a person is living alone or is alone and suffering tick-induced anaphylaxis symptoms, s/he should open the front door, chock it open, and then lie down and put their feet up on a chair/lounge. As above, the person who is alone should call 000 and explain that the reaction is life-threatening. They should also use an adrenaline autoinjector (EpiPen®, Anapen®) if available, while waiting for emergency services if there is any closing over of their throat, breathing difficulty or impending loss of consciousness. The person should leave a note beside them noting they have been bitten by a tick, if time permits.

Australian authority advice on removing ticks when people are travelling overseas

The Australian Government Department of Health advises overseas travellers to kill attached ticks *in situ* if an appropriate ether-containing product is available (and without delay), but otherwise follow local guidance, for example, from the CDC.[6] However, if Australian travellers are known to have a tick allergy, they should go to a hospital to have the tick removed.

See *Overseas-acquired tick-borne diseases: Lyme disease* Guidance Note for more detail about preventing and managing tick bites when travelling overseas, including using the Australian-developed technique to remove ticks safely to prevent tick-induced allergies.

[6] https://www.cdc.gov/ticks/removing_a_tick.html

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