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Essays on Environmental Management and Economics: Public Health, Risk and Strategic Environmental Assessment

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Abstract
Current large-scale environmental and climate change leads to the emergence of new and potentially dramatic risks for individuals and societies. The welfare costs associated with these risks largely depend on our ability to take them into account in decision-making and adapt to new circumstances. By analysing how people perceive and manage risks individually and collectively, this thesis aims to improve the understanding of how these environmentally related welfare costs may be reduced. Papers 1–3 focus on risk perceptions and decision-making at the individual level and concern how people perceive and manage risks in relation to the increasing incidence of Lyme borreliosis (LB) and tick-borne encephalitis (TBE). The empirical analysis is based on a survey with 1500 randomly selected respondents in Sweden. Papers 4 and 5 focus on risk assessment and decision-making at the collective level and concern how strategic environmental assessments are used to manage environmental risks in low- and middle-income countries. The empirical analysis is based on interviews with stakeholders involved in environmental assessments of policy reforms.

Paper 1: Learning to Live with Ticks? The Role of Exposure and Risk Perceptions in Protective Behaviour Against Tick-Borne Diseases
We analyse the role of risk perceptions and exposure for five protective measures against tick bites and the related diseases TBE and LB. We find a strong positive association between exposure and checking the skin for ticks, but no or weak associations between exposure and the use of protective clothing, tucking trousers into socks, the use of repellent or avoidance of tall grass in areas with ticks.

Paper 2: Valuation When Baselines Are Changing: Tick-borne Disease Risk and Recreational Choice
We estimate willingness to pay to avoid recreational areas with ticks, LB and TBE risk. In northern Sweden, where the presence of ticks is relatively new, the willingness to pay to avoid risk is significantly higher than in southern Sweden, where ticks are endemic. We also find that TBE-vaccinated respondents have a lower willingness to pay. These differences in willingness to pay for risk reduction between groups with different baseline risk should be taken into account when estimating welfare costs of the spread of disease vectors to new areas due to environmental and climate change.

Paper 3: The Willingness to Pay for Vaccination against Tick-Borne Encephalitis and Implications for Public Health Policy: Evidence from Sweden
We estimate the TBE-vaccination rate to 33% in TBE-risk areas and analyse the role of vaccine price, income and other factors influencing the demand for vaccination. We project that a subsidy making TBE vaccines free of charge could increase the vaccination rate in TBE risk areas to around 78%, with a larger effect on low-income households, whose current vaccination rate is only 15% in risk areas.

Paper 4: Greening Growth through Strategic Environmental Assessment of Sector Reforms
Based on an evaluation of a World Bank programme, we analyse whether strategic environmental assessments can contribute to greening sector reforms in low- and middle-income countries. We find that the institutional context plays a crucial role for the performance of environmental assessments and suggest that increased attention to institutional aspects could improve effectiveness.

Paper 5: Challenges to Institutionalising Strategic Environmental Assessment: the Case of Vietnam
We develop a conceptual framework for analysing constraints to the institutionalisation of strategic environmental assessments at four different institutional levels. The framework is tested in an empirical analysis of the environmental assessment system in Vietnam.

Key words: risk, risk perception, public health, strategic environmental assessment, institutions, governance, willingness to pay, protective behaviour, vector-borne diseases, ticks, TBE, tick-borne encephalitis, Lyme borreliosis, climate change

JEL Classification: D61, I12, I18, O19, O44, P47, Q51, Q54, Q57

Sammanfattning

Dagens storskaliga miljö- och klimatförändringar leder till nya och potentiellt dramatiska risker för individer och samhällen. De välfärdskostnader som dessa miljöförändringar orsakar beror i stor utsträckning på vår förmåga att bedöma risker och anpassa oss till nya förutsättningar. Genom att analysera hur människor uppfattar och hanterar risker individuellt och kollektivt syftar denna avhandling till att bidra till en ökad förståelse av hur dessa miljörelaterade välfärdskostnader kan minskas. Avhandlingen består av fem självständiga men relaterade artiklar. I artikel 1-3 analyserar vi riskuppfattning och beslutsfattande på individnivå kopplat till den ökande förekomsten av fästingar och de fästingburna sjukdomarna borreliainfektion och fästingburen encefalit (TBE). Det empiriska underlaget utgörs av svaren från 1500 slumpmässigt utvalda respondenter på en enkätundersökning i Sverige. I artikel 4 och 5 analyserar vi riskbedömning och beslutsfattande på kollektiv nivå genom en studie av hur strategiska miljöbedömningar används för att hantera miljörisker i olika låg- och medelinkomstländer. Det empiriska underlaget utgörs av intervjuer med intressenter involverade i strategiska miljöbedömningar av naturresursrelaterade ekonomiska reformer.

Artikel 1: Fästingburna sjukdomar, riskuppfattning och beteende
Vi analyserar vilken roll riskuppfattningar och riskexponering spelar för fem olika sätt att skydda sig mot fästingbett, TBE och borrelia. Vi finner ett starkt positivt samband mellan exponering och att undersöka kroppen för fästingar, men inga eller svaga samband mellan exponering och att använda skyddande kläder, ha strumporna utanpå byxorna, använda fästingmedel eller undvika högt gräs eller andra områden där fästingar kan förekomma.

Artikel 2: Ekonomisk värdering när risker förändras - fästingburna sjukdomar och friluftsbeteende
Vi analyserar betalningsviljan för att undvika områden med fästingar samt borrelia- och TBE-risk. I Norrlandslänen där förekomsten av fästingar är relativt ny är betalningsviljan för att undvika risk väsentligt högre än i andra län. Vi finner även att TBE-vaccinerade respondenter har en lägre betalningsvilja. Dessa skillnader i betalningsvilja för riskreducering bör beaktas vid ekonomisk värdering av nya risker orsakade av miljö- och klimatförändringar.

Artikel 3: Betalningsvilja för TBE-vaccination och konsekvenser för folkhälsopolitiken i Sverige
Vi skattar vaccinationsgraden till 33% i TBE-riskområden och analyserar hur pris, inkomst och andra faktorer påverkar efterfrågan på vaccin. Vi bedömer att en subvention som gör det gratis att vaccinera sig mot TBE skulle öka vaccinationsgraden i TBE-riskområden till cirka 78%, med störst effekt på hushåll med låg inkomst, vars nuvarande vaccinationsgrad endast är 15% i riskområden.

Artikel 4: Kan strategiska miljöbedömningar av sektorreformer bidra till en grönare tillväxt?
Baserat på en utvärdering av ett Världsbanksprogram analyserar vi under vilka förutsättningar som strategiska miljöbedömningar kan bidra till att integrera miljöaspekter i sektorreformer i låg- och medelinkomstländer. Vi föreslår att institutionella aspekter bör ges större uppmärksamhet.

Artikel 5: Utmaningar för institutionalisering av strategiska miljöbedömningar: fallet Vietnam
Vi utvecklar ett analytiskt ramverk för att analysera institutionalisering av strategiska miljöbedömningar på fyra olika institutionella nivåer. Ramverket testas i en empirisk analys av systemet för strategiska miljöbedömningar i Vietnam.

Nyckelord: risk, riskuppfattning, folkhälsa, betalningsvilja, värdering, skyddsbeteende, vektorburna infektioner, fästingar, borrelia, fästingburen encefalit, TBE, strategisk miljöbedömning, miljöanalys, institutioner, styrning, klimatförändringar

JEL-klassificering: D61, I12, I18, O19, O44, P47, Q51, Q54, Q57

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This thesis is the result of a long journey in both time and space. Most of it may not seem very spectacular as I spent it reading and writing in my office, but the journey also included more exotic elements such as visits to the Kayelekera uranium mine in Northern Malawi, lively government offices in Nairobi, the shiny premises of the World Bank in Washington D.C. and TBE hotspots in Swedish forests. Completing this thesis would not have been possible without the support of the many people who accompanied me along the way, to whom I would like to extend my warmest appreciation.

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Gothenburg, 13 July 2017

Daniel Slunge

Contents

Introduction

This thesis is written in times of large-scale environmental change, leading to the emergence of new and potentially dramatic risks for individuals and societies (IPCC, 2014; Prüss-Ustün et al., 2016; Rockström et al., 2009). While the natural sciences play an important role in identifying new risks, the welfare costs of these risks largely depend on our ability to take them into account when making decisions individually and collectively (Ferguson, 2007; Ruth et al., 2012; Shogren and Crocker, 1999).

It is hard to correctly value environmental damage and to design appropriate policies. Even in the absence of risk, there may be disagreement about the distribution of costs and benefits of various alternatives. When there are considerable elements of risk, we need not only to deal with a wider space of possible outcomes. We must also realize that different people have widely varying preferences for risk per se and that there are large differences in how risks are perceived (Manski, 2004).

Information about environmental health risks, for example expressed in terms of fatality rates or disease incidence, can be cognitively challenging to process. Judgements are influenced by heuristics and biases (Tversky and Kahneman, 1974). For example, there is substantial evidence that people systematically overestimate small probabilities and underestimate large ones (Kahneman and Tversky, 1979). Hazards that are new, involuntary, difficult to control, potentially catastrophic, or that cause strong feelings at the moment of decision-making tend to be associated with high risk perceptions relative to expert assessments (Fischhoff et al., 1978; Loewenstein et al., 2001; Slovic, 1987). Risks can get amplified through media, personal networks and other social mechanisms, further widening the gap between the risk perceptions of laypeople and experts (Kasperson et al., 1988). Perceptions of risk are also intrinsically related to values and norms and situated in a historic, cultural and political context (Boholm, 2015; Jasanoff, 1999).

This systematic bias in risk perceptions presents a dilemma for public policy-making. Should it be guided by measures of objective risk or by the risk perceptions of the general public (Pollak, 1998; Portney, 1992)? While there are strong arguments that objective risk according to the best available scientific evidence rather than subjective perceptions should guide public policy, people's perceptions and associated preferences also play obvious roles in decisions by democratic governments. In practice, and based on both moral and theoretical arguments, policy-makers need and should take both objective risk measures and the public risk perceptions into account (Johansson-Stenman, 2008).

Providing information about risks to the public in general or to particular groups at risk is a central policy measure in risk management. If 'accurate' information about risks is accessible, people have greater possibilities to adapt to risks through protective measures or by demanding governmental or private sector action for risk reduction. Information about risks can also be a necessary prerequisite for introducing other measures to reduce risks, such as laws restricting certain activities or products, as the implementation of such measures is often dependent on public support. However, there are many obstacles to effective risk communication (Fischhoff, 1995). For example, when trust in authorities or industries is limited or when value conflicts surround decision-making on risk management, just providing information based on scientific risk assessments is rarely effective (Boholm, 2015; Slovic, 1993). Consequently, risk communication has evolved from an initial focus on closing the gap between expert risk assessments and public risk perceptions by educating the public to understand probabilities and 'get the numbers right' (Fischhoff, 1995; Fischhoff and Scheufele, 2013). Current approaches to risk communication or risk governance stress the importance of dialogue between experts, authorities and stakeholders instead of one-way transfer of information from expert risk assessments to the public. Through public participation and the establishment of partnerships between experts and stakeholders, a dialogue on how to manage uncertain, complex or ambiguous risks can take place. This has the potential to enhance trust in authorities and strengthen the legitimacy of decision-making processes (Renn et al., 2011). This reflects a broader shift in the view of risk assessment and management from a purely technical and expert-oriented exercise to a social and political process situated in a specific institutional context and involving multiple perspectives, stakeholders and values (Boholm, 2015; Jasanoff, 1999; Kørnøv and Thissen, 2000).

Accordingly, to assess and manage risks effectively, there is a need to understand not only the factual dimension of risk as informed by medicine and the natural sciences. A scientifically informed understanding of how people perceive and manage risks individually and collectively in specific institutional contexts is equally relevant (Fenichel et al., 2011; Ferguson, 2007; Renn et al., 2011; Shogren and Crocker, 1999).

By combining detailed analyses of risk perceptions and behavioural responses to environmental health risks at the individual level with analyses of environmental risk management procedures and decision-making at the policy level, this thesis aims to contribute to the understanding and practice of risk assessment and management. The thesis consists of five self-contained but related papers. Papers 1–3 focus on risk perceptions and decision-making at the individual level and concern how people perceive and manage risks in relation to the increasing incidence of Lyme borreliosis (LB) and tick-borne encephalitis (TBE). Through a survey with 1 500 randomly selected respondents in Sweden, we analyse risk perceptions, willingness to pay for risk reduction and behavioural responses to these environmental health risks. Papers 4 and 5 focus on risk assessment and decision-making at the collective level and concern how strategic environmental assessments are used to manage environmental risks in various decision-making and institutional contexts. The empirical analysis is based on interviews with a wide range of stakeholders involved in strategic environmental assessments of policy reforms in low- and middle-income countries.

The thesis makes several contributions. First, in papers 1–3 we show that the welfare cost associated with tick-borne diseases goes beyond the cost of illness documented in earlier studies. While the perceived risk of falling ill from tick bites as well as the willingness to pay to avoid the risk of contracting tick-borne diseases are high on average, the use of protective measures is uneven. These findings are relevant to the development of a policy response to the growing health risk of tick-borne diseases and, more in general, also to other vector-borne diseases spreading to new areas due to climate change. If a vaccine subsidy forms part of such a policy response, our willingness-to-pay estimates for a TBE vaccine should be informative. While our willingness-to-pay estimates are relevant for policy development, we suggest that our analysis of the role that baseline risk and adaptive behaviour play for these estimates is conceptually more interesting. We show that residents in areas where ticks and the risk of tick-borne diseases are emerging are willing to pay significantly more for a risk reduction compared with residents in areas where ticks and disease are endemic. This indicates that the loss of a 'risk free' environment has a considerable value and that people learn to live with risk and adapt both their risk perceptions and behaviour, thereby reducing the perceived welfare costs imposed by a new environmental health risk over time. It is philosophically difficult to say how we should reconcile ex post and ex ante welfare costs associated with disease vectors or other emerging risks.

Second, our analysis of the role of institutions for the performance of strategic environmental assessment makes conceptual and empirical contributions to the literature and practice of environmental assessment. A growing critique of the limited influence of technically oriented environmental assessments on decision-making calls for a greater emphasis on participation, deliberation, negotiation and learning as well as an increased understanding of the institutional context for the effectiveness of environmental assessments (Ahmed and Sánchez Triana, 2008; Bina, 2008; Kørnøv and Thissen, 2000; Owens et al., 2004; Runhaar and Driessen, 2007). Building on the findings from an evaluation of a World Bank programme, paper 4 provides an empirically grounded analysis of the mechanisms through which strategic environmental assessments may move beyond the mere provision of technical information to also contribute to improved governance. The role of formal and informal institutions for the effectiveness of strategic environmental assessment is analysed in papers 4 and 5. Paper 5 contributes with an analytical framework based on new institutional theory (Ostrom, 2005; Williamson, 2000) for studying institutional constraints to the use of environmental assessments. Both paper 4 and paper 5 may be relevant for the many low- and middle-income countries currently developing legal frameworks and practices for strategic environmental assessments.

Third, by combining environmental economic valuation and environmental assessment, this thesis provides a bridge between these scientific fields and practices. On the one hand, we suggest that the practice of environmental assessment would benefit from a better use of the results from environmental valuation and the insights and methods developed in the field of environmental and behavioural economics. The valuation of risks and comparison of impacts in environmental assessments are often based on the use of rudimentary impact assessment matrixes and benefit transfers. Consultants elaborating these assessments are often far removed from the more detailed valuation of environmental attributes. Progress in how to value environmental attributes has been rapid, not least in how to avoid common biases and double counting and when and how benefit transfers can be applied (Adamowicz et al., 1994; Bateman, 2002; Carlsson, 2010; Carson, 2012; Richardson et al., 2015). On the other hand, we suggest that the practice of environmental valuation would benefit from an increased understanding of how the uptake of scientific information, such as results from environmental valuation, is influenced by political and institutional factors. This has received considerable attention in the literature on environmental assessment and we discuss several such factors in papers 4 and 5. For example, if conducted in a more iterative manner, environmental valuation could be better targeted to inform decisions on particular trade-offs during specific decision-making windows and form part of a broader learning process. A greater emphasis in environmental valuation on analysing the distribution of costs and benefits among different groups in society could also increase the relevance of environmental valuation for policy making purposes. This may contribute to narrowing the gap between the considerable academic interest in methods for environmental valuation and their actual use in policy-making (Adamowicz, 2004).

Summary of papers

The purpose of papers 1–3 is to analyse risk perceptions and behavioural responses to the spread of ticks, tick-borne encephalitis (TBE) and Lyme borreliosis (LB) in Sweden and to estimate people's willingness to pay for risk reduction.

The spread of vector-borne infectious diseases is one of the most tangible impacts of climate change on human health (McMichael et al., 2006; Semenza, 2009). With global warming, the regions where vectors of infectious disease can be found have expanded to higher latitudes and altitudes. This represents a new and growing health risk in these areas. While the impacts of climate change on the spread of malaria through mosquitos have received considerable attention, the costs associated with the spread of tick-borne diseases are poorly covered in the scientific literature, even though the consequences of these diseases can be quite severe (Lindquist and Vapalahti, 2008; Stanek et al., 2012).

Sweden provides an interesting case study because of its large geographic variation in the abundance of ticks and the incidence of LB and TBE. Ticks have become more abundant and have spread further north, to areas where they were not previously present (Jaenson et al., 2012). This provides a possibility to compare risk perceptions and behaviour before and after adaptation to a new environmental health risk. The popularity of outdoor recreation in Sweden, not least in forest areas, also provides a relevant context for studying how people perceive and manage risks related to ticks and tick-borne diseases.

The empirical analyses in papers 1–3 are based on survey data collected in October 2013 from 1 500 randomly selected respondents (the full survey is included in the Appendix). We combine this survey data with data on exogenous disease risks in different geographical regions.

Analysing the role of risk perception and exposure for protective behaviour against tick-borne diseases is complicated by a potential endogeneity problem (Lloyd-Smith et al., 2016; Shogren and Crocker, 1999). While high risk perceptions may lead individuals to invest in vaccines or other forms of costly self-protection, there may be important feedback mechanisms from this behaviour to risk perceptions and exposure. For example, vaccination may reduce the perceived health risk from tick bites and lead to increased exposure. By including demographic factors and exogenously determined risk variables in the analysis, we partly address this problem.

In paper 1, *Learning to Live with Ticks? The Role of Exposure and Risk Perceptions in Protective Behaviour Against Tick-Borne Diseases* (co-authored with Anders Boman), we analyse factors associated with the use of five specific measures that individuals can undertake to protect themselves against tick bites and tick-borne diseases. We find that the share of respondents who frequently use protective clothing (64%), perform tick checks (63%) or avoid tall grass while in areas with ticks (48%) is relatively high. However, the use of protective measures is inconsistent and a considerably lower share tuck their trousers into their socks (18%), use repellent against ticks (16%) or use a combination of protective measures. There is also a segment of respondents who, despite high exposure, never or rarely check their skin for ticks (12% of the respondents) or use protective clothing (18%).

Thirty-one per cent of the respondents report one or more tick bites in the last year and 68% report one or more lifetime tick bites, indicating that it is difficult to protect oneself completely against tick bites. Exposure is strongly positively associated with checking the skin for ticks, but only weakly associated with other protective measures. Tick bites are perceived as a serious health risk by as many as 43% of the respondents. Forty-two per cent perceive that it is rather or very serious to get bitten by a tick. This indicates a divide in risk perceptions between tick experts and lay people. The perception that a single tick bite is serious is negatively associated with actual exposure to ticks, while the opposite is true for the perception that tick bites constitute a serious lifetime health risk. This points to a learning effect in relation to risk perceptions and the performance of tick checks, but not in relation to other protective measures.

In paper 2, *Valuation When Baselines Are Changing: Tick-borne Disease Risk and Recreational Choice* (co-authored with Thomas Sterner and Vic Adamowicz), we conduct a choice experiment where respondents choose between visiting recreational areas differing in prevalence of ticks and incidence of LB and TBE. The distance to the recreational areas also varies, so the respondent is faced with a trade-off between health risks on the one hand and monetary and time cost of travel on the other hand.

In line with Berry et al. (2017), who find that LB risk has a significant negative effect on the time people in the US spend outdoors, our study indicates that ticks and the pathogens they carry may have non-trivial welfare effects. These effects can be manifested in many ways. In this paper they are monetised by looking at the cost of the additional distance people say they are willing to travel in order to avoid ticks and disease risk but have an otherwise comparable trip experience. The mean WTP per recreational trip to avoid areas with ticks and an incidence of LB of 500 cases per 100 000 inhabitants is estimated to equal 210 SEK/24 EUR. The WTP to avoid recreational areas where there also is a high incidence of TBE (40 cases per 100 000 inhabitants) was on average 680 SEK/78 EUR per recreational trip.

Comparing WTP estimates among groups of respondents with different exogenous baseline risk, defined by the prevalence of ticks and the incidence of LB and TBE in the area of residence, we find that the WTP for risk reduction decreases with baseline risk. TBE-vaccinated respondents have a significantly lower WTP for avoiding areas with TBE risk, indicating that disease risk is endogenous to behaviour.

Residents in endemic risk areas generally have a better knowledge about tick-borne diseases than people living in areas with no or few ticks and adapt to a higher baseline risk through vaccination and other protective measures. Residents in emerging risk areas may have greater difficulties assessing disease probabilities and adaptation costs. However, their risk perceptions and preferences for risk reduction should not be dismissed as not being valid as the new risk may constitute a real and sizeable loss compared with their reference point utility. One might argue that the risk perceptions in areas where risk is new or emerging are biased by an exaggerated fear of the unknown or of very small probabilities. One could however equally well argue that the willingness to pay in endemic areas are biased by a forced resignation and adaptation of preferences to the inevitable change.

The study points to the difficulties involved in valuing welfare effects of environmental change over time. If the differences in WTP for risk reduction between inhabitants in endemic risk areas and emerging risk areas are not accounted for, there is a risk of underestimating the welfare costs. If adaptation to an increase in risk is not taken into account, welfare costs over time may be overestimated. Hence, differences in WTP for risk reduction between groups with differing baseline risks should be taken into account when estimating welfare costs associated with a spread of disease vectors, such as ticks, to new areas due to climate or other environmental change.

In paper 3, *The Willingness to Pay for Vaccination against Tick-Borne Encephalitis and Implications for Public Health Policy: Evidence from Sweden* (Published in 2015 in *PLOS ONE*)[1], we estimate vaccination coverage in areas with differing TBE risk levels and analyse the role of vaccine price and other factors influencing the demand for vaccination. We find that the average rate of TBE vaccination in Sweden is 33% in TBE risk areas and 18% elsewhere. Income, age and risk-related factors such as incidence of TBE in the area of residence, frequency of visits to areas with TBE risk and experience with tick bites are positively associated with demand for TBE vaccine. Using contingent valuation, we estimate the mean willingness to pay for TBE vaccination (the recommended three doses of TBE vaccine) among the unvaccinated respondents to be 465 SEK (approximately 46 EUR or 40% of the current market price). We project that a subsidy making TBE vaccines free of charge could increase the vaccination rate in TBE risk areas to around 78%, with a larger effect on low-income households, whose current vaccination rate is only 15% in risk areas. However, price is not the only factor affecting demand. We also find a significant positive effect of trust in vaccine recommendations, perceptions about tick bite-related health risks and knowledge

[1] Implications for public health policy are further discussed in the follow-up publication Bergström, T., Norberg, P., and Slunge, D. (2016). Dags att diskutera subventionerad TBE-vaccination (Time to discuss subsidized tick-borne encephalitis vaccination). *Läkartidningen*, 113(31-33).

about ticks and tick-borne diseases on vaccination behavior. Hence, increasing knowledge and trust, as well as ease of access to vaccinations, can also be important measures to increase the vaccination rate.

Papers 4 and 5 deal with risk assessment and decision-making at the collective level and concern how strategic environmental assessments are used to manage environmental risks and problems in various decision-making and institutional contexts.

Environmental assessments of activities involving significant risks to health and the environment comprise one of the most common legally binding procedural rules for risk assessment and management. The mandated use of environmental impact assessments (EIA) was first introduced in the US in 1969. Currently, more than 180 countries have legislation on EIA (Kolhoff, 2016). Following criticism that EIAs of projects were often conducted too late in the decision-making process to have substantial influence on risk management, many countries have introduced legal requirements for strategic environmental assessments (SEA) of programmes, plans and in rare cases even policies (Ahmed and Sánchez Triana, 2008). By combining the synthetization of scientific risk assessment information with public participation, environmental assessment procedures, in principle, incorporate several key aspects of modern risk management frameworks. However, in practice, many environmental assessments have been mainly technically oriented with limited influence on decision-making. Papers 4 and 5 add to a growing body of research stressing the importance of institutions and governance conditions as well as participation, deliberation and learning for the performance of environmental assessment systems (Ahmed and Sánchez Triana, 2008; Bina, 2008; Kolhoff, 2016; Kørnøv and Thissen, 2000; Owens et al., 2004; Runhaar and Driessen, 2007). This literature forms part of a broader recognition within social science and development policy of the fundamental role of institutions and governance for economic and social development as well as environmental and natural resources management (Acemoglu et al., 2004; Ostrom, 2005; Vatn, 2005).

In paper 4, *Greening Growth through Strategic Environmental Assessment of Sector Reforms* (co-authored with Fernando Loayza, published in 2012 in *Public Administration and Development*)[2], we argue that in order to make growth greener and more inclusive, it is crucial to enhance the performance of the institutions and incentive structures in national sector reform processes and to involve poor and vulnerable groups in decision-making. The article analyses the role SEAs can play in such reform processes. The empirical basis for the article is drawn from a World Bank programme

[2] The paper is supported by the following three publications: (i) Slunge, D., Nooteboom, S., Ekbom,A., Dijkstra, G., and Verheem, R. (2011). Conceptual Analysis and Evaluation Framework for Institution-Centered Strategic Environmental Assessment. In *Strategic Environmental Assessment in Policy and Sector Reform – Conceptual Model and Operational Guidance*, World Bank, 2011, Washington DC.; (ii) Slunge, D., Ekbom, A., Loayza, F., Nyangena, W., and Guthiga, P. (2015). Can Strategic Environmental and Social Assessment of REDD+ Improve Forest Governance?, In *Forest Tenure Reform in Asia and Africa - Local Control for Improved Management, and Carbon Sequestration*, Chapter: 16, RFF Press, Eds.: Bluffstone, R.A., and Robinson, E.J.Z. pp.251–267; (iii) Axelsson, A., Annandale, D., Cashmore, M., Slunge, D., Ekbom, A., Loayza, F., Verheem, R. (2012). Policy SEA: lessons from development co-operation. *Impact Assessment and Project Appraisal*, 30 (2) p. 124–129.

involving SEAs of different sector reforms (mining, forestry, urban planning and infrastructure) in Africa (Kenya, Malawi, Sierra Leone, Guinea and Liberia) and Asia (China, Bangladesh and Pakistan). We suggest that SEAs can contribute to greening growth if it draws attention to environmental priorities when the sector reform agenda is set, fosters policy learning processes through repeated and sustained stakeholder interaction, and facilitates access to information and empowerment of environmental constituencies. The institutional context plays a crucial role for the success of such efforts.

The role of institutions for the performance of strategic environmental assessments is further analysed in paper 5, *Challenges to Institutionalizing Strategic Environmental Assessment: the Case of Vietnam* (co-authored with Trang Thi Huyen Tran, published in 2014 in *Environmental Impact Assessment Review*). Building on new institutional theory (Ostrom, 2005; Williamson, 2000), we develop an analytical framework for analysing constraints to the institutionalisation of SEAs at four different institutional levels. The framework is tested in an empirical analysis of the environmental assessment system in Vietnam, which is a frontrunner among low- and middle-income countries regarding the introduction and use of SEAs. Building on interviews with Vietnamese and international experts, as well as an extensive literature review, we identify institutional constraints that challenge the effective use of SEAs in Vietnam. We conclude that commonly identified constraints, such as inadequate training, technical guidelines, baseline data and financial resources, are strongly linked to constraints at higher institutional levels, such as incentives not to share information between ministries and restrictions on freedom of association and expression. Without a thorough understanding of these institutional constraints, there is a risk that attempts to improve the use of SEAs are misdirected. Thus, a careful institutional analysis should guide efforts to improve the use of SEAs in Vietnam and other countries. The analytical framework for analysing constraints to institutionalisation of SEAs presented in this paper represents a systematic effort in this direction.

Concluding remarks

This thesis combines two rather separate literatures and methodologies that we believe would benefit from more contact. On the one hand studies using behavioural and experimental economics to value environmental attributes where more policy context would be very appropriate and on the other hand strategic environmental assessment where better valuation methods are needed. The thesis casts some light on risk perceptions and behavioural responses to the growing health risks posed by tick-borne diseases as well as on the role of institutions for the performance of strategic environmental assessments. To conclude, we discuss some policy implications.

Providing information about tick-borne disease and protective measures is an apparent and ongoing policy response to the increasing disease incidence. Such information may be especially important in emerging risk areas by facilitating the process of adaptation to living in a new risk context. Information on the effectiveness of various protective measures as well as the importance of implementing them in combination should form part of such information. The possibilities to provide targeted information to groups with high exposure, for example hunting associations and other organisations involved in outdoor activities, could be further explored, and the effects of geographically based information on the level of risk of LB and TBE in different areas should be further analysed. Our choice experiment indicates that such information can affect recreational choice, but it could also potentially influence physical planning decisions such as the locations of pre-schools or camping sites.

However, a key challenge in providing information related to ticks and tick-borne diseases is how to encourage precaution without causing alarm, so that engagement in outdoor recreational activities – which may have associated health benefits – rather than avoidance is promoted. In addition, the expectations on the possibilities of reducing disease incidence by just providing risk-related information should be modest.

Given the high exposure to tick bites and the growing incidence of LB and TBE, other preventive measures should be further discussed, including vaccination programmes. Subsidised TBE vaccination programmes have been effective in reducing disease incidence in Austria and in highly endemic areas of Finland. Similar programmes could be tested in TBE risk areas in Sweden. The cost-effectiveness of such programmes should be further explored.

Our findings regarding the importance of institutions for the performance of environmental assessments are relevant for the many public agencies in low- and middle-income countries currently developing legal frameworks and practices in this field. A crucial challenge to enhance the use of SEAs is to create incentives for the lead agencies to use SEAs repeatedly as a strategic decision-support tool. Without strong ownership by the sector agencies, there is a risk that the legal requirements for SEAs will be viewed mainly as bureaucratic hurdles to be circumvented with the lowest effort possible. While developing legal requirements is necessary for institutionalising SEAs, the legal framework should arguably develop gradually on the basis of experience. The great diversity in formal and informal institutions across countries calls for avoiding blueprint approaches to the application of SEAs. If well managed, SEAs may be particularly relevant as a decision-support tool in low- and middle-income countries, where information about environmental risks is often scattered.

However, also in countries like Sweden, the use of strategic environmental assessments may provide valuable insights. As a synthesis of this thesis, we propose a strategic environmental health assessment to analyse problems and policy options related to ticks and tick-borne diseases in Sweden. Such an assessment would be motivated by the growing disease incidence of TBE, the lack of robust estimates of the incidence of LB and the high average risk perceptions related to ticks.

Besides analysing the magnitude of the problem under different scenarios, the assessment should analyse the costs and benefits of possible risk communication strategies, vaccination programmes and other policy options to reduce the risks associated with ticks and tick-borne diseases. Examples of other policy options include measures to reduce the abundance of ticks through landscape management, cultivation patterns, the culling of deer, rodents or other vectors and finally the use of pesticides, all of which are surrounded by considerable scientific uncertainty and ambiguity. The proposed assessment could also form part of a broader analysis of emerging infectious disease risks resulting from climate change. By combining this analytical work with a structured participatory process involving authorities, researchers, interest groups and the public, the capacity to manage the growing risks posed by tick-borne diseases, and other vector-borne diseases, could be enhanced.

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Paper I

Learning to Live with Ticks? The Role of Exposure and Risk Perceptions in Protective Behaviour Against Tick-Borne Diseases

Daniel Slunge[‡] and Anders Boman[§]

Abstract

The purpose of this study is to analyse the role of risk perceptions and exposure for protective behaviour against tick bites and the related diseases Lyme borreliosis (LB) and tick-borne encephalitis (TBE), both of which are growing health concerns. We use data from a national survey in Sweden with respondents in geographical areas with substantial differences in both abundance of ticks and incidence of LB and TBE. We find that the share of respondents who frequently use protective clothing (64%), perform tick checks (63%) or avoid tall grass while in areas with ticks (48%) is relatively high. However, the use of protective measures is uneven and a considerably lower share tuck their trousers into their socks (18%), use repellent against ticks (16%) or use a combination of protective measures. Thirty-one per cent of the respondents report one or more tick bites in the last year and 68% report one or more lifetime tick bites, indicating that it is difficult to protect oneself from tick bites. There is a strong positive association between exposure and checking the skin for ticks, but exposure is only weakly associated with other protective measures. Tick bites are perceived as a serious health risk by as many as 43% of the respondents. The perception that a single tick bite is serious is negatively associated with actual exposure to ticks, while the opposite is true for the perception that tick bites constitute a serious lifetime health risk. This indicates a learning effect in relation to risk perceptions and the performance of tick checks, but not in relation to other protective measures. Recommendations include informing people of the risks associated with tick bites, the efficacy of various protective measures and the importance of combining multiple types of protection. Given the high exposure to tick bites, the growing incidence of TBE and LB, and the difficulties in preventing tick bites, other preventive measures should be further discussed, including vaccination programmes.

Key words: risk perception, protective behaviour, ticks, tick-borne disease, Lyme borreliosis, TBE

JEL Classification: I12, I18, Q54, Q57

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1. Introduction

While risk perceptions play an important role in protective behaviour against various health risks (Conner and Norman, 2005; Dickie and Gerking, 1996; Gerking et al., 2016), perceived risk is often inconsistent with objective measures of risk (see e.g. Slovic, 1987). This inconsistency is especially common for new health risks perceived as difficult to control (Sjöberg, 2000; Slovic, 1987) and may lead to levels of protection that are not optimal from an individual or a societal perspective.

The purpose of this study is to analyse the role of exposure and risk perceptions for protective behaviour against tick-borne diseases, which have become a growing public health problem in Europe and elsewhere. Partly due to climate change, ticks have spread to areas where they were not present earlier (Jaenson et al., 2012a; Jore et al., 2014) and the pathogens carried by ticks represent a new health threat in these regions. The incidence of the two most common tick-borne diseases – tick-borne encephalitis (TBE) and Lyme borreliosis (LB) – has increased in many countries (Lindquist and Vapalahti, 2008; Stanek et al., 2012).[1]

TBE is caused by the TBE virus, a flavivirus transmitted to humans by ticks that can cause severe infection of the central nervous system. Around 40% of those infected by the European subtype of the virus suffer from serious long-term or permanent sequelae (Haglund and Günther, 2003; Lindquist and Vapalahti, 2008). LB infection is caused by spirochetes belonging to the *Borrelia burgdorferi* sensu lato complex. The infection may affect several organs and tissues of the human body. While symptoms can be mild or absent for some individuals, they can be severe for others, especially if not treated at an early stage (Stanek et al., 2012). There is no cure for TBE but the disease can be effectively prevented by vaccine (Heinz et al., 2013; Kunz, 2003). The situation is the opposite for LB, i.e. there is no vaccine available on the market but the infection can be treated with antibiotics.

Risk assessment is complicated by the heterogeneous distribution of the TBE virus and different *Borrelia* species. While the mean prevalence of TBE virus in ticks in northern Europe[2] is estimated at 0.28% and the mean prevalence of *Borrelia burgdorferi* species in ticks in 24 European countries is estimated at 14%, the regional variation in prevalence can be considerable (Pettersson et al., 2014; Rauter and Hartung, 2005). Despite a higher mean prevalence (26%) of ticks collected in Sweden that carried *Borrelia* bacteria, only 2% of those who had been bitten by a tick were diagnosed with LB (Wilhelmsson et al., 2016; Wilhelmsson et al., 2013). This indicates that that even after a bite by a tick that carries *Borrelia*, the risk of developing LB is low in each individual case. Nevertheless, given the large number of tick bites and the spread of ticks to new regions, this may still be a cause for concern.

Should public policy address this growing health threat more actively? Normally, public costs for health interventions need to be motivated by the avoidance of externalities (such as the spread of contagious

[1] Other tick-borne diseases include Babesiosis, Crimean Congo haemorrhagic fever, Rickettsiosis and relapsing fever.

[2] Sweden, Norway, Denmark and Finland.

diseases) or the provision of public goods (such as a healthy society). Because tick-borne diseases cannot be transmitted from one person to another, there is no positive external effect from individual vaccination (no so-called herd immunization) or other types of protective behaviour. Yet, if the costs to society caused by tick-borne disease are large, in a country with a publicly financed health system, public policy measures may still be motivated. Policy measures could also be justified for reasons sometimes referred to as paternalistic, i.e. the more informed regulator would encourage people to protect themselves out of concern for their health if the people for some reason do not protect themselves in a way that is optimal from a societal perspective (Johansson-Stenman, 2008).

One such reason could be the difficulties involved in assessing events with small probabilities but a potentially large impact, such as the risk of contracting a tick-borne disease. For such events, laypeople tend to focus more on the perceived severity of the event if it does occur, while experts focus more on the probability (Fischhoff, 1995; Sjöberg, 2000; Slovic, 1987). There is some evidence that an expert-layman divide exists in risk perceptions related to LB (Aenishaenslin et al., 2014). Risks related to ticks may also be overestimated due to perceptions that they are difficult to control, or because ticks cause feelings of disgust and are often portrayed in alarmist media headlines (Loewenstein et al., 2001; Mowbray et al., 2014; Sjöberg, 2006; Slovic, 1987). While it is common that 'risk alarmists' – people with high risk perceptions – are vocal in the public debate (see e.g. Tonks, 2007 in relation to LB), there is often a larger and more silent group of 'risk deniers' – people with very low risk perceptions despite the fact that real risks do exist (Sjöberg, 2006).

The most common policy measure to reduce the risk of tick-borne diseases is for health authorities to undertake information campaigns and education interventions aimed at increasing the use of various protective measures that individuals can undertake. Protective measures commonly recommended include avoiding risk areas or staying on trails while in risk areas, using protective clothing (long sleeves and trousers), tucking trousers into socks, using tick repellent, and checking the body for ticks and removing them before or as soon as possible after they attach (Lindsay et al., 2015; Piesman and Eisen, 2008).[3] In countries where TBE is endemic, health authorities also commonly recommend vaccination against TBE for people in risk areas (Heinz et al., 2013). There is mixed evidence on the effectiveness of these protective measures. Protective clothing makes it more difficult for ticks to attach (Gutiérrez and Decker, 2012; Piesman and Eisen, 2008), some repellents have been proved to deter ticks (Piesman et al., 2001) and the risk of LB is reduced if attached ticks are removed within 24–48 hrs (Piesman et al., 2001; Sood et al., 1997).[4] However, only few studies using control trials on the effectiveness of protective clothing and tick checks in preventing tick bites exist. In one such study, Vazquez et al. (2008)

[3] See Clark and Hu (2008) and Piesman and Eisen (2008) for reviews of other risk-reduction policy measures available, including controlling the tick population through the use of insecticides in smaller areas such as gardens or public parks, through landscape management, or by treating roe deer with acaricides (a type of pesticide) at feed stations. Subsidized vaccination programmes against TBE have been introduced in e.g. Austria and parts of Finland (Heinz et al., 2013; Slunge, 2015).

[4] The risk of developing a Borrelia infection after a bite by a Borrelia-infected tick increases with the duration of tick feeding (Wilhelmsson et al., 2016). Quick removal of an attached tick does not reduce the risk of transmission of the TBE virus.

finds evidence that protective clothing but not tick checks is effective in preventing tick bites. Several studies find that vaccination is effective in preventing TBE (Heinz et al., 2007; Heinz et al., 2013).

Despite the existence of risk-reducing measures, their use is uneven and can be surprisingly low in areas where ticks and LB are endemic (Herrington, 2004; Jones et al., 2002; Shadick et al., 1997; Stjernberg and Berglund, 2005). Temporary visitors to endemic areas are more likely than full-time residents to undertake protective measures (Stjernberg and Berglund, 2005; Valente et al., 2015). A number of studies find only weak or ambiguous associations between exposure and protection (Aenishaenslin et al., 2015; Beaujean et al., 2013; Herrington, 2004). This is surprising since the benefits of protection should increase with exposure to risk.

One possible explanation to the weak association between exposure and protection is that risk perceptions are dulled in endemic areas as people get used to living with the risk of tick-borne diseases and perceive them as less serious than residents in lower incidence areas (Herrington, 2004) or temporary visitors (Stjernberg and Berglund, 2005; Valente et al., 2015). Several studies have found that the perceived risk of tick bites and LB have a stronger association with protective behaviour than does actual exposure to risk (Aenishaenslin et al., 2015; Beaujean et al., 2013; Herrington, 2004). However, explaining protective behaviour with risk perceptions is complicated by a potential endogeneity problem (Lloyd-Smith et al., 2016). While higher risk perceptions may lead to a higher use of protective measures, there may be important feedback mechanisms from this behaviour to risk perceptions. We discuss this further below.

A second explanation may be that the cost of using a protective measure is perceived to be greater than the benefit. Perceived costs of using protective measures against tick-borne diseases include discomfort (wearing protective clothing in summer is too warm), image issues (looking stupid with trousers tucked into socks), informational costs (not knowing how to remove a tick) and health risks from the use of repellents (Beaujean et al., 2013; Mowbray et al., 2014). Negative associations between the cost of using a protective measure and its use have been found in relation to several other health risks (Abdalla, 1990; Bresnahan et al., 1997; Harrington et al., 1989).

From a public health perspective, it is hence important to further understand how exposure and risk perceptions are associated with protective behaviour against tick bites and tick-borne diseases. Is increased exposure to risk associated with more frequent use of protective measures? Or is exposure associated with a downward adjustment in risk perceptions leading to an ambiguous association between exposure and protective behaviour? If the latter is true, risk perception is a poor predictor of protective behaviour in groups with high exposure.

In this paper, we try to answer these questions through a careful investigation of the associations between exposure, risk perceptions and protective behaviour within a large sample of respondents in Sweden. Sweden provides an interesting case study because of its large geographic variation in the abundance of ticks and the incidence of LB and TBE (Jaenson et al., 2012a; Jaenson et al., 2012b).

Our analysis contributes to the existing literature in several ways. First, the exogenous geographic variation in the risk of contracting LB or TBE in the various areas of residence of our survey respondents enables us to analyse exposure, risk perceptions and protective behaviour in a variety of risk contexts. In this way, we partly address the potential endogeneity involved in explaining protective behaviour in connection with risk perceptions or exposure (Lloyd-Smith et al., 2016). A similar approach was taken by (Aenishaenslin et al., 2015), who compared risk perceptions and protective behaviour between respondents in an LB-endemic region in Switzerland and respondents in an emerging risk area in Canada. However, in our study, all respondents are in the same political and institutional context, reducing the potential confounding factors that can be found in cross-country studies.

Second, by using two distinct measures of risk perception, we show that, while the perceived seriousness of a single tick bite decreases with exposure and experience, the perceived lifetime health risk from tick bites increases with experience.

Third, we contribute to the ambiguous literature on demographic factors associated with protective behaviour and identify groups of respondents who have high exposure but a low degree of protective behaviour. It may be particularly important to target such groups in risk management efforts by public authorities.

Finally, despite the significant presence of ticks, LB and TBE in Sweden, surprisingly little is known about risk perceptions and protective behaviour. Stjernberg and Berglund (2005) investigate protective behaviour on the small island of Aspö in southern Sweden, where LB and TBE are endemic. However, this is the first national survey and analysis of risk perceptions and protective behaviour related to ticks and tick-borne diseases in Sweden.

2. Data and methodology

2.1. Empirical strategy

Analysing the role of risk perception and exposure for these protective behaviours is complicated by a potential endogeneity problem (Lloyd-Smith et al., 2016). While risk perception may be positively linked to protective behaviour, for example the use of protective clothing, there may be important feedback mechanisms from this behaviour to risk perceptions. This could also lead to risk compensation, where a perceived increase in the level of protection leads to increased exposure (Cassell et al., 2006). There may also be unobserved factors that affect protective behaviour against ticks, factors that may be correlated with risk perceptions, leading to omitted variable bias. Ignoring this potential endogeneity problem may lead to biased estimates of the effect of risk perception on protective behaviour.

We partly address this problem by including exogenous variables in our analysis. These are demographic variables and variables capturing the level of risk of getting tick bites, LB and TBE when visiting tick habitats in various areas.

We focus on five different kinds of protective behaviour against ticks and tick-borne diseases: checking the skin for ticks after having spent time in tick habitats, using protective clothing (long sleeves and trousers), tucking trouser legs into socks, using insect repellent and avoiding tall grass and bushes while in areas with ticks. We also discuss associations between these behaviours and TBE vaccination.

Because earlier studies have shown that there are differences in the factors associated with distinct protective behaviours (Aenishaenslin et al., 2015; Beaujean et al., 2013), we first analyse each behaviour independently of the others. We use a logistic regression model with the following specification to analyse which explanatory variables are associated with each type of protective behaviour. In a first step, we analyse how a protective behaviour is associated with exposure and demographic variables:

$$(1) \quad protect_{ij} = \beta_0 + \beta_1 D_i + \beta_2 R_i + \beta_3 E_i + u_i$$

where, in line with other recent studies (Aenishaenslin et al., 2015; Beaujean et al., 2013), $protect_{ij}$ is a dummy variable equal to one if respondent *i* uses protective measure *j* often or always (and zero if never or rarely). D_i is a vector of demographic characteristics, R_i is a vector of objective risk variables in a geographical area and E_i is a vector of exposure variables. u_i is an error term.

Next, we expand the model by adding variables concerning risk perceptions (P_i) and knowledge about ticks and tick-borne diseases (K_i).

$$(2) \quad protect_{ij} = \beta_0 + \beta_1 D_i + \beta_2 R_i + \beta_3 E_i + \beta_4 P_i + \beta_5 K_i + u_i$$

In a third step, we assess the robustness of our results by introducing a set of control variables. These include the perceived efficacy of protective measures,[5] education, ownership of an outdoor pet, access to a summerhouse in a TBE risk area, TBE vaccination and work-related exposure to tick bites.

To analyse if the behaviours are implemented in combination or as substitutes, we also analyse the behaviours jointly using a count model as well as a multinomial logit model. First we use a dependent variable, *protect 0–5*, which is defined on a scale from zero (0) to five (5) depending on the number of protective measures used. To estimate the associations between this dependent variable and our independent variables, we use a Poisson count model. A limitation of the count model is that there is no ranking of the different measures, so that for example checking the body for ticks is ranked equally with using repellent or avoiding tall grass and bushes, even though checking the body for ticks may provide protection superior to the two other measures jointly. We compare the results from using *protect 0–5* as dependent variable with the results when using a somewhat different count variable, *protect 0–15,* as dependent variable. This variable also takes into account the frequency of the use of each protective measure (See Appendix A1 for variable definitions and A4 for estimated results).

[5] Several studies show expected significant positive associations between the perceived efficacy of a protective measure and the use of the measure. However, similar endogeneity problems as outlined above are connected with these variables.

Second, we use a multinomial logit regression model to analyse associations with the most frequent combinations of protective measures. The dependent variable *protect MNL* is defined on a scale from zero (0) to nine (9) where 0 represents no protective measure used and values 1–8 represent those protective measures or combination of measures used most frequently. Value 9 indicates a combination of measures used infrequently (by less than 5% of the respondents) and is not analysed (See Appendix A1 for variable definitions and A5 for multinomial logit regression results).

Definitions and summary statistics of the independent variables used in the analysis are provided in Table 1 and Appendix 1 contains a more detailed version. We use the variance inflation factor (VIF) to control for potential multicollinearity between the independent variables. Mean VIF when all control variables are included in the regression analysis is 2.8. The highest VIF value is 7.1, which is found for the knowledge variable. This is below 10, which is the standard benchmark for multicollinearity.

To account for the considerable heterogeneity in the risk of encountering ticks and getting infected with LB or TBE in Sweden, we classify the risk in the area of residence of the respondents into three categories. Figure 1 shows the geographical locations of these areas. Our identification of TBE risk areas is based on geographical data for the 2 687 TBE cases in Sweden 1986–2012 reported by the Swedish Public Health Agency, which we cluster in areas based on three-digit postal codes. We define *TBE risk areas* as areas with two or more reported cases of TBE in a three-digit postal code area in the years 1986–2012. This is similar to the classification of risk areas used by Swedish regional health authorities when producing TBE risk maps (Swedish Public Health Agency, 2014). We define the *emerging risk area* as the geographical area of Norrland. In this area, which is situated north of the biogeographical boundary Limes Norrlandicus, there were no ticks in the past, but ticks have spread to the area in recent decades, partly as a result of an increasingly warmer climate (Jaenson et al., 2012a; Jaenson et al., 1994) . Remaining areas are defined as *tick risk areas,* that is areas situated south of Norrland that are not classified as TBE risk areas. Although this is a very rough division, it reflects the considerably longer history and higher presence of ticks and LB risk in tick risk areas than in the emerging risk area (Jaenson et al., 2012a). This classification of risk areas corresponds to the pattern of tick bites and experience with tick-borne diseases found in our data (see Figure 2 and Table 1).

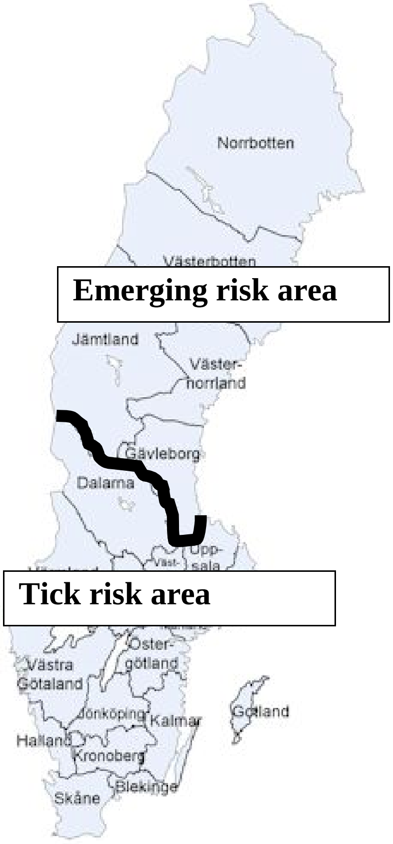

Figure 1a. TBE risk areas defined as areas with two or more reported cases of TBE. Each dot represents one of 2 687 reported TBE cases 1986–2012

Figure 1b. The region of Norrland defined as emerging risk area. Tick risk area defined as south of Norrland but outside TBE risk areas.

Figure 1. TBE risk area, tick risk area and emerging risk area

2.2. Data collection

A questionnaire (Appendix B) was developed based on focus group discussions, two pilot tests and key informant interviews with doctors and epidemiologists specialising in tick-borne diseases. The survey was performed under informed consent and approved by the Regional Ethical Review Board at the University of Gothenburg (decision number 544-13). The design of the questionnaire was informed by earlier studies on variables associated with protective behaviour and risk perceptions and included questions about experience, exposure, risk perception, knowledge and protective behaviour related to ticks and tick-borne diseases, as well as socio-economic information about the respondent and his/her household.

The questionnaire was distributed online in October 2013 to 6 000 respondents aged 18–85 years in a national internet panel representative of the Swedish population. The internet panel consists of approximately 8 000 members recruited through telephone interviews with randomly sampled respondents (selection into the sample is therefore reduced compared with e.g. a voluntary opt-in survey). After two reminders, responses from 2 066 participants were received, corresponding to a response rate of 34%. This paper uses only the 1 510 respondents (25%) who answered all questions corresponding to the variables included in this analysis.

The low response rate raises concerns about potential sample selection bias. Web-panel respondents may, for example, spend less time outdoors than the population in general and would hence be less exposed to the risk of tick bites. Another possibility is that the respondents are more concerned about ticks and related diseases and more likely to exhibit protective behaviour than the population average. Because this is the first national study in Sweden on protective behaviour against ticks and tick-borne diseases, there are no good comparative statistics for many of our variables. However, we can compare the share of vaccinated respondents in our study with a recent study of TBE vaccination rates in Stockholm County (Askling et al., 2015), which finds that 53% of the population in Stockholm County has ever had a TBE vaccine shot. TBE is endemic to Stockholm County, and it is expected that the vaccination rate within its borders is considerably higher than the Swedish average. In our study, 24% of all respondents and 48% of the respondents living in Stockholm County were vaccinated. This indicates that our study found approximately the same vaccination rate as the survey used by Askling et al. (2015). The large share of the respondents in the survey who engage in outdoor activities very frequently also corresponds to findings about outdoor habits from other surveys of the Swedish population (Fredman and Bladh, 2008). This reduces our concerns about the response rate.

3. Results

3.1. Descriptive statistics

Table 1 provides definitions and summary statistics of the variables included in the analysis (see also Appendix 1). Column 1 reports summary statistics for all respondents. In Columns 2–4, respondents are divided into three groups according to the prevalence of ticks, LB and TBE in their area of residence. Of the 1 510 respondents in the sample, 12% live in the emerging risk area, 59% live in tick risk areas and 29% live in TBE risk areas. Columns 5–6 report summary statistics for respondents vaccinated/not vaccinated against TBE, respectively.

We find some small but statistically significant differences in socio-economic characteristics between our survey respondents and the Swedish population.[6] In Section 4, we discuss possible implications of these differences for our results.

A large share of the respondents state that they often or always check their body for ticks after being outdoors in areas with ticks (63%) or use protective clothing when in forests or other areas with ticks (64%). A much lower share tuck their trousers into their socks (18%) or use repellent (16%) as protective measures. Forty-eight per cent report they avoid tall grass or bushes while in areas with ticks. However, considerably fewer respondents use a combination of these protective measures.

[6] Using a t-test, we cannot reject the hypothesis of equal mean values between the sample and the population. In 2013, the mean age in the population was 49 and 51 in the sample. The share of women was 50% in the population and 54% in the sample. The mean monthly household income was SEK 40 600 in the population and SEK 44 000 in the sample (Statistics Sweden, 2013). Based on a comparison with geographically coded population statistics, we find that the geographical distribution of the respondents is largely representative of the Swedish population.

Table 1. Descriptive statistics (mean values)

VARIABLES	(1) All respondents	(2) Emerging risk area	(3) Tick risk area	(4) TBE risk area	(5) Not TBE vaccinated	(6) TBE vaccinated
Female respondent	0.54	0.55	0.54	0.53	0.54	0.54
Age[a]	50.9	50.3	50.5	51.9	50.1	54.2
Household pre-tax income/month (SEK)[b]	44.0	41.7	43.9	45.1	42.3	49.7
Has studied at university	0.52	0.50	0.55	0.47	0.60	0.50
Has child under 18 years	0.26	0.28	0.25	0.28	0.27	0.24
Lives in the countryside/small village	0.30	0.37	0.28^{Ω}	0.31	0.33	0.24
Monthly or more frequent visits to areas with ticks	0.83	$0.70^{\#}$	0.84	0.87	0.80	0.93
Monthly or more frequent visits to areas with risk of TBE	0.37	0.13*	0.35*	0.53*	0.28	0.67
Has had 1 or more tick bites in lifetime	0.68	$0.25^{\#}$	0.73	0.76	0.64	0.85
Had at least 1 tick bite in last 12 months	0.31	$0.04^{\#}$	0.34	0.37	0.26	0.48
Respondent has had a tick-borne disease	0.12	$0.02^{\#}$	0.13	0.14	0.09	0.20
Family member/close friend has had a tick-borne disease	0.41	$0.18^{\#}$	0.43	0.46	0.36	0.56
Perception: tick bites rather or very high risk to health	0.43	0.19*	0.44*	0.50*	0.38	0.60
Perception: rather or very serious to get tick bite	0.42	0.42	0.42	0.42	0.41	0.43
No. of correct answers on knowledge questions (0–7)	3.82	$2.87^{\#}$	3.92	4.03	3.58	4.73
No. of protective measures used often/always (0–5)	2.10	$1.74^{\#}$	2.10	2.24	2.06	2.26
Check body for ticks	0.63	$0.29^{\#}$	0.67	0.70	0.59	0.77
Covering clothing	0.64	0.64	0.64	0.66	0.65	0.64
Tuck trousers into socks	0.18	0.18	0.16	0.21	0.19	0.18
Repellent	0.16	0.21	0.15^{Ω}	0.16	0.15	0.19
Avoid tall grass and bushes while in areas with ticks	0.48	0.42	0.48	0.50	0.48	0.49
Vaccinated against TBE	0.24	0.07*	0.23*	0.35*	0	1
Observations[c]	1510	187	884	439	1113	361

Notes: [a] Age: the standard deviation among all respondents is 17.0 years; min=18 years; max=80 years; [b] Income: the standard deviation among all respondents is SEK 23 000; min=SEK 5 000; max=SEK 115 000. Respondents indicated their income in intervals of SEK 10 000. The average income is generated from the mean in each interval.

[c] The number of observations was 1 502 for *has studied at university*, 1 507 for *family member/close friend has had a tick-borne disease* and 1 474 for *vaccinated against TBE*.

*Mean estimates for the different risk areas are significantly different from each other ($p<0.05$, Pearson Chi-square statistic).

$^{\#}$ Mean estimate is significantly different from other risk areas ($p<0.05$, Pearson Chi-square statistic).

$^{\Omega}$ Mean estimate is significantly different from emerging risk area ($p<0.05$, Pearson Chi-square statistic).

Forty-five per cent of the respondents use protective clothing *and* perform tick checks, and 15% use these two measures in combination with tucking their trousers into socks. Four per cent report that they use all five of these protective measures often or always. Twenty-four per cent were vaccinated against TBE.

The use of tick checks and protective clothing found in this study is somewhat higher and the use of repellent lower than in the LB- and TBE-endemic Swiss region Neuchâtel (Aenishaenslin et al., 2015).[7] It is also considerably higher than in the Netherlands, where, according to Beaujean et al. (2013), 37% use protective clothing and 32% check their bodies for ticks. One possible explanation for the considerably higher use of protective measures in Sweden than in the Netherlands is the higher exposure to ticks. Sixty-eight per cent of the respondents in our sample had been bitten by one or more ticks, compared with 21% in the study from the Netherlands.

Spending time outdoor in forests or other areas where there may be ticks is very common, with 83% of the respondents reporting spending time in such areas on a monthly or more frequent basis from May to September. Thirty-seven per cent of the respondents report spending time in areas where they know the ticks may be infected with TBE.

Experience with tick bites and tick-borne disease is common among the respondents. Only 32% reported they had never had a tick bite. Thirty-one per cent had had one or several tick bites in the last 12 months and 12% reported to have been diagnosed with a tick-borne disease[8]. Because there is no requirement in Sweden to notify public health authorities about LB cases, there are no comparative disease statistics. A study of a highly LB-endemic area in Sweden found that 25% of the respondents had been treated for LB at least once (Stjernberg and Berglund, 2005). In the LB-endemic region of Neuchatel in Switzerland, Aenishaenslin et al. (2014) found that 6% had been diagnosed with LB. Forty-one per cent of the respondents report they have a family member or a close friend who has had a tick-borne disease.

The average perceived risk concerning ticks and tick-borne diseases is very high. Forty-two per cent perceive that it is rather or very serious to be bitten by a tick, and 43% of the respondents answered that tick bites generally constitute a rather large or very large risk to his/her health or the health of his/her family[9]. In comparison, 26% and 31% answered that air pollution and traffic accidents, respectively, constitute a rather or very large risk.

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[7] Fifty-seven per cent of the respondents performed tick checks, 53% used protective clothing and 29% used repellent often or always.

[8] Out of the 179 respondents reporting they had been diagnosed with a tick-borne disease, 169 had been diagnosed with LB, seven with TBE and three with other tick-borne diseases.

[9] There is indication of a divide between experts and laypeople in risk perceptions. We conducted a poll among experts attending the annual meeting of the Swedish network of tick researchers in May 2015. Among 35 respondents, 9% stated it was rather serious to get a tick bite (0% stated very serious). Twelve per cent stated that tick bites constitute a rather large risk for their own or their family's health (0% stated very high risk). A similar divide has been found between experts and laypeople in Canada (Aenishaenslin et al., 2014).

Comparing respondents in the different risk areas (Table 1, Columns 2–4), we find notable differences regarding exposure, risk perceptions and knowledge. As expected, tick bites are mainly experienced in tick-risk areas and TBE risk areas, with only 4% of respondents in the emerging risk area reporting at least one tick bite in the last 12 months. In comparison, 34% of the respondents living in tick risk areas and 37% living in TBE risk areas reported one or more tick bites in the last 12 months. In addition, experience with and knowledge about tick-borne diseases increase with the level of risk in the area of residence. Figure 2 illustrates the geographical location of the area of residence of the respondents, places where respondents report they were bitten by ticks in the previous year and the area of residence of TBE-vaccinated respondents.

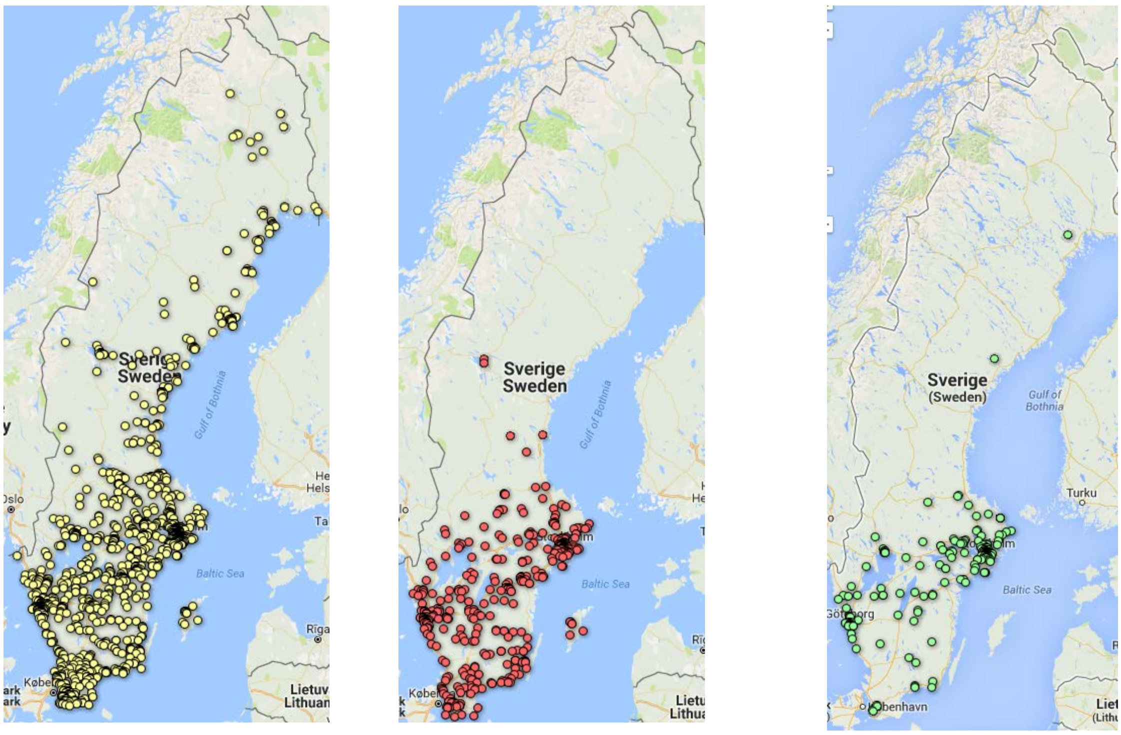

Figure 2a. Place of residence of respondents (n=1510)

Figure 2b. Place of tick bite in last 12 months reported by respondents (n=615)

Figure 2c. Place of residence of TBE-vaccinated respondents (n=362)

Figure 2. Geographical location of respondents' place of residence, reported tick bites and TBE-vaccinated respondents

Considering the large difference in experience with ticks, there is surprisingly little difference between the shares of the respondents in the different risk areas who use protective measures. Besides TBE vaccination, checking the body for ticks after being outdoors is the only protective measure used significantly more in tick and TBE risk areas than in the emerging risk area. We find no significant differences between respondents in the emerging risk area and in the other risk areas in their use of protective clothing, tucking trousers into socks or avoiding tall grass and bushes. The use of repellent is significantly higher in the emerging risk area than in tick risk areas, indicating that respondents use – or have become accustomed to use – repellent for other reasons than ticks, for example as protection against mosquitos. This could also be true for other protective measures. In a study of protective measures in the UK, frequent use of long trousers was primarily due to factors such as the weather or avoidance of cuts and scrapes and not to an intention to prevent tick bites (Mowbray et al., 2014). The only statistically significant difference between respondents in tick risk areas and TBE risk areas is found in relation to TBE vaccination and tucking trousers into socks.

Statistically significant differences between TBE vaccinated and unvaccinated respondents are discussed in Slunge (2015). Regarding protective behaviour, we find that checking the body for ticks is a significantly more frequent behaviour among vaccinated respondents ($p<0.01$, Pearson Chi-square statistic). Also the use of repellent is more common among vaccinated respondents ($p=0.09$, Pearson Chi-square statistic). We find no significant differences in relation to the other three protective behaviours (Table 1, columns 5–6).

3.2. Exposure, risk perceptions and protective behaviour

Table 2 reports results on variables associated with the five forms of protective behaviour. In columns 1–5, each of the five protective measures is estimated separately with logit. In column 6, the count variable *protect 0–5* is estimated with a Poisson count model. Following equation 2, explanatory variables include demographic characteristics, exposure, risk perceptions and knowledge. In Appendix A3 and A4, results are reported with only demographic and exposure variables as explanatory variables (equation 1) as well as with control variables included.

We find statistically significant and positive associations between all the exposure variables in the model – visits to areas with ticks and/or TBE risk, residing in tick risk or TBE risk area and experience with tick bites – and checking the body for ticks. The strength of the associations increases with the number of tick bites experienced.

We do not find similar strong positive associations between exposure and the other protective measures: While monthly or more frequent visits to areas with ticks is positively associated with the use of protective clothing, there is a negative association between visits to areas with TBE risk and the use of protective clothing. Having had more than 10 lifetime tick bites is the only exposure variable that is significantly associated with tucking trousers into socks (at the 10 per cent level). The use of repellent is negatively associated with residing in tick risk areas or TBE risk areas. Living in a TBE risk area is weakly positively associated with avoiding tall grass or bushes. Having had more than 10 tick bites and living in a rural area is negatively associated with avoiding high grass or bushes while in areas with ticks.

We find significant positive associations between exposure to tick bites and the count variable *protect 0–5* (column 6). This reflects the positive association between exposure and checking the body for ticks.

Table 2. Analysis of protective behaviour; marginal probabilities evaluated at sample means

VARIABLES	(1) Check skin[a]	(2) Prot. Clothing[a]	(3) Socks[a]	(4) Repellent[a]	(5) Avoid[a]	(6) Protect 0-5[b]
Female respondent	0.128***	0.041	0.186***	0.101***	0.058**	0.488***
	(0.029)	(0.027)	(0.019)	(0.020)	(0.028)	(0.068)
Age 18–30	-0.031	-0.097**	-0.032	-0.064***	-0.032	-0.238**
	(0.048)	(0.047)	(0.027)	(0.024)	(0.048)	(0.103)
Age 46–65	-0.035	-0.024	-0.005	-0.080***	-0.059	-0.203**
	(0.041)	(0.038)	(0.026)	(0.022)	(0.040)	(0.088)
Age > 65	-0.092**	-0.032	-0.043	-0.079***	-0.064	-0.295***
	(0.045)	(0.041)	(0.026)	(0.024)	(0.043)	(0.093)
Household pre-tax income/ month (SEK 1 000)	-0.001	-0.002***	-0.001**	-0.000	-0.001	-0.004***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
Has child under 18 years	0.015	-0.025	-0.004	-0.046**	0.007	-0.067
	(0.037)	(0.035)	(0.024)	(0.023)	(0.038)	(0.085)
Lives in the countryside/small village	-0.036	-0.021	0.004	-0.022	-0.124***	-0.167**
	(0.031)	(0.028)	(0.019)	(0.019)	(0.029)	(0.068)
Monthly or more frequent visits to areas with ticks	0.122***	0.082**	-0.009	0.023	-0.059	0.150
	(0.042)	(0.038)	(0.027)	(0.024)	(0.039)	(0.102)
Monthly or more frequent visits to areas with risk of TBE	0.088***	-0.066**	0.008	0.024	-0.028	0.018
	(0.030)	(0.028)	(0.020)	(0.021)	(0.030)	(0.068)
1 tick bite in lifetime	0.082**	0.031	0.026	-0.006	0.045	0.184
	(0.039)	(0.042)	(0.033)	(0.030)	(0.046)	(0.121)
2–10 tick bites in lifetime	0.199***	-0.003	0.035	-0.008	0.020	0.235***
	(0.031)	(0.034)	(0.025)	(0.024)	(0.036)	(0.091)
>10 tick bites in lifetime	0.290***	-0.040	0.066*	-0.002	-0.096**	0.237**
	(0.028)	(0.044)	(0.037)	(0.030)	(0.045)	(0.117)
Lives in tick risk area	0.184***	-0.019	-0.047	-0.082***	0.058	0.102
	(0.046)	(0.042)	(0.031)	(0.031)	(0.045)	(0.122)
Lives in TBE risk area	0.168***	0.013	-0.005	-0.067**	0.089*	0.208
	(0.043)	(0.046)	(0.031)	(0.027)	(0.050)	(0.137)
Perception: tick bites rather or very high risk to health	0.132***	0.056**	0.016	-0.012	0.054*	0.207***
	(0.029)	(0.028)	(0.019)	(0.020)	(0.030)	(0.069)
Perception: rather or very serious to get tick bite	0.102***	0.078***	0.058***	0.027	0.168***	0.397***
	(0.029)	(0.027)	(0.020)	(0.020)	(0.028)	(0.070)
No. of correct answers on knowledge questions	0.033***	0.016**	0.006	0.017***	0.011	0.077***
	(0.008)	(0.008)	(0.005)	(0.006)	(0.008)	(0.020)
Observations	1510	1510	1510	1510	1510	1510
Pseudo-R2	0.19	0.03	0.11	0.05	0.05	0.034

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

[a] Dummy variable, estimated with logit.

[b] Count variable 0–5 estimated with Poisson. A goodness-of-fit chi-squared test is not statistically significant indicating that a Poisson model fits the data. We also control for overdispersion by running the same regression model using negative binomial distribution.

[c] See Appendix A3–A4 for models with only demographic and exposure variables as well as with control variables.

Turning to knowledge and risk perceptions, we find that a higher score on the seven knowledge questions is positively associated with tick checks, protective clothing and the use of repellent but not with the other protective measures. A perception that tick bites constitute a rather large or very large risk to the health of the respondent or the respondent's family is positively and significantly associated with tick checks, using protective clothing and avoiding tall grass and bushes. There is also a positive and statistically significant association between perceiving that it is rather or very serious to get a tick bite and the use of all of the protective measures except for repellent. We find significant positive associations between knowledge and the count variable *protect 0–5* as well as between the two risk perception variables and *protect 0–5* (column 6).

However, there are important differences between how our different definitions of risk perceptions are associated with protective behaviours and exposure to ticks. While there is a significant *negative* association between exposure to ticks and the perceived seriousness of a *single* tick bite, there is a significant *positive* association between exposure and the perceived *lifetime* health risk from tick bites (Figure 3 and Appendix A2). This indicates that people get used to having tick bites and adjust their risk preferences accordingly. They seem to learn that the probability of falling ill from a single tick bite is low, yet perceive that the cumulative effect of repeated tick bites constitutes a serious health risk. Frequent visits to areas with TBE risk is significantly and positively associated with both of the two risk perception variables, indicating that respondents perceive that a bite from a tick is more serious if received in an area with TBE risk (Appendix 2).

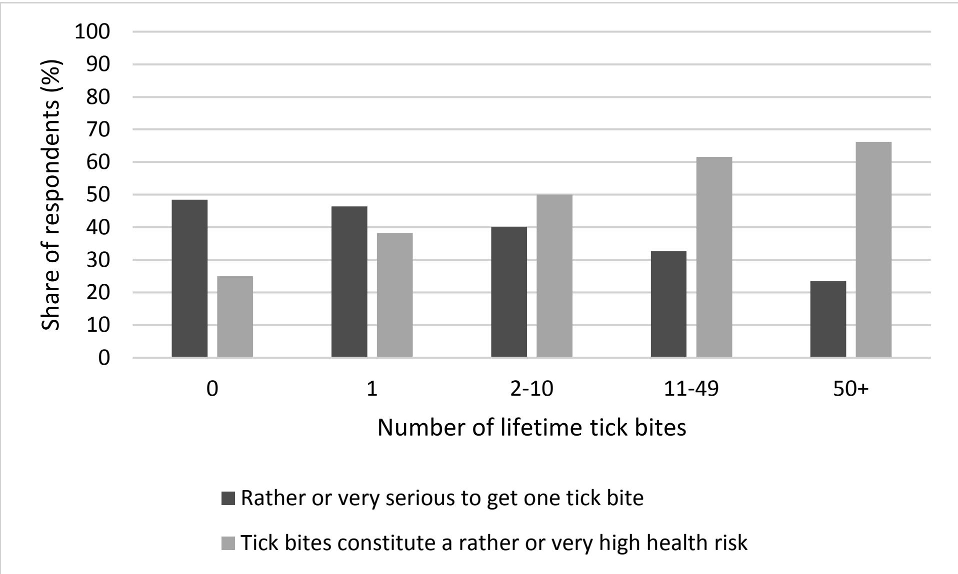

Figure 3. Risk perception and experience with tick bites

In Appendices 3–5, we assess the robustness of our findings. In Appendix 3, we find out whether the results reported above remain valid when a set of control variables are included in the model. While parameter estimates for the different measures of exposure and risk perception change when control variables are included, these changes are moderate and with few exceptions[10] the significant associations reported above remain valid.

Among the control variables, we find expected positive associations between a perception that a specific protective measure is very effective and its use. This confirms findings from earlier studies (Aenishaenslin et al., 2015; Beaujean et al., 2013). We also find a negative association between having a cat, dog or other outdoor pet and the use of protective clothing, tucking trousers into socks and repellent. Among the control variables, we also find a positive association between having a job where there is a risk of getting bitten by ticks and the use of protective clothing. We find no significant association between being vaccinated against TBE and other protective behaviours in the multivariate analysis.

In Appendix 4, we compare the results for the model with the count variable *protect 0–5* as dependent variable with those for the model with the count variable *protect 0–15* as dependent variable. The latter variable also includes the frequency of usage of each protective measure. The two count variables produce similar results.

In Appendix 5, we use a multinomial logit model to estimate the use of protective measures separately and in combination. This specification confirms the results reported above. We find significant positive associations between exposure and the use of tick checks only or tick checks in combination with protective clothes and/or socks and repellent. There is also a positive association between frequent visits to areas with TBE risk and a combination of checking the body for ticks and avoiding tall grass and bushes while in these areas. Exposure is significantly negatively associated with the use of protective clothing as the only protective measure as well as with a combination of protective clothes and avoidance of tall grass and bushes when visiting areas with ticks. Combinations of protective measures not involving tick checks are infrequent.

3.3. Demographic factors and protective behaviour

We find significant associations between gender, age, income and protective behaviour (Table 2). On average, women consistently use protective measures to a greater degree than men,[11] perceive a higher level of risk and are more knowledgeable about tick-borne diseases.[12] We find no significant

[10] Knowledge is not significantly associated with protective clothes when control variables are included. Similarly, having had more than 10 tick bites is not significantly associated with tucking trousers into socks or avoiding tall grass and bushes, and living in a tick risk area is negatively associated with tucking trousers into socks (significant at the 10 per cent level) when control variables are included. We ensure that these differences are not due to the reduced sample size when control variables are included by running the regression models specified in equations 1 and 2 with the lower sample size (n=1 416).

[11] The coefficient for female is not significant for protective clothing (Table 2, column 2), but when only demographic variables and exposure variables are included as explanatory variables, we find a significant association (Appendix A3). In a univariate analysis, there is a significant association between female and protective clothing ($p<0.01$). Since women have higher risk perceptions than men, the significance of the association between female and protective clothing disappears when risk perceptions are introduced as explanatory variables.

[12] These differences are significant at the 1 per cent level in a univariate analysis (Pearson chi test, $p<0.01$).

differences between men and women regarding exposure. Several other studies also find that men are less likely than women to check their skin for ticks (Aenishaenslin et al., 2015; Jones et al., 2002; Stjernberg and Berglund, 2005), but other studies find no such associations (Beaujean et al., 2013; Mowbray et al., 2014).

We find that respondents older than 65 years are less likely than younger ones to conduct tick checks and that 18–30-year-old respondents are less likely than older age groups to use protective clothing (the reference group is *age 31–45*). This may be caused by increased costs due to taste preferences regarding appearance among young age groups and increased effort due to difficulties performing full body tick checks among the elderly. Respondents in the 31–45 age group are more likely to use repellent than other age groups. Aenishaenslin et al. (2015) also find a negative association between youth and the use of protective clothing, but most other studies do not find associations between age and protective behaviour. Our finding that income is negatively associated with the use of protective clothing corresponds to the finding that being unemployed is positively associated with the use of protective clothing (Beaujean et al., 2013). Higher income is also known to be associated with lower risk perceptions (Sjöberg, 2006). Having a child below age 18 in the household is negatively associated with frequent use of tick repellent. Respondents living in the countryside are less likely to avoid tall grass and bushes when in areas with ticks. Using a multinomial logit model, we also find a positive association between living in a rural area and using protective clothing as the only protective measure (Appendix A5).

3.4. Protective behaviour of highly exposed persons

From a risk management perspective, it is important to analyse the behaviour of groups that are particularly exposed to risk. We find that 12% of the respondents never or rarely check their body for ticks despite visiting areas with ticks weekly or daily and having experienced one or several tick bites. Similarly, 18% of the respondents never or rarely use protective clothing despite this high exposure. Six per cent of the high exposure respondents neither use protective clothing nor check ticks often or always. Four per cent never or rarely use any protective measure.

Table 3 reports factors associated with low use of skin checks and protective clothing for the group of high-exposure respondents.[13] Columns 1 and 3 include demographic variables and variables related to the risk in the area of residence. In columns 2 and 4 we add explanatory variables related to risk perceptions, knowledge, the perceived efficacy of protective measures and TBE vaccination.

In line with the results reported above, we find that men are more likely not to use these protective measures despite high exposure. Income is also positively associated with high exposure and low protection, but this association disappears when risk perception and TBE vaccination variables are included.

[13] Protective behaviours not including skin checks or protective clothing is rare and hence not included in this analysis.

Table 3. Factors associated with high exposure[a] and low protection[b], marginal probabilities after logit evaluated at sample means

VARIABLES	(1) Check skin never/rarely	(2) Check skin never/rarely	(3) Prot.Clothes never/rarely	(4) Prot.Clothes never/rarely
Female respondent	-0.055***	-0.037**	-0.044**	-0.044**
	(0.017)	(0.016)	(0.020)	(0.020)
Age	0.000	0.000	-0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Household pre-tax income/month (SEK)	0.001**	0.001	0.001***	0.001
	(0.000)	(0.000)	(0.000)	(0.000)
Has child under 18 years	-0.018	-0.012	-0.012	0.000
	(0.019)	(0.018)	(0.022)	(0.022)
Lives in the countryside/small village	0.052***	0.058***	0.020	0.023
	(0.020)	(0.020)	(0.022)	(0.022)
Cat owner	-0.008	-0.010	0.041	0.050*
	(0.021)	(0.020)	(0.029)	(0.030)
Dog owner	0.064**	0.070***	0.041	0.029
	(0.025)	(0.025)	(0.027)	(0.026)
Other outdoor animal	0.020	0.011	0.138**	0.143**
	(0.044)	(0.040)	(0.063)	(0.071)
Lives in tick risk area	0.014	0.026	0.157***	0.117***
	(0.025)	(0.025)	(0.037)	(0.038)
Lives in TBE risk area	0.032	0.045	0.204***	0.135**
	(0.030)	(0.032)	(0.058)	(0.056)
Perception: tick bites rather or very high risk to health		-0.024		0.042**
		(0.016)		(0.020)
Perception: rather or very serious to get tick bite		-0.032**		-0.038**
		(0.016)		(0.019)
No. of correct answers on knowledge questions		0.000		0.013**
		(0.004)		(0.006)
Perception: Checking body for ticks is very effective protection		-0.051***		-0.010
		(0.019)		(0.021)
Perception: Protective clothing is very effective protection		0.024		-0.079***
		(0.017)		(0.019)
Vaccinated against TBE		0.029		0.103***
		(0.021)		(0.026)
Protective clothing		-0.063***		
		(0.017)		
Check body for ticks				-0.025
				(0.021)
Observations	1510	1473	1510	1473
Pseudo-R2	0.034	0.067	0.038	0.085

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

[a] High exposure is defined as visiting forests or other areas with ticks weekly or daily during the period May–September and having had at least one lifetime tick bite.

[b] Low protection is defined as never or rarely conducting tick checks (for the dependent variable in columns 1 and 2) and never or rarely using protective clothing (columns 3 and 4) when in areas with ticks.

Having a dog as well as residing in a rural area is positively associated with high exposure and no or infrequent tick checks. Having a cat or an outdoor animal – this may be a horse or a farm animal – is positively associated with high exposure and no or infrequent use of protective clothing. Living in a tick risk area or TBE risk area is also positively associated with high exposure and no or infrequent use of protective clothing.

There is a significant negative association between a perception that it is serious to get a tick bite and belonging to the low protection/high exposure group. There is also a negative association between the perceived efficacy of using the protective measure and belonging to the low protection/high exposure group. Surprisingly, we find that the low use of protective clothing/high exposure group is positively associated with knowledge about ticks, as well as with the perceived health risk from multiple tick bites. In line with earlier results reported by Shadick et al. (1997), this indicates that increased knowledge and a general awareness of tick-borne diseases is not enough to make high-exposure people use protective clothing.

We also find that TBE-vaccinated respondents are 10 percentage points more likely to belong to the group of high-exposure respondents who never or rarely use protective clothing. This indicates that there is a share of the population who see TBE vaccination as a substitute for using protective clothing. The negative association between the use of protective clothes and infrequent tick checks indicates that these protective behaviours are complements and not substitutes in groups with high exposure.

4. Discussion

In this paper, we have analysed the role of risk perception and exposure for protective behaviour against tick bites, Lyme borreliosis (LB) and tick-borne encephalitis (TBE). We use empirical data from a national survey in Sweden with respondents in geographical areas differing in abundance of ticks and incidence of LB and TBE.

Outdoor recreation in forests and other areas with ticks is very common in Sweden. Also using protective measures against tick bites is frequent with over 60% of the respondents using protective clothing or checking their skin for ticks ‘often’ or ‘always’ in relation to visits to forests or other areas with ticks. However, despite the widespread use of these protective measures, experience with tick bites is high among the respondents, including in the last year. This indicates that it is difficult to protect oneself from tick bites.

The low share of respondents who use repellent (16%) or tuck their trousers into their socks (18%) or who use a combination of protective measures may partly explain the many tick bites reported in this study. The difference between using a protective measure often or always may also explain some of the exposure to ticks reported. Only 17% of the respondents report that they always use protective clothing when in areas with ticks and 27% that they always perform tick checks. There is also a segment of respondents who, despite very high exposure, never or rarely check their skin for ticks (12% of the respondents) or use protective clothing (18%).

The use of protective measures is associated with demographic factors. We find that men on average are less likely than women to use protective measures against ticks. While this finding is in line with the general risk perception literature showing that women tend to perceive risks as more serious (Sjöberg, 2000; Slovic, 1987), earlier literature on gender and protective behaviour against ticks is ambiguous. Our finding that people younger than 30 are less likely to use protective clothing and that people older than 65 are less likely to perform tick checks may also be important from a health communication perspective.

There is a strong positive association between different measures of exposure – visits to tick and TBE areas, residence in risk areas and experience with tick bites – and checking the skin for ticks. However, we find only weak associations between exposure and other protective measures. Earlier studies also find that experience with tick bites is a significant determinant of checking the skin but not a predictor of the use of protective clothing (Beaujean et al., 2013). This suggests that there is a strong learning effect regarding tick checks but not regarding protective clothing and that checking the skin for ticks is a more easily adopted measure than other ways of preventing tick bites (Gould et al., 2008; Steenbergen et al., 2013). The cost of protection may also partly explain these findings. Using protective clothing on a warm summer day may be perceived as a high cost compared with checking the skin for ticks. Younger age groups may perceive a high 'image cost' from using protective clothing and older people may find it difficult or costly to conduct tick checks.

The perceived risk concerning ticks and tick-borne diseases is very high among the respondents. Forty-two per cent of the respondents perceive that being bitten by a tick is rather or very serious. The share of respondents stating that tick bites constitute a rather high or very high health risk is 43%, which is considerably higher than respondents' perceived health risk associated with traffic accidents (30%). This is inconsistent with objective risk measures. In 2013, road traffic accidents in Sweden caused 260 fatalities, 2 700 serious injuries and 17 500 mild injuries (Trafikanalys, 2014). In comparison, there are 200–300 reported cases of TBE per year in Sweden with 1–2 fatal cases (Swedish Public Health Agency, 2014). LB is much more frequent[14] but also usually a much less serious disease, curable with antibiotics. Similar biases in risk perceptions have been found in many fields, for example in the transport sector, where travel by car is perceived as safer than by commercial airlines (Johansson-Stenman, 2008). A framing of tick-borne diseases as a new risk and as uncontrollable, high impact-low probability events may partly explain these high risk perceptions (Sjöberg, 2000; Slovic, 1987).

In line with earlier studies, we find significant positive associations between risk perception and the use of protective measures (Aenishaenslin et al., 2015; Beaujean et al., 2013; Herrington, 2004; Mowbray et al., 2014). However, we identify important differences between how the perceived seriousness of a single tick bite and the (lifetime) health risk from tick bites are associated with exposure to ticks and the use of protective measures. There is a significant negative association between exposure and the perceived seriousness of a tick bite, indicating that people seem to get used

[14] Lyme borreliosis is not a notifiable disease in Sweden, so exact numbers are lacking.

to having tick bites and learn that the probability of falling ill from a single tick bite is low. We find a positive association between the perceived health risk from tick bites and exposure, indicating that people also learn that the cumulative effect of repeated tick bites constitutes a serious health risk.

Our analysis of exposure and risk perceptions indicate that there are groups of respondents that can be characterized as risk deniers and risk alarmists, respectively (Sjöberg, 2006). The negative association between a perception that a tick bite is rather or very serious and belonging to the group of respondents who despite high exposure never or rarely use protective measures indicates risk denial. The high average risk perceptions found among the respondents indicate that there may be a segment of the population who could be characterised as risk alarmists.

While promoting increased awareness about risks could be an area of policy intervention, a key challenge in providing advice related to ticks, TBE and LB is how to encourage precaution without causing alarm so that engagement – which may have associated health benefits – rather than avoidance of outdoor recreational activities is promoted (Quine et al., 2011).

In line with earlier studies, we find positive and statistically significant associations between the level of knowledge about tick-borne diseases, a perception that a protective measure is effective, and the use of both protective clothing and tick checks. Consequently, one way of increasing the use of protective measures could be to actively inform people of the effectiveness of the different measures. Targeting groups with high exposure to ticks may be especially important. While only a few randomized control trials of information campaigns and education interventions exist, there are indications that information about risks and risk-reducing measures can induce an increase in the use of protective measures against tick-borne diseases (Mowbray et al., 2012).

However, earlier studies find important barriers to increased use of protective clothing and repellents (Beaujean et al., 2013; Mowbray et al., 2014; Steenbergen et al., 2013), so expected success of such interventions should be modest. Given the high exposure to tick bites and the growing incidence of TBE and LB, other preventive measures, including vaccination programmes, should be further discussed (Piesman and Beard, 2012; Piesman and Eisen, 2008). Subsidized TBE vaccination programmes have been successful in Austria and in highly endemic areas of Finland, and similar programmes may be cost effective also in other contexts (Askling et al., 2015; Heinz et al., 2013; Slunge, 2015; Smit, 2012). After failed attempts to introduce a vaccine against LB in the US in the early 2000s, new attempts have been made to introduce such a vaccine, which may provide effective protection for certain groups at high risk of LB (Kaajik, 2016).

There are several limitations to this study. A cross-sectional study can provide rich baseline data and identify statistically significant associations between variables but cannot determine causality. We also acknowledge the potential endogeneity between protective behaviour, risk perceptions and exposure. Our survey's low response rate could imply a sample selection bias. Estimated parameter values should hence be considered approximations. As this is the first national survey of risk perceptions and protective behaviour related to tick-borne diseases in Sweden, there is a lack of comparative data to assess the magnitude and direction of this potential sample selection bias. However, a comparison with other studies regarding the share of TBE-vaccinated respondents gives no reason to believe that the respondents to this survey are more likely than the population in general to protect themselves against ticks.

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Appendix A

A1 Extended descriptive statistics and variable definitions

Table A1.1. Summary statistics and definitions of dependent variables

Protective measures	Mean	Variable definitions
Use of specific measures 'often' or 'always'		
Covering clothing	0.644	=1 if the respondent states that he or she uses the protective measure 'often' or 'always' and zero (0) if 'never' or 'rarely'.
Check body for ticks	0.630	
Tuck trousers into socks	0.179	
Repellent	0.163	
Avoid tall grass and bushes while in areas with ticks	0.481	
Count variables		
No. of protective measures used often/always (0–5)	2.10	=0–5 depending on the number of protective measures used 'often' or 'always'
No. and frequency of protective measures used (0–15)	6.46	=the number of protective measures used * the frequency. Number=0–5; Frequency=0–3 (0=never; 1=rarely; 2=often; 3=always). Min=0; Max=15
Protective measures in combination		
Noprotection	0.133	No protective measure used 'often' or 'always'.
Protclothesonly	0.078	Protective clothes is the only measure used 'often' or 'always'.
Checkbodyonly	0.085	Tick checks is the only measure used 'often' or 'always'.
Clothes&Body	0.111	Protective clothes in combination with tick checks used 'often' or 'always'.
Clothes&Avoid	0.069	Protective clothes in combination with avoiding tall grass and bushes used 'often' or 'always'.
Body&Avoid	0.066	Tick checks in combination with avoiding tall grass and bushes used 'often' or 'always'.
Clothes&Body&Avoid	0.142	Protective clothes, tick checks and avoiding tall grass and bushes used 'often' or 'always'.
Clothes&Body&Avoid&Other	0.134	Protective clothes, tick checks and avoiding tall grass and bushes is used 'often' or 'always' in combination with tucking trousers into socks and/or repellent.
Clothes&Body&Socks&Other	0.068	Protective clothes, tick checks, and tucking trousers into socks is used 'often' or 'always' in combination with repellent and/or avoiding tall grass and bushes.
Other measures and combinations	0.113	Specific measures or combinations used by less than 5% of the respondents.
Observations	1 510	

Table A1.2. Summary statistics and definitions of independent variables

VARIABLES	Mean	Obs.
Demographic characteristics (D)		
Female respondent	0.538	1510
Age 19–30. inclusive	0.149	1510
Age 46–65. inclusive	0.306	1510
Age > 65	0.288	1510
Household pre-tax income/month (SEK)	44.0	1510
Has studied at university	0.523	1502
Has child under 18 years	0.262	1510
Lives in the countryside	0.087	1510
Objective risk variables (R)		
Lives in emerging risk area	0.124	1510
Lives in tick risk area	0.585	1510
Lives in TBE risk area	0.291	1510
Exposure variables (E)		
Cat owner	0.164	1510
Dog owner	0.175	1510
Other outdoor animal	0.038	1510
Spends time in a summer home in area with TBE	0.169	1489
Work involves risk of tick bites	0.099	1501
Visits areas with ticks monthly	0.205	1498
Visits areas with ticks weekly	0.366	1498
Visits areas with ticks daily	0.266	1498
Visits areas with risk of TBE monthly	0.114	1510
Visits areas with risk of TBE weekly	0.138	1510
Visits areas with risk of TBE daily	0.119	1510
Has never had a tick bite	0.320	1510
Has had 1 tick bite in lifetime	0.121	1510
Has had 2–10 tick bite in lifetime	0.388	1510
Has had more than 10 tick bites in lifetime	0.171	1510
Had at least 1 tick bite in last 12 months	0.311	1510
Diagnosed with LB	0.113	1510
Diagnosed with TBE	0.005	1510
Diagnosed with other tick-borne disease	0.002	1510
Knowledge variables (K)		
Knowledge: Low risk of getting ill from tick bite	0.593	1510
Knowledge: LB not contagious from person to person	0.821	1510
Knowledge: Mosquito repellent also repels ticks	0.181	1510
Knowledge: There is a vaccine against TBE	0.613	1510
Knowledge: TBE cannot be treated with antibiotics	0.322	1510
Knowledge: LB can be treated with antibiotics	0.666	1510
Knowledge: LB is more common than TBE in Sweden	0.625	1510
Risk perception variables (P)		
Perception: tick bites rather or very high risk to health	0.428	1510
Perception: rather or very serious to get tick bite	0.419	1510
Perception: Checking body for ticks is very effective protection	0.698	1509
Perception: Protective clothing is very effective protection	0.440	1510
Perception: Avoiding tall grass and bushes is very effective protection	0.470	1503
Perception: Tucking trousers into socks is very effective protection	0.309	1503
Perception: Using repellent is very effective protection	0.083	1503
TBE vaccination		
Vaccinated against TBE	0.245	1474

A2: Risk perceptions and exposure

Table A2. Analysis of factors associated with two measures of risk perception – marginal probabilities after logit evaluated at sample means

VARIABLES	(1) Serious to get one tick bite [a]	(2) Health risk from tick bites [b]
Female respondent	0.193***	0.203***
	(0.026)	(0.027)
Age 18–30	-0.050	-0.121***
	(0.047)	(0.045)
Age 46–65	0.093**	-0.032
	(0.041)	(0.040)
Age > 65	0.187***	-0.015
	(0.044)	(0.044)
Household pre-tax income/month (SEK)	-0.001	-0.001
	(0.001)	(0.001)
Has child under 18 years old	0.071*	-0.016
	(0.039)	(0.038)
Lives in the countryside/small village	0.061**	0.051*
	(0.030)	(0.030)
Monthly or more frequent visits to areas with ticks	-0.003	0.183***
	(0.038)	(0.036)
Monthly or more frequent visits to areas with TBE risk	0.103***	0.146***
	(0.030)	(0.029)
1 tick bite in lifetime	-0.055	0.084*
	(0.043)	(0.049)
2–10 tick bites in lifetime	-0.137***	0.167***
	(0.033)	(0.036)
>10 tick bites in lifetime	-0.229***	0.296***
	(0.034)	(0.041)
Lives in tick risk area	0.070	0.170***
	(0.044)	(0.051)
Lives in TBE risk area	0.064	0.191***
	(0.049)	(0.057)
Observations	1 510	1 510
Pseudo-R2	0.062	0.123

Robust standard errors in parentheses ; *** p<0.01, ** p<0.05, * p<0.1

[a] The dependent variable is equal to 1 if the respondent states that it is rather or very serious to get a tick bite and 0 if 'not serious at all' or 'a little serious'

[b] The dependent variable is equal to 1 if the respondent states that tick bites constitute a rather high or very high risk to the health of the respondent or the respondent's family, 0 if 'rather low risk' or 'very low risk'

A3: Analysis of protective behaviour

Table A3. Analysis of factors associated with five different protective measures against tick bites and tick-borne diseases – marginal probabilities after logit evaluated at sample means

VARIABLES	(1) Check skin	(2) Check skin	(3) Check skin	(4) Prot. Clothes	(5) Prot. Clothes	(6) Prot. Clothes	(7) Socks	(8) Socks	(9) Socks
Female respondent	0.183***	0.128***	0.131***	0.072***	0.041	0.048*	0.203***	0.186***	0.191***
	(0.028)	(0.029)	(0.030)	(0.026)	(0.027)	(0.028)	(0.018)	(0.019)	(0.020)
Age 18–30	-0.058	-0.031	-0.028	-0.112**	-0.097**	-0.104**	-0.039	-0.032	-0.028
	(0.050)	(0.048)	(0.052)	(0.047)	(0.047)	(0.050)	(0.027)	(0.027)	(0.028)
Age 46–65	-0.025	-0.035	-0.043	-0.016	-0.024	-0.040	0.001	-0.005	-0.015
	(0.041)	(0.041)	(0.044)	(0.038)	(0.038)	(0.041)	(0.026)	(0.026)	(0.026)
Age > 65	-0.069	-0.092**	-0.110**	-0.017	-0.032	-0.060	-0.034	-0.043	-0.053*
	(0.044)	(0.045)	(0.048)	(0.041)	(0.041)	(0.044)	(0.027)	(0.026)	(0.028)
Household pre-tax income/month (SEK)	-0.001	-0.001	-0.001	-0.002***	-0.002***	-0.002***	-0.001**	-0.001**	-0.001*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
Has child under 18 years old	0.010	0.015	0.008	-0.024	-0.025	-0.027	-0.001	-0.004	-0.003
	(0.037)	(0.037)	(0.040)	(0.035)	(0.035)	(0.037)	(0.025)	(0.024)	(0.026)
Lives in the countryside/small village	-0.028	-0.036	-0.048	-0.016	-0.021	-0.005	0.006	0.004	0.008
	(0.031)	(0.031)	(0.035)	(0.028)	(0.028)	(0.031)	(0.019)	(0.019)	(0.021)
Monthly or more frequent visits to areas with ticks	0.152***	0.122***	0.108**	0.097***	0.082**	0.083**	-0.005	-0.009	0.003
	(0.042)	(0.042)	(0.044)	(0.037)	(0.038)	(0.041)	(0.026)	(0.027)	(0.026)
Monthly or more frequent visits to areas with TBE risk	0.114***	0.088***	0.105***	-0.048*	-0.066**	-0.056*	0.015	0.008	0.019
	(0.029)	(0.030)	(0.031)	(0.028)	(0.028)	(0.030)	(0.020)	(0.020)	(0.022)
1 tick bite in lifetime	0.094**	0.082**	0.092**	0.035	0.031	0.018	0.029	0.026	0.031
	(0.038)	(0.039)	(0.040)	(0.042)	(0.042)	(0.046)	(0.033)	(0.033)	(0.035)
2–10 tick bites in lifetime	0.220***	0.199***	0.199***	0.007	-0.003	-0.013	0.036	0.035	0.030
	(0.030)	(0.031)	(0.033)	(0.033)	(0.034)	(0.036)	(0.024)	(0.025)	(0.026)
>10 tick bites in lifetime	0.314***	0.290***	0.286***	-0.023	-0.040	-0.040	0.064*	0.066*	0.064
	(0.026)	(0.028)	(0.030)	(0.041)	(0.044)	(0.047)	(0.035)	(0.037)	(0.040)
Lives in tick risk area	0.218***	0.184***	0.190***	0.001	-0.019	0.004	-0.040	-0.047	-0.055*
	(0.046)	(0.046)	(0.049)	(0.041)	(0.042)	(0.044)	(0.030)	(0.031)	(0.032)

VARIABLES	(1) Check skin	(2) Check skin	(3) Check skin	(4) Prot. Clothes	(5) Prot. Clothes	(6) Prot. Clothes	(7) Socks	(8) Socks	(9) Socks
Lives in TBE risk area	0.197***	0.168***	0.147***	0.032	0.013	0.020	0.003	-0.005	-0.017
	(0.042)	(0.043)	(0.046)	(0.045)	(0.046)	(0.048)	(0.032)	(0.031)	(0.032)
Perception: Tick bites rather or very high risk to health		0.132***	0.140***		0.056**	0.049*		0.016	0.021
		(0.029)	(0.030)		(0.028)	(0.029)		(0.019)	(0.020)
Perception: Rather or very serious to get tick bite		0.102***	0.089***		0.078***	0.059**		0.058***	0.049**
		(0.029)	(0.031)		(0.027)	(0.028)		(0.020)	(0.020)
No. of correct answers on knowledge questions		0.033***	0.031***		0.016**	0.011		0.006	0.005
		(0.008)	(0.009)		(0.008)	(0.008)		(0.005)	(0.006)
Perception: Checking body for ticks is very effective protection			0.204***			0.057*			0.008
			(0.036)			(0.032)			(0.022)
Perception: Protective clothing is very effective protection			-0.040			0.129***			0.010
			(0.035)			(0.032)			(0.022)
Perception: Avoiding tall grass and bushes is very effective protection			-0.031			-0.007			-0.023
			(0.033)			(0.031)			(0.021)
Perception: Tucking trousers into socks is very effective protection			0.045			0.006			0.081***
			(0.038)			(0.036)			(0.028)
Perception: Using repellent is very effective protection			0.048			0.014			-0.016
			(0.054)			(0.051)			(0.032)
Has studied at university			-0.036			-0.028			-0.044**
			(0.030)			(0.027)			(0.019)
Has cat, dog or other outdoor animal			-0.027			-0.053*			-0.032*
			(0.034)			(0.031)			(0.019)
Spends time in a summer home in area with TBE			-0.015			-0.013			-0.001
			(0.044)			(0.037)			(0.027)
Work involves risk of tick bites			0.040			0.107***			0.030
			(0.050)			(0.041)			(0.034)
Vaccinated against TBE			0.006			-0.020			-0.026
			(0.039)			(0.035)			(0.023)
Observations	1510	1510	1416	1510	1510	1416	1510	1510	1416
Pseudo-R2	0,161	0,189	0,217	0,017	0,027	0,051	0,098	0,106	0,134

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table A3. Analysis of factors associated with five different protective measures against tick bites and tick-borne diseases – marginal probabilities after logit evaluated at sample means (continued)

	(10)	(11)	(12)	(13)	(14)	(15)
VARIABLES	Repellent	Repellent	Repellent	Avoid	Avoid	Avoid
Female respondent	0.112***	0.101***	0.105***	0.102***	0.058**	0.076**
	(0.019)	(0.020)	(0.019)	(0.027)	(0.028)	(0.031)
Age 18–30	-0.067***	-0.064***	-0.063***	-0.048	-0.032	-0.008
	(0.023)	(0.024)	(0.023)	(0.047)	(0.048)	(0.052)
Age 46–65	-0.076***	-0.080***	-0.096***	-0.043	-0.059	-0.049
	(0.022)	(0.022)	(0.022)	(0.039)	(0.040)	(0.043)
Age > 65	-0.072***	-0.079***	-0.098***	-0.032	-0.064	-0.076
	(0.024)	(0.024)	(0.023)	(0.042)	(0.043)	(0.047)
Household pre-tax income/month (SEK)	-0.000	-0.000	-0.000	-0.001	-0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Has child under 18 years	-0.046**	-0.046**	-0.044*	0.015	0.007	0.041
	(0.023)	(0.023)	(0.023)	(0.037)	(0.038)	(0.041)
Lives in the countryside/small village	-0.024	-0.022	-0.015	-0.111***	-0.124***	-0.142***
	(0.020)	(0.019)	(0.021)	(0.029)	(0.029)	(0.033)
Monthly or more frequent visits to areas with ticks	0.028	0.023	0.028	-0.045	-0.059	-0.054
	(0.024)	(0.024)	(0.024)	(0.038)	(0.039)	(0.042)
Monthly or more frequent visits to areas with TBE risk	0.026	0.024	0.025	-0.003	-0.028	-0.018
	(0.021)	(0.021)	(0.021)	(0.029)	(0.030)	(0.033)
1 tick bite in lifetime	-0.001	-0.006	-0.008	0.044	0.045	0.094*
	(0.030)	(0.030)	(0.031)	(0.045)	(0.046)	(0.050)
2–10 tick bites in lifetime	-0.001	-0.008	-0.005	0.014	0.020	0.044
	(0.024)	(0.024)	(0.024)	(0.034)	(0.036)	(0.039)
>10 tick bites in lifetime	0.009	-0.002	0.006	-0.104**	-0.096**	-0.041
	(0.030)	(0.030)	(0.033)	(0.042)	(0.045)	(0.052)
Lives in tick risk area	-0.072**	-0.082***	-0.085***	0.078*	0.058	0.066
	(0.031)	(0.031)	(0.031)	(0.044)	(0.045)	(0.049)
Lives in TBE risk area	-0.060**	-0.067**	-0.072***	0.108**	0.089*	0.097*
	(0.027)	(0.027)	(0.027)	(0.048)	(0.050)	(0.053)
Perception: Tick bites rather or very high risk to health		-0.012	0.000		0.054*	0.066**
		(0.020)	(0.020)		(0.030)	(0.033)

VARIABLES	(10) Repellent	(11) Repellent	(12) Repellent	(13) Avoid	(14) Avoid	(15) Avoid
Perception: Rather or very serious to get tick bite		0.027	0.017		0.168***	0.148***
		(0.020)	(0.020)		(0.028)	(0.030)
No. of correct answers on knowledge questions		0.017***	0.014**		0.011	0.008
		(0.006)	(0.006)		(0.008)	(0.009)
Perception: Checking body for ticks is very effective protection			0.023			-0.075**
			(0.021)			(0.035)
Perception: Protective clothing is very effective protection			0.047**			0.025
			(0.024)			(0.037)
Perception: Avoiding tall grass and bushes is very effective protection			-0.030			0.251***
			(0.021)			(0.032)
Perception: Tucking trousers into socks is very effective protection			-0.028			0.041
			(0.024)			(0.040)
Perception: Using repellent is very effective protection			0.240***			0.004
			(0.053)			(0.057)
Has studied at university			-0.024			-0.023
			(0.019)			(0.030)
Has cat, dog or other outdoor animal			-0.050***			-0.043
			(0.019)			(0.033)
Spends time in a summer home in area with TBE			-0.009			-0.078*
			(0.025)			(0.041)
Work involves risk of tick bites			-0.019			0.039
			(0.029)			(0.049)
Vaccinated against TBE			0.031			-0.003
			(0.025)			(0.038)
Observations	1510	1510	1416	1510	1510	1416
Pseudo-R2	0,041	0,049	0,093	0,026	0,047	0,098

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

A4. Analysis of protective behaviour using count variables

Table A4. Analysis of factors associated with protective measures against tick bites and tick-borne diseases

VARIABLES	(1) Protect 0–5 [a]	(2) Protect 0–5 [a]	(3) Protect 0–5 [a]	(4) Protect 0–15 [b]	(5) Protect 0–15 [b]	(6) Protect 0–15 [b]
Female respondent	0.638***	0.488***	0.508***	1.453***	1.123***	1.118***
	(0.065)	(0.068)	(0.069)	(0.142)	(0.146)	(0.149)
Age 18–30	-0.306***	-0.238**	-0.221**	-0.786***	-0.642***	-0.561**
	(0.103)	(0.103)	(0.105)	(0.223)	(0.220)	(0.231)
Age 46–65	-0.162*	-0.203**	-0.241***	-0.182	-0.279	-0.358*
	(0.091)	(0.088)	(0.091)	(0.196)	(0.190)	(0.197)
Age > 65	-0.220**	-0.295***	-0.374***	-0.488**	-0.660***	-0.821***
	(0.095)	(0.093)	(0.095)	(0.209)	(0.203)	(0.211)
Household pre-tax income/month (SEK)	-0.004***	-0.004***	-0.003**	-0.008**	-0.009***	-0.007**
	(0.001)	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
Has child under 18 years	-0.053	-0.067	-0.043	-0.025	-0.054	0.007
	(0.088)	(0.085)	(0.088)	(0.188)	(0.181)	(0.190)
Lives in the countryside/small village	-0.156**	-0.167**	-0.150**	-0.352**	-0.381**	-0.339**
	(0.070)	(0.068)	(0.073)	(0.154)	(0.151)	(0.161)
Monthly or more frequent visits to areas with ticks	0.212**	0.150	0.155	0.315	0.180	0.156
	(0.101)	(0.102)	(0.102)	(0.227)	(0.229)	(0.231)
Monthly or more frequent visits to areas with TBE risk	0.092	0.018	0.066	0.199	0.034	0.098
	(0.068)	(0.068)	(0.072)	(0.146)	(0.145)	(0.152)
1 tick bite in lifetime	0.222*	0.184	0.208*	0.598**	0.534**	0.535**
	(0.124)	(0.121)	(0.123)	(0.263)	(0.255)	(0.256)
2–10 tick bites in lifetime	0.282***	0.235***	0.238**	0.650***	0.567***	0.537***
	(0.090)	(0.091)	(0.093)	(0.190)	(0.190)	(0.193)
>10 tick bites in lifetime	0.307***	0.237**	0.292**	0.613***	0.490**	0.511**
	(0.113)	(0.117)	(0.125)	(0.235)	(0.242)	(0.255)
Lives in tick risk area	0.188	0.102	0.101	0.562**	0.376	0.383
	(0.125)	(0.122)	(0.121)	(0.270)	(0.263)	(0.265)
Lives in TBE risk area	0.301**	0.208	0.161	0.893***	0.691**	0.597**
	(0.143)	(0.137)	(0.135)	(0.315)	(0.303)	(0.300)

VARIABLES	(1) Protect 0–5 [a]	(2) Protect 0–5 [a]	(3) Protect 0–5 [a]	(4) Protect 0–15 [b]	(5) Protect 0–15 [b]	(6) Protect 0–15 [b]
Perception: Tick bites rather or very high risk to health		0.207***	0.224***		0.441***	0.484***
		(0.069)	(0.069)		(0.148)	(0.147)
Perception: Rather or very serious to get tick bite		0.397***	0.313***		0.919***	0.740***
		(0.070)	(0.069)		(0.150)	(0.149)
No. of correct answers on knowledge questions		0.077***	0.061***		0.166***	0.126***
		(0.020)	(0.020)		(0.041)	(0.043)
Perception: Checking body for ticks is very effective protection			0.200**			0.560***
			(0.079)			(0.169)
Perception: Protective clothing is very effective protection			0.176**			0.152
			(0.076)			(0.167)
Perception: Avoiding tall grass and bushes is very effective protection			0.139**			0.235
			(0.069)			(0.151)
Perception: Tucking trousers into socks is very effective protection			0.106			0.480***
			(0.080)			(0.177)
Perception: Using repellent is very effective protection			0.232*			0.744***
			(0.119)			(0.272)
Has studied at university			-0.142**			-0.383***
			(0.065)			(0.144)
Has cat, dog or other outdoor animal			-0.186***			-0.329**
			(0.071)			(0.156)
Spends time in a summer home in area with TBE			-0.085			-0.123
			(0.084)			(0.181)
Work involves risk of tick bites			0.175*			0.245
			(0.103)			(0.211)
Vaccinated against TBE			-0.027			0.132
			(0.079)			(0.167)
Observations	1510	1510	1416	1510	1510	1416
Pseudo-R2	0.024	0.034	0.045	0.023	0.032	0.045

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

[a] Count variable estimated with poisson

[b] Count variable estimated with negative binomial regression

A5. Multinomial logit; **Table A5:a: Multinomial logit model with demographic variables and exposure as explanatory variables**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Clothes	CheckBody	Clothes &Body	Clothes &Avoid	Body &Avoid	Clothes, Body&Avoid	Clothes, Body,Avoid &Other	Clothes, Body,Socks &Other	Other
Female respondent	-0.065***	-0.000	-0.023	-0.035***	0.009	-0.029	0.160***	0.039***	0.034*
	(0.015)	(0.013)	(0.017)	(0.011)	(0.013)	(0.021)	(0.019)	(0.012)	(0.018)
Age 18–30	-0.014	-0.010	-0.020	-0.025*	0.015	0.016	-0.028	-0.034**	-0.034
	(0.025)	(0.022)	(0.031)	(0.013)	(0.025)	(0.038)	(0.028)	(0.014)	(0.025)
Age 46–65	0.018	-0.022	0.026	-0.007	-0.018	-0.014	0.008	-0.007	-0.056**
	(0.023)	(0.018)	(0.028)	(0.014)	(0.018)	(0.030)	(0.027)	(0.016)	(0.023)
Age > 65	0.033	-0.021	0.032	-0.007	-0.037**	-0.003	0.001	-0.043***	-0.034
	(0.026)	(0.019)	(0.031)	(0.014)	(0.018)	(0.033)	(0.030)	(0.015)	(0.025)
Household pre-tax income/month (SEK)	0.000	0.001***	-0.000	-0.000	0.000	-0.000	-0.001*	-0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Has child under 18 years	-0.018	-0.018	0.016	-0.010	0.001	0.032	0.004	-0.019	-0.030
	(0.019)	(0.017)	(0.026)	(0.013)	(0.019)	(0.031)	(0.026)	(0.015)	(0.023)
Lives in the countryside/small village	0.022	0.001	0.017	-0.030***	-0.009	-0.032	-0.014	0.027*	-0.043**
	(0.016)	(0.015)	(0.019)	(0.011)	(0.015)	(0.022)	(0.019)	(0.015)	(0.019)
Monthly or more frequent visits to areas with ticks	0.013	0.044**	0.046*	-0.015	-0.001	0.033	-0.015	0.045***	-0.037
	(0.017)	(0.018)	(0.024)	(0.014)	(0.022)	(0.029)	(0.027)	(0.014)	(0.027)
Monthly or more frequent visits to areas with TBE risk	-0.025*	0.015	0.012	-0.047***	0.040**	0.006	0.013	0.009	0.001
	(0.015)	(0.015)	(0.019)	(0.012)	(0.016)	(0.022)	(0.020)	(0.013)	(0.020)
1 tick bite in lifetime	-0.020	0.033	0.027	-0.012	0.004	0.029	0.022	-0.013	-0.023
	(0.017)	(0.038)	(0.038)	(0.013)	(0.026)	(0.040)	(0.033)	(0.022)	(0.025)
2–10 tick bites in lifetime	-0.056***	0.060**	0.049*	-0.031***	0.024	0.046	0.008	0.016	-0.034
	(0.015)	(0.025)	(0.026)	(0.011)	(0.019)	(0.028)	(0.023)	(0.018)	(0.021)
>10 tick bites in lifetime	-0.058***	0.161***	0.062*	-0.068***	0.007	-0.005	-0.000	0.070**	-0.070***
	(0.013)	(0.046)	(0.035)	(0.010)	(0.023)	(0.033)	(0.028)	(0.031)	(0.021)
Lives in tick risk area	-0.049**	0.050	0.089**	-0.018	0.030	0.041	0.030	0.003	-0.117***
	(0.021)	(0.033)	(0.040)	(0.015)	(0.029)	(0.039)	(0.033)	(0.025)	(0.029)
Lives in TBE risk area	-0.047***	0.015	0.094	-0.015	0.034	0.015	0.060	0.008	-0.115***
	(0.018)	(0.042)	(0.060)	(0.014)	(0.039)	(0.046)	(0.043)	(0.028)	(0.021)
Observations	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510
Pseudo-R2	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081	0.081

Table A5:b: Multinomial logit model with demographic, exposure, risk perceptions and knowledge as explanatory variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Clothes	CheckBody	Clothes &Body	Clothes &Avoid	Body &Avoid	Clothes, Body&Avoid	Clothes, Body,Avoid &Other	Clothes, Body,Socks &Other	Other
Female respondent	-0.057***	-0.000	-0.028	-0.034***	-0.001	-0.046**	0.141***	0.039***	0.036*
	(0.016)	(0.014)	(0.018)	(0.012)	(0.014)	(0.022)	(0.020)	(0.013)	(0.019)
Age 18 -30	-0.016	-0.009	-0.016	-0.026*	0.022	0.026	-0.017	-0.033**	-0.036
	(0.025)	(0.023)	(0.032)	(0.013)	(0.026)	(0.040)	(0.030)	(0.015)	(0.026)
Age 46 -65	0.021	-0.021	0.032	-0.006	-0.021	-0.020	0.003	-0.006	-0.059**
	(0.024)	(0.019)	(0.029)	(0.014)	(0.018)	(0.031)	(0.028)	(0.017)	(0.023)
Age > 65	0.041	-0.019	0.040	-0.006	-0.042**	-0.015	-0.009	-0.043***	-0.036
	(0.028)	(0.020)	(0.033)	(0.015)	(0.018)	(0.033)	(0.029)	(0.016)	(0.026)
Household pre-tax income/month (SEK)	0.000	0.001**	-0.000	-0.000	0.000	-0.000	-0.001**	-0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Has child under 18 years	-0.017	-0.017	0.022	-0.011	-0.000	0.032	0.004	-0.018	-0.030
	(0.019)	(0.018)	(0.027)	(0.014)	(0.019)	(0.031)	(0.026)	(0.016)	(0.023)
Lives in the countryside/small village	0.026	0.001	0.016	-0.032***	-0.012	-0.034	-0.017	0.028*	-0.044**
	(0.017)	(0.015)	(0.020)	(0.011)	(0.015)	(0.022)	(0.019)	(0.015)	(0.019)
Monthly or more frequent visits to areas with ticks	0.014	0.043**	0.039	-0.014	-0.009	0.027	-0.028	0.044***	-0.032
	(0.017)	(0.019)	(0.026)	(0.014)	(0.024)	(0.031)	(0.029)	(0.015)	(0.027)
Monthly or more frequent visits to areas with TBE risk	-0.020	0.015	0.008	-0.047***	0.033**	-0.000	0.003	0.009	0.003
	(0.015)	(0.015)	(0.019)	(0.013)	(0.016)	(0.023)	(0.020)	(0.014)	(0.021)
1 tick bite in lifetime	-0.020	0.034	0.022	-0.010	0.004	0.029	0.017	-0.015	-0.019
	(0.018)	(0.039)	(0.038)	(0.014)	(0.026)	(0.041)	(0.033)	(0.022)	(0.027)
2–10 tick bites in lifetime	-0.058***	0.060**	0.039	-0.027**	0.022	0.047	0.003	0.012	-0.026
	(0.016)	(0.026)	(0.027)	(0.012)	(0.020)	(0.030)	(0.024)	(0.019)	(0.022)
>10 tick bites in lifetime	-0.058***	0.162***	0.044	-0.066***	0.005	-0.002	-0.003	0.059*	-0.059**
	(0.014)	(0.049)	(0.036)	(0.011)	(0.024)	(0.036)	(0.029)	(0.031)	(0.024)
Lives in tick risk area	-0.045**	0.051	0.087**	-0.018	0.024	0.032	0.018	-0.000	-0.117***
	(0.021)	(0.035)	(0.042)	(0.015)	(0.030)	(0.041)	(0.034)	(0.026)	(0.030)
Lives in TBE risk area	-0.043**	0.015	0.091	-0.014	0.028	0.008	0.049	0.007	-0.114***
	(0.018)	(0.043)	(0.061)	(0.015)	(0.038)	(0.047)	(0.043)	(0.028)	(0.022)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Clothes	CheckBody	Clothes &Body	Clothes &Avoid	Body &Avoid	Clothes, Body&Avoid	Clothes, Body,Avoid &Other	Clothes, Body,Socks &Other	Other
Perception: Tick bites rather or very high risk to health	-0.017	0.006	0.045**	-0.008	0.034**	0.003	0.039**	0.014	-0.045**
	(0.015)	(0.015)	(0.020)	(0.012)	(0.016)	(0.023)	(0.020)	(0.014)	(0.020)
Perception: Rather or very serious to get tick bite	-0.031**	-0.012	-0.027	0.004	0.027*	0.057**	0.055***	-0.011	0.025
	(0.014)	(0.015)	(0.019)	(0.011)	(0.015)	(0.023)	(0.020)	(0.013)	(0.020)
No. of correct answers on knowledge questions	-0.004	0.000	0.001	-0.005	0.002	0.012*	0.009*	0.003	-0.001
	(0.004)	(0.004)	(0.006)	(0.003)	(0.004)	(0.007)	(0.006)	(0.004)	(0.006)
Observations	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510
Pseudo-R2	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096	0.096

Robust standard errors in parentheses; p<0.01, ** p<0.05, * p<0.1

Table A5:c: Multinomial logit model with demographic, exposure, risk perceptions, knowledge and control variables

VARIABLES	(1) Clothes	(2) CheckBody	(3) Clothes &Body	(4) Clothes &Avoid	(5) Body &Avoid	(6) Clothes, Body&Avoid	(7) Clothes, Body,Avoid &Other	(8) Clothes, Body,Socks &Other	(9) Other
Female respondent	-0.055***	-0.009	-0.035*	-0.028**	-0.003	-0.049*	0.156***	0.040***	0.036*
	(0.016)	(0.015)	(0.021)	(0.012)	(0.015)	(0.025)	(0.021)	(0.015)	(0.020)
Age 18–30	-0.015	-0.008	-0.024	-0.026**	0.027	0.044	-0.020	-0.041**	-0.015
	(0.023)	(0.022)	(0.035)	(0.012)	(0.028)	(0.049)	(0.032)	(0.016)	(0.030)
Age 46–65	0.021	-0.015	0.027	-0.001	-0.017	-0.004	-0.018	-0.012	-0.064**
	(0.022)	(0.020)	(0.032)	(0.013)	(0.019)	(0.036)	(0.028)	(0.019)	(0.025)
Age > 65	0.034	-0.010	0.046	-0.006	-0.051***	0.001	-0.038	-0.052***	-0.035
	(0.024)	(0.022)	(0.037)	(0.014)	(0.017)	(0.040)	(0.029)	(0.018)	(0.028)
Household pre-tax income/month (SEK)	0.000	0.001*	-0.000	-0.000	0.000	-0.000	-0.001	-0.001**	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
Has child under 18 years	-0.018	-0.024	0.003	-0.006	0.009	0.048	0.003	-0.022	-0.024
	(0.016)	(0.018)	(0.030)	(0.013)	(0.019)	(0.038)	(0.028)	(0.018)	(0.025)
Lives in the countryside/small village	0.050**	-0.005	0.003	-0.024**	-0.024	-0.032	-0.024	0.034*	-0.047**
	(0.021)	(0.017)	(0.021)	(0.010)	(0.015)	(0.026)	(0.021)	(0.019)	(0.021)
Monthly or more frequent visits to areas with ticks	0.023	0.035*	0.034	-0.009	-0.012	0.014	-0.013	0.042**	-0.027
	(0.016)	(0.021)	(0.030)	(0.013)	(0.025)	(0.035)	(0.030)	(0.018)	(0.030)
Monthly or more frequent visits to areas with TBE risk	-0.024*	0.012	0.009	-0.046***	0.032*	0.001	0.016	0.012	-0.005
	(0.015)	(0.017)	(0.021)	(0.013)	(0.017)	(0.027)	(0.022)	(0.016)	(0.022)
1 tick bite in lifetime	-0.036**	0.032	0.012	-0.008	0.006	0.059	0.009	-0.016	-0.005
	(0.015)	(0.039)	(0.041)	(0.012)	(0.030)	(0.049)	(0.034)	(0.023)	(0.031)
2–10 tick bites in lifetime	-0.066***	0.055**	0.041	-0.021*	0.026	0.052	0.003	0.009	-0.027
	(0.017)	(0.026)	(0.030)	(0.012)	(0.022)	(0.033)	(0.026)	(0.021)	(0.024)
>10 tick bites in lifetime	-0.060***	0.126***	0.042	-0.053***	0.021	0.006	0.006	0.054	-0.055*
	(0.014)	(0.048)	(0.040)	(0.011)	(0.030)	(0.041)	(0.035)	(0.034)	(0.028)
Lives in tick risk area	-0.039*	0.038	0.104**	-0.012	0.010	0.049	0.025	0.000	-0.131***
	(0.022)	(0.034)	(0.047)	(0.015)	(0.032)	(0.046)	(0.037)	(0.029)	(0.032)
Lives in TBE risk area	-0.037**	-0.001	0.106	-0.003	0.021	0.007	0.051	0.003	-0.129***
	(0.017)	(.)	(0.070)	(0.015)	(0.039)	(0.053)	(0.047)	(0.031)	(0.025)
Perception: Tick bites rather or very high risk to health	-0.023	0.004	0.042*	-0.004	0.048***	-0.006	0.044**	0.020	-0.049**
	(0.015)	(0.015)	(0.021)	(0.011)	(0.018)	(0.025)	(0.022)	(0.015)	(0.021)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	Clothes	CheckBody	Clothes &Body	Clothes &Avoid	Body &Avoid	Clothes, Body&Avoid	Clothes, Body,Avoid &Other	Clothes, Body,Socks &Other	Other
Perception: Rather or very serious to get tick bite	-0.031**	-0.010	-0.027	0.005	0.023	0.056**	0.040*	-0.008	0.027
	(0.014)	(0.015)	(0.020)	(0.010)	(0.016)	(0.026)	(0.021)	(0.014)	(0.022)
No. of correct answers on knowledge questions	-0.006	0.002	0.002	-0.004	0.001	0.011	0.007	0.003	-0.004
	(0.004)	(0.005)	(0.006)	(0.003)	(0.005)	(0.008)	(0.006)	(0.005)	(0.006)
Perception: Checking body for ticks is very effective protection	-0.019	0.044***	0.064***	-0.050***	0.010	0.038	0.016	0.025*	-0.055*
	(0.017)	(0.014)	(0.020)	(0.018)	(0.016)	(0.027)	(0.023)	(0.015)	(0.029)
Perception: Protective clothing is very effective prot.	0.032*	-0.052***	-0.006	0.014	-0.002	0.009	-0.004	0.028	0.028
	(0.018)	(0.018)	(0.026)	(0.012)	(0.016)	(0.028)	(0.023)	(0.018)	(0.026)
Perception: Avoiding tall grass and bushes is very effective protection	-0.041***	-0.064***	-0.043*	0.042***	0.032*	0.083***	0.015	-0.057***	0.030
	(0.015)	(0.018)	(0.023)	(0.014)	(0.017)	(0.026)	(0.022)	(0.016)	(0.026)
Perception: Tucking trousers into socks is very effective protection	-0.009	0.028	-0.019	-0.016	-0.010	-0.017	0.080***	-0.005	-0.005
	(0.018)	(0.022)	(0.028)	(0.011)	(0.018)	(0.029)	(0.029)	(0.018)	(0.029)
Perception: Using repellent is very effective prot.	-0.044**	-0.042*	-0.013	-0.002	0.019	-0.048	0.080*	0.019	0.049
	(0.017)	(0.023)	(0.038)	(0.016)	(0.033)	(0.038)	(0.043)	(0.033)	(0.046)
Has studied at university	0.010	0.005	0.011	0.015	0.013	-0.015	-0.054***	-0.006	0.008
	(0.013)	(0.015)	(0.020)	(0.010)	(0.015)	(0.024)	(0.020)	(0.014)	(0.021)
Has cat, dog or other outdoor animal	-0.025*	0.023	0.032	-0.010	-0.005	0.002	-0.052***	-0.009	0.005
	(0.015)	(0.018)	(0.023)	(0.010)	(0.016)	(0.027)	(0.019)	(0.015)	(0.023)
Spends time in a summer home in area with TBE	0.013	0.009	-0.005	-0.043***	-0.061***	0.027	-0.017	-0.005	0.027
	(0.024)	(0.018)	(0.025)	(0.011)	(0.013)	(0.032)	(0.026)	(0.019)	(0.030)
Work involves risk of tick bites	-0.036**	-0.008	0.047	0.038	-0.033*	0.022	0.043	0.004	-0.047
	(0.017)	(0.021)	(0.035)	(0.027)	(0.018)	(0.042)	(0.038)	(0.022)	(0.030)
Vaccinated against TBE	0.043*	0.004	-0.020	-0.010	0.019	-0.016	0.006	-0.004	0.019
	(0.023)	(0.018)	(0.022)	(0.014)	(0.019)	(0.030)	(0.026)	(0.017)	(0.027)
Observations	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416	1,416
Pseudo-R2	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

APPENDIX B. SURVEY
TICK SURVEY, Final version, October 2013
[This is a freely translated version from the original survey in Swedish. It is not formatted as it was when presented to the respondents.]
Link to the formatted web survey in Swedish: http://www.enkatfabriken.com/survey/index.php?sid=51721&lang=sv&token=n9wqfjw9ugpukz2

GÖTEBORGS UNIVERSITET

Ticks, TBE and Lyme borreliosis

A study of the risk of tick-borne diseases and how it affects our behaviour

Ticks and the tick-borne diseases Lyme borreliosis and TBE are becoming more common in Sweden. We want to know how you are affected!

Our research will increase knowledge of how different people perceive the risk of tick-borne diseases and measures to reduce risk. The research is conducted at the University of Gothenburg with funding from the Region Västra Götaland.

You are part of a random sample of individuals participating in a web panel and therefore receive this survey. To answer the survey is voluntary.

The survey takes about 15 minutes to fill in.

Even if you think that some questions are difficult to answer precisely, answer as best you can. Your responses are valuable even if they are approximate.

The survey results will be presented at various seminars and in scientific publications.

Your answers will be treated so that unauthorized access to them will be prevented. Responsible for your personal information - in accordance with the Data Protection Act (1998: 204) – is University of Gothenburg, Privacy Officer Kristina Ullgren, Box 100, SE-405 30 Gothenburg, tel. 031-7861092, email: kristina.ullgren@gu.se.

Many thanks for your participation in our research! For additional information about the survey and its results, or if there are any questions, please feel free to contact us.

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Introductory questions

1. **When were you born? [scroll bar]**
2. **Sex**
   - ☐ **female**
   - ☐ **male**
3. **Area of living? [Name: of municipality in [scroll bar] (compulsory question)**
4. **Zip code: ___________**

5. **How do you rate your general health status?**

Very bad	Rather bad	Neither good or bad	Rather good	Very good
1	2	3	4	5
○	○	○	○	○

6. **How large risk do you think that the following things may have for your or your family´s health? (please tick one option per line)**

	Very low risk	Rather low risk	Rather high risk	Very high risk	No opinion
Trafik accidents					
Air pollution					
Additives or pesticide residues in food					
A new pandemic					
Side effects from vaccinations					
Tick bites					

7. **How much trust do you have in………?**

	1.Very low trust	2. Rather low trust	3. Neither low or high trust	4. Rather high trust	5.Very high trust	No opinion
The Swedish health care						
The County Council where you live						
The medical center						

where you are listed						
Vaccine recommendations from the health care system						

Exposure to ticks and tick-borne diseases

8. **Have you ever had a tick bite?**

☐ Yes
☐ No → Q 15
☐ Don´t know

9. [If yes] How many?

☐ 1
☐ 2-10
☐ 11-49
☐ 50 or more

10. **[If yes on Q 8] How many tick bites have you had in the last 12 months?**

☐ 0
☐ 1-2
☐ 3-5
☐ 6-10
☐ More than 10

11. In which municipality did you get bitten by ticks during the last 12 months?(several answers possible)

☐ In my home municipality
☐ In another municipality (scroll bar)
☐ In another country
☐ Don't know

12. Have you ever had a tick-borne disease?

☐ Yes
☐ No → Q 15
☐ Don´t know

13.[If yes] Which disease? (several answers possible)

☐ Lyme borrelosis
☐ TBE (tick-borne encephalitis)
☐ Other disease (specify):___________________
☐ Don´t know

14. Was the disease diagnosed by a doctor?

☐ Yes
☐ No
☐ Don´t know

15. Do you have children below the age of 18 years?

☐ Yes
☐ No → Q 22

16. [If yes] Has your child/any of your children ever been bitten by a tick?

☐ Yes
☐ No
☐ Don´t know

17. **[If yes / do not know at Q16] Has your child / any of your children ever had a tick-borne disease?**

☐ Yes
☐ No → Q 22
☐ Don´t know

18. [If yes] Which disease? (several answers possible)

☐ Lyme borreliosis
☐ TBE (tick-borne encephalitis)
☐ Other disease (specify):__________________
☐ Don´t know

19. Was the disease diagnosed by a doctor?

☐ Yes
☐ No
☐ Don´t know

20. Do you have another family member or someone in your immediate circle of acquaintances who has ever had a tick-borne disease?

☐ Yes
☐ No → Q 22
☐ Don´t know

21. [If yes] Which disease? (several answers possible)

☐ Lyme borreliosis
☐ TBE (tick-borne encephalitis)
☐ Other disease (specify):__________________
☐ Don´t know

22. Do you have animals?

☐ No → Q 27
☐ Only indoor pets (including indoor cat)
☐ cat
☐ dog
☐ Other animal (e.g. horse, cow or sheep)

23. By how many ticks has your animal been bitten during the last 12 months? (If you have more than one animal choose the one that has been bitten by most ticks)

- ☐ 0
- ☐ 1
- ☐ 2-10
- ☐ 11-50
- ☐ More than 50
- ☐ Don't know

24. How often do you check your animal for ticks during the summer?

Daily	
1-3 times a week	
1-2 times a month	
More rarely	
Never	

25. How often do you protect your cat or dog through using a special necklace, spot-on, a spray or other item?

- ☐ Always
- ☐ Often
- ☐ Rarely
- ☐ Never

26. How much did you approximately pay for this type of protection for your cat or dog during the last 12 months? (if you have several pets specify the total amount)

- ☐ 0 kr
- ☐ 1-100 kr
- ☐ 101-300 kr
- ☐ 301-500 kr
- ☐ 501-1000 kr
- ☐ More than 1000 kr

Risk perception

27. How serious do you think it is to:

Choose the correct answer for each item:

	Not serious at all	A little serious	Rather serious	Very serious	Don´t know
Get bitten by a tick					
Get the tick-borne Lyme borrelosis					
Get TBE					

28. How likely do you think that any of the following events occur during the next 12 months?

Choose the correct answer for each item:

	Not likely at all	A little bit likely	Rather likely	Very likely	Don´t know
You get bitten by a tick					
You become ill as a result of a tick bite					
You are diagnosed with Lyme borrelosis					
You are diagnosed with TBE (tick-borne encephalitis)					

29. [IF HAVE CHILDREN] How likely do you think that any of the following events occur during the next 12 months?

	Not likely at all	A little bit likely	Rather likely	Very likely	Don´t know
Your child/ any of your children get diagnosed with Lyme Borrelosis or TBE					

30. Which of the following statements do you think are correct? (tick true or false for each statement)

	True	False	Don´t know
If you get bitten by a tick there is a large risk that you get ill	[ ]	[ ]	[ ]
Borrelia can be passed from one person to another	[ ]	[ ]	[ ]
Mosquito repellent decrease the risk of getting a tick-bite	[ ]	[ ]	[ ]
There is a vaccine you can buy that can prevent TBE	[ ]	[ ]	[ ]
TBE can be treated with antibiotics	[ ]	[ ]	[ ]
Borrelia can be treated with antibiotics	[ ]	[ ]	[ ]
Borrelia is more common than TBE in Sweden	[ ]	[ ]	[ ]

31. Information about TBE and Lyme borreliosis

Please read the following information before you proceed.

Information about TBE and Lyme borreliosis	
The disease TBE TBE (tick-borne encephalitis) is a disease that can be transmitted between animals and humans by ticks. Common symptoms of TBE are high fever, severe headache and occasional convulsions and paralysis. About 40 percent of those infected develop long-term or permanent symptoms such as fatigue, memory lapses, and in rare cases, paralysis. Today there is no cure for TBE, however, there is an effective vaccine.	**Lyme borreliosis** Among approximately half of those infected with Lyme borreliosis a ring-shaped redness at the site of the tick bite develops. If the infection is not treated with antibiotics, it can months progress to a more severe illness with central nervous system symptoms after a couple of weeks to. You can also get joint problems and in rare cases also affect the heart. The disease can be treated with antibiotics.
Where can you get infected with TBE and how many are infected? TBE virus are mainly found among ticks in the archipelagos of Uppland and Södermanland and in parts of Lake Mälaren. Most people get infected around Södertörn, Södertäljeviken and central parts of the Lake Mälaren. The virus is also found around Vänern and Vättern and in some places along the west coast. In 2011 and 2012, there were about 280 reported cases of TBE per year in Sweden. Each dot on the map below indicates where someone was infected with TBE in 2012.	**Where can you get Lyme borreliosis and how many are infected?** Borrelia bacteria exists where ticks are present. There are no reliable statistics on the number of cases of Lyme borreliosis in Sweden. Studies indicate that there may be around 10 000 cases per year in southern Sweden. North of the Dalälven, there are few cases. Studies also show that even if you get bitten by a tick carrying the Borrelia bacteria, the risk of getting infected is low.
Vaccine It is possible to get vaccinated against TBE. Three doses of the vaccine gives an effective protection for three years among almost 100% of those who take the vaccine. The side effects from the vaccine are mild. Vaccination is usually recommended for permanent and summer residents in risk areas and to people who spend a lot of time in forest areas in TBE risk areas, and that often gets bitten by a tick.	**Vaccine** Today there is no vaccine for Lyme borreliosis to buy, but there are ongoing efforts to develop such a vaccine.

TBE cases 2012

Outdoor activities

32. Is there a risk that you get bitten by a tick while working on your job?

- ☐ Yes
- ☐ No
- ☐ Don't know

33. How many hours per day do you usually spend outdoors during the months May to September?

	0	1-3	4-8	9 or more
Weekdays				
Weekends/vacation				

34. How often did you spend time in forests or other areas where you may come into contact with ticks during the months of May to September this year?

Just select one of the following:

- ☐ Daily
- ☐ 1-3 Times a Week
- ☐ 1-2 Times a Month
- ☐ More Rarely
- ☐ Never
- ☐ Don´t know

✓ Ticks thrive in the forests and meadows with tall grass and scrubland.

35. How often, during the months of May to September this year, did you spend time in areas where you may come into contact with ticks and where you also know or have heard that there is TBE?

Just select one of the following:

- ☐ Daily
- ☐ 1-3 Times a Week
- ☐ 1-2 Times a Month
- ☐ More Rarely
- ☐ Never
- ☐ Don´t know

Reported cases of TBE 2012

Each dot on the map to the right indicates where someone was infected with TBE in 2011.

Protective measures against tick-bites

36. **How often do you protect yourself against tick bites, in any of the following ways, when you are in forests or in other areas where you may get in contact with ticks?** Put a cross on each line.

	Never	Rarely	Often	Always
Uses covering trousers and long-sleeved shirt / jacket	☐	☐	☐	☐
Uses anti-mosquito or tick repellant	☐	☐	☐	☐
Have socks outside the trousers	☐	☐	☐	☐
Avoid tall grass and go near the bushes	☐	☐	☐	☐
Examining body for ticks after being outdoors	☐	☐	☐	☐

37. **[If child <18 years] How often do you protect yourself against tick bites, one of the following ways, when you are in areas with ticks?**

	Never	Rarely	Often	Always
Examines my child's body for ticks after being outdoors	☐	☐	☐	☐

38. How good protection against tick bites do you think that the following measures provide:

	No protection	Rather poor	Rather good	Very good
Use covering trousers and long-sleeved shirt / jacket	☐	☐	☐	☐
Use anti-mosquito or tick repellant	☐	☐	☐	☐
Have socks outside the trousers	☐	☐	☐	☐
Avoid tall grass and go near the bushes	☐	☐	☐	☐
Examining body for ticks after being outdoors	☐	☐	☐	☐
[respondents with outdoor pets:] Examine pets for ticks when they have been outdoor	☐	☐	☐	☐

39. Do you avoid activities or areas where there is a risk that you get bitten by ticks? (For example, if you refrain from going for a walk in a certain forest area or if you are walking on a road instead of a path with high grass to avoid ticks)

☐ Yes, very often
☐ Yes, rather often
☐ Yes, but rarely
☐ No, never
☐ Don't know

40. Briefly describe what type of activities or areas that you avoid:

____

Choice between recreational areas

Imagine that it is late summer and that you have decided to spend four hours during the weekend outdoors engaging in activities such as walking, picking berries or mushrooms, picnicking, or other things you enjoy doing. Imagine that you are to choose between spending the four hours outdoors in one of two areas (area A or B).

We will now describe areas A and B and then ask you to **select the area in which you would prefer to spend the four hours**:

The following things distinguish areas A and B from each other:

<u>Area characteristics</u>
Imagine that you have rated the area after a previous visit. This can include how beautiful the area is, its natural values or the presence of mushrooms and berries. You have divided the areas into the following categories:
- ordinary area,
- nice area,
- very nice area.

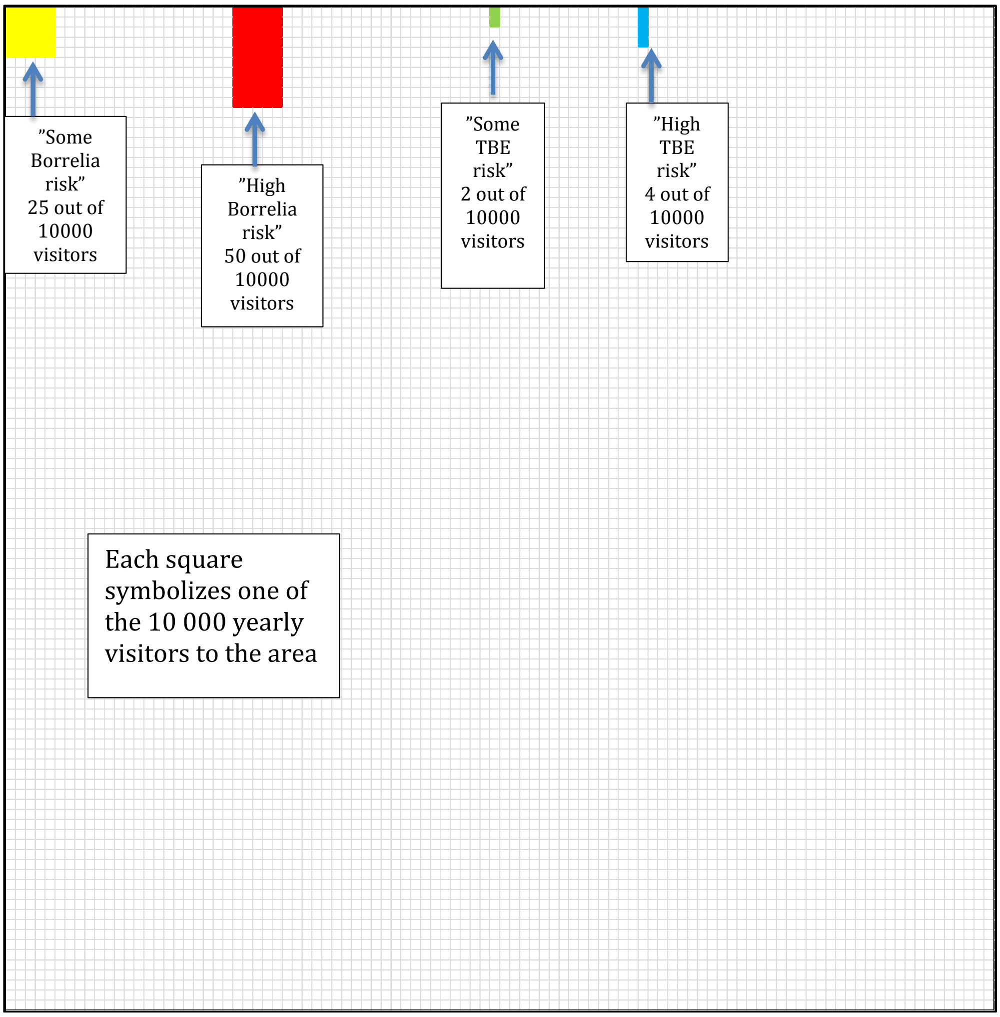
<u>The presence of ticks:</u>

- **no ticks**
- **some ticks** – it is likely that you will get 1–2 ticks on your clothes or your skin if you walk in tall grass or in the forest during your stay in the area
- **many ticks** – it is likely that you will get 4 or more ticks on your clothes or your skin if you walk in tall grass or in the forest during your stay in the area

<u>The distance to the area</u>

- 1 km
- 5 km
- 30 km
- 70 km

<u>The risk of contracting Lyme borreliosis and TBE</u>
Both Areas A and B are about 10 square kilometres and are visited by about 10 000 people per year. The figure below contains 10 000 squares. Each square symbolises 1 person who visits the area.



- **Some Borrelia risk** – means that 25 of the 10 000 visitors get Lyme borreliosis every year after visiting the area. This is symbolised by the 25 yellow-coloured squares in the figure.
- **High Borrelia risk** – means that 50 people get Lyme borreliosis every year after visiting the area. This is symbolised by 50 red-coloured squares in the figure.
- **Some TBE risk** – means that 2 people get TBE every year after visiting the area. This is symbolised by the 2 green-coloured squares in the figure.
- **High TBE risk**– means that 4 people get TBE every year after visiting the area. This is symbolised by the 4 blue-coloured squares in the figure.

This means that *only a very small share of the visitors become infected with Lyme borreliosis or TBE every year.*

41. To be sure that you understand the information, we ask you to answer the following question:

If we state that an area has some Borrelia risk and high TBE risk, is there then a greater risk of contracting Borrelia than TBE while visiting the area? [compulsory question]
Select just one of the following:

☐ Yes

☐ No

[If yes, the following text is shown:) Correct answer!

[If no, the following text is shown:]
- Some Borrelia risk – means that 25 of the 10 000 visitors contract Lyme borreliosis each year in conjunction with visits to the area.
- High TBE risk – means that 4 of the 10 000 visitors get infected with TBE each year in conjunction with visits to the area.
Thus, there is a greater risk of contracting Lyme borreliosis than TBE while visiting the area.

Read about what characterises areas A and B in the table below. Select whether you would choose to go to area A or B to spend the four hours outdoors. If, under the given circumstances, you would choose not to visit either of the areas, mark alternative C, 'Not go'.

Read the text in the box before making your choice:

Experiences from other similar surveys show that it is common that people make other choices in a survey than they would in real life. Some may state that they would travel 70 km to visit an area while in real life they would only be willing to travel 30 km. We want you to state the choice you would make if this was a real situation.

	Area A	**Area B**	**Not go (C)**
Area characteristics	Nice area	Nice area	
Presence of ticks	No ticks	Some ticks	
Risk of Borrelia	No Borrelia risk	Some Borrelia risk	
Risk of TBE	No TBE risk	Some TBE risk	
Distance	5 km	1 km	
Mark if you would choose A, B or C:	[ ]	[ ]	[ ]

We will now modify the properties of Area A and Area B. After examining the characteristics of each area we want you to select Area A or B, or the alternative C (not go). Make every choice without thinking of your previous choices.

	Area A	**Area B**	**Not go (C)**
Area characteristics	Nice area	Nice area	
Presence of ticks	No ticks	Many ticks	
Risk of borrelia	No borrelia risk	High borrelia risk	
Risk of TBE	No TBE risk	HighTBE risk	
Cost	5 km	1 km	
Mark if you would you choose A, B or C:	[ ]	[ ]	[ ]

Continue to make your choice after reading what applies to each area.
Make every choice without thinking of your previous choices.

	Area A	Area B	Not go (C)
Area characteristics	Nice area	Nice area	
Presence of ticks	Many ticks	Some ticks	
Risk of borrelia	High borrelia risk	Some borrelia risk	
Risk of TBE	High TBE risk	SomeTBE risk	
Distance	1 km	1 km	
Mark if you would you choose A, B or C:	[ ]	[ ]	[ ]

[The three tables above are presented to all respondents and constitute a transitivity test. All respondents are presented to four additional tables which are created using statistical design methodology and divided into four different blocks. The order in which the tables are presented are randomized among the respondents.]

Vaccine against Lyme borreliosis

Today there is no vaccine against Lyme borreliosis to buy, but there are ongoing efforts to develop such a vaccine. Imagine that there was a vaccine that gave almost 100% of those vaccinated a good protection against Lyme borreliosis and that the side effects from the vaccine were mild. As with today's TBE vaccination three doses of the vaccine would be necessary to protect ONE PERSON during at least 3 years.

42. **Would you vaccinate yourself or someone in your household against Lyme borrelosis if it cost a total of [100; 250; 500; 1000; 5000] SEK for the three doses of the vaccine that protects ONE person for at least three years' time?** *(One of the numbers in [ ] is presented to the respondent)*

PLEASE READ THE INFORMATION IN THE TEXT BOX BEFORE RESPONDING TO THE QUESTION

> *Experiences from other similar surveys show that it is common to make other choices in a survey than one would make in real life. Some may state that they would be willing to pay a higher price for a vaccine than they would actually pay in real life. This may be due to the fact that one does not really consider how big an impact an extra cost actually has to the family budget. We want you to state the choice you would make if this was a real situation.*
> *Disregard any answers you gave to similar questions earlier in the survey.*

☐ Yes
☐ No [jump to Q.48]

43. **[IF YES] Enter the number of adults in your household that you would choose to vaccinate at this cost: ______________________**

44. Enter the number of children below age 18 in your household that you would choose to vaccinate at this cost: ________________________________

45. The total cost to vaccinate [x] people in your household would be [yy] kr.

You now have the possibility to adjust your choice!

46. How certain are you that this is the choice you would make in a real world situation?

☐ Very uncertain
☐ Rather uncertain
☐ Rather certain
☐ Very certain

47. Do you think other persons resembling yourself (e.g. persons that have the same age, sex and lives in the same municipality as you) would choose to get vaccinated against Lyme borreliosis if it cost a total of [*SAME PRICE AS ABOVE PRESENTED*] SEK for the three doses of the vaccine that protects ONE person for at least three years' time?

☐ Yes
☐ No

48. [IF NO] Would you vaccinate yourself or someone in your household against Lyme Borreliosis if the vaccine was free of charge?

☐ Yes
☐ No
☐ Don´t know

49. [FOLLOW-UP QUESTION TO RESPONDENTS WHO SAYS YES TO INTEREST OF BUYING BORRELIA VACCINE] **Why would you buy a vaccine against Lyme borrelosis?** Select all that apply:

☐ I often stay in areas with ticks
☐ I often get bitten by ticks
☐ I would not need to worry about Lyme borreliosis
☐ Someone close to me (eg, friend, family member) has had Lyme borreliosis
☐ I've heard a lot about Lyme borreliosis in the media
☐ Other reason, please specify: ________________________________
☐ Do not know

50. [FOLLOW-UP QUESTION TO RESPONDENTS WHO SAYS NO TO INTEREST OF BUYING BORRELIA VACCINE] **Why would not you buy a vaccine against Lyme borreliosis?**

Select all that apply:

☐ I'm never / rarely in tick-affected areas
☐ The risk of contracting Lyme borreliosis is so small that I do not need the vaccine
☐ The vaccine costs too much
☐ If I become infected with Lyme borreliosis, I expect that I can treat it with antibiotics

☐ I am afraid of negative side effects of the vaccine
☐ I do not think that the vaccine would be effective
☐ Medical reasons
☐ I'm afraid of needles
☐ Other reason, please specify: ______________________________
☐ Do not know

Vaccine against TBE

51. Have you been vaccinated against TBE?
Just select one of the following:
☐ Yes
☐ Yes, I have started vaccination against TBE but not had time to take all doses
☐ I have started but discontinued vaccination against TBE [PROCEED TO QUESTION 52]
☐ No [PROCEED TO QUESTION 57]
☐ Don´t know

52. [IF "YES, I have started", "YES" or "I have started but discontinued vaccination against TBE"] **What year did you take your last dose of the vaccine?**
Year: (scroll bar)

53. [IF YES, I have started or YES] **Enter the number of adults in your household who are vaccinated against TBE.** Number of adults: ____________

54. [IF YES, I have started or YES] **Enter the number of children in your household who are vaccinated against TBE.**
Number of children under 18 years: ________________

55. [IF YES, I have started or YES] **What were the main reasons that you got vaccinated against TBE?**
Select all that apply:
☐ I live in a TBE risk area
☐ I travel to TBE risk areas
☐ I often stay in areas with ticks
☐ I often get bitten by ticks
☐ I do not need to worry anymore about TBE
☐ Someone close to me (eg, friend or family member) has contracted TBE
☐ Seen, read or heard about TBE in the media
☐ My doctor recommended TBE vaccination
☐ My family/friends recommended TBE vaccination
☐ Other reason, please specify: ______________________________
☐ Do not know

56. Have you changed your behavior in any of the following ways after you got vaccinated against TBE? (state to what extent you agree with the following statements, please tick one option per line)

	Don´t agree at all	Agree to some extent	Agree completely	Don´t know
I worry less about tick bites				
I spend more time in forests				
I less often do not avoid to go to areas with TBE risk				
I do not check my body for ticks after being outdoors as carefully as before				
I wear protective clothing less often when I am in forest areas				

57. [IF NO TO Q51] **Why are you not vaccinated against TBE?**

Select all that apply

- ☐ I'm never / rarely in areas with ticks
- ☐ I'm never / rarely in areas where there is a risk of contracting TBE
- ☐ The risk of contracting TBE is so small that I do not need to be vaccinated
- ☐ I did not know there was a vaccine against TBE
- ☐ The vaccine costs too much
- ☐ I have intended to get vaccinated, but have not gotten to it
- ☐ Have never thought about it
- ☐ It is complicated / take too long to get vaccinated
- ☐ I'm afraid of getting side effects from the vaccine
- ☐ I'm afraid of needles
- ☐ Medical reasons
- ☐ Other reason, please specify: ____
- ☐ Do not know

58. [IF NO to Q51] **Would you vaccinate yourself or someone in your household against TBE if it cost a total of [100, 250, 500, 750, 1000] SEK for the three doses of the vaccine that protects ONE person for at least three years' time?** *(One of the numbers in [ ] is presented to the respondent)*

PLEASE READ THE INFORMATION IN THE TEXT BOX BEFORE RESPONDING TO THE QUESTION

> *Experiences from other similar surveys show that it is common to make other choices in a survey than one would make in real life. Some may state that they would be willing to pay a higher price for a vaccine than they would actually pay in real life. This may be due to the fact that one does not really consider how big an impact an extra cost actually has to the family budget. We want you to state the choice you would make if this was a real situation.*
> *Disregard any answers you gave to similar questions earlier in the survey.*

☐ Yes
☐ No [JUMP TO Q63]

59. **[IF YES] Enter the number of adults in your household that you would choose to vaccinate at this cost: ______________________**

60. **[IF YES] Enter the number of children below age 18 in your household that you would choose to vaccinate at this cost:**
____

The total cost to vaccinate [x] people in your household would be [yy] kr.
You now have the possibility to adjust your choice!

61. **How certain are you that this is the choice you would make in a real world situation?**
☐ Very uncertain
☐ Rather uncertain
☐ Rather certain
☐ Very certain

62. **Do you think other persons resembling yourself (e.g. persons that have the same age, sex and lives in the same municipality as you) would choose to vaccinate against TBE if it cost a total of** *[SAME PRICE AS ABOVE]* **SEK for the three doses of the vaccine that protects ONE person for at least three years' time against TBE?**
☐ Yes
☐ No

63. **[IF NO] Would you vaccinate yourself or someone in your household against TBE if the vaccine was free?**

☐ Yes
☐ No
☐ Don´t know

64. [IF "I have started but discontinued vaccination against TBE" IN Q51]
Why have not you finished your TBE vaccination?
Select all that apply

- ☐ Forgot to do it
- ☐ I have intended to continue to take TBE vaccine, but have not gotten to it
- ☐ Too busy to do a follow-up meeting
- ☐ Lack of information, not sure when I would take follow-up injections
- ☐ No longer live in a TBE-risk area
- ☐ Do not travel to TBE risk areas
- ☐ The vaccine costs to much
- ☐ I discussed it with friends / family and came to the conclusion that I do not need TBE vaccination
- ☐ I'm afraid of side effects from the vaccine
- ☐ I'm already protected with the doses I have taken, I do not take any more doses of vaccine
- ☐ Other reason, please specify: ______________________
- ☐ Do not know

Public programs to reduce the risk of tick-borne diseases

65. Swedish authorities can take various measures to reduce the risk of tick-borne diseases. Below are a number of possible actions. What is your opinion on each of them?
Choose one answer for each item:

Program	*Very good proposal*	*Rather good proposal*	*Neither good nor bad proposal*	*Rather bad proposal*	*Very bad proposal*
Reduce the price of TBE vaccinations to people living in areas at risk					
Reduce the price of TBE vaccination to anyone who wants to get vaccinated in Sweden					
Include TBE vaccination in the general vaccination program for children					
Increase resources for research on tick-borne diseases					
Increase communication efforts on tick-borne diseases					
Drastically reducing the number of deer in Sweden by hunting (deer are an important host animals for ticks)					

Information about you and your household

66. Where do you live today? (Tick the option that best describes your living area)

☐ Countryside with just a few houses in sight
☐ Village or small town in the countryside
☐ Small town (less than about 50 000 inhabitants)
☐ Medium-sized town (about 50 000 - 200 000 residents)
☐ Larger city (more than 200 000 inhabitants)

67. Which people live in your household?

Select all that apply:

☐ I live alone
☐ I live with / share regularly household with adults 18 years and older
☐ I live with / regularly share of household with children below 18 years

68. Including yourself, how many adults aged 18 or older, are there in the household?: ____

69. How many children below 18 years are there in the household?:_________

70. Please indicate <u>YOUR</u> total monthly income (before tax).
Estimate your total income from all sources or income, such as wages, pensions, social security, unemployment compensation, net income from business, child support or any other income. (please circle one alternative)

☐ Less than 10 000 kronor
☐ 10 000 - 19 999 kronor
☐ 20 000 - 29 999 kronor
☐ 30 000 - 39 999 kronor
☐ 40 000 - 49 999 kronor
☐ 50 000 - 59 999 kronor
☐ 60 000 - 69 999 kronor
☐ 70 000 - 79 999 kronor
☐ Above 80 000 kronor

71. Please indicate the total monthly income of your <u>HOUSEHOLD</u> (before tax). Estimate your total household income from all sources or income, such as wages, pensions, social security, unemployment compensation, net income from business, child support or any other income. (please circle one alternative)

☐ Less than 10 000 kronor
☐ 10 000 - 19 999 kronor
☐ 20 000 - 29 999 kronor
☐ 30 000 - 39 999 kronor
☐ 40 000 - 49 999 kronor
☐ 50 000 - 59 999 kronor
☐ 60 000 - 69 999 kronor
☐ 70 000 - 79 999 kronor
☐ 80 000 – 89 999 kronor
☐ 90 000 – 99 999 kronor
☐ 100 000 – 110 000 kronor
☐ Above 110 000 kronor

72. Were you ....:

- ☐ Born in Sweden
- ☐ Born in another country

73. Do you own or have regular access to a summer house?

- ☐ Yes
- ☐ No, [GO TO QUESTION 79]

74. Where is your summer house located?

- ☐ In Sweden
- ☐ Abroad [go to Q77]

75. In which municipality? [scroll bar]

76. Which zip code? ___________________

77. In which country? (scroll bar)

78. How many days or parts of days did you spend in the summerhouse during the period May to September this year?

- ☐ 0 days
- ☐ 1-7 days
- ☐ 8-21 days
- ☐ More than 21 days
- ☐ Do not know

79. Do you or your household own a car?

- ☐ Yes, one car
- ☐ No, but I have regular access to a car
- ☐ No

80. What is the highest level of schooling you have completed?

Please circle one alternative.

- ☐ Not completed elementary school
- ☐ Elementary school
- ☐ Secondary school 1-2 years
- ☐ Secondary school 3 years
- ☐ University 1-3 years
- ☐ University more than 3 years
- ☐ Doctoral studies

81. Life Situation / Employment

Just select one of the following:

- ☐ Employment in the private or public sector (including sick leave, maternity leave)
- ☐ Working in own business (self employed)
- ☐ Have work in labor market programs / Undergoing employment training
- ☐ Unemployed
- ☐ Retired, Age Pensioners
- ☐ Have "sick or activity payment" (ex early retirement / disability pensioner)
- ☐ Student
- ☐ Other: ______________________________

Final questions

82. ANY OTHER COMMENTS about ticks and tick-borne diseases or about the survey?

____

____

THANK YOU FOR YOUR COOPERATION!

The questionnaire contains brief information about Lyme borreliosis and TBE. Detailed information on tick-borne diseases can be found at the following websites: www.SMI.se and www.Internetmedicin.se.

The information on Lyme borreliosis risk and TBE risk given for the hypothetical areas A and B are based on information about the areas in Sweden, with the highest incidence of Lyme borreliosis and TBE. In most places, the risk is much lower.

The actual risk of becoming infected with TBE or Lyme borreliosis is largely dependent on factors such as:

- where you live and where you are in the summer, since ticks carrying TBE or Lyme borreliosis is more common in certain parts of Sweden
- Leisure activities / work habits (if you spend much time in the forest, scrubland or high grass, the risk of becoming infected is higher)
- if you dress in protective clothing, such as pants and long sleeves , when you walk in the woods or in tall grass, the risk of becoming infected is lower
- if you check your body for ticks after being out in the woods or tall grass, the risk of becoming infected is lower
- if you are vaccinated against TBE the risk of getting TBE is minimal.

Paper II

Valuation When Baselines Are Changing: Tick-borne Disease Risk and Recreational Choice

Daniel Slunge[‡], Thomas Sterner[π] and Vic Adamowicz[§]

Abstract

Understanding how changes in baseline risk influence preferences for risk reduction is important when valuing the welfare effects of environmental change, including the spread of disease. We conduct a survey-based choice experiment in Sweden where respondents choose between visiting recreational areas differing in prevalence of ticks and incidence of Lyme borreliosis (LB) and tick-borne encephalitis (TBE). By varying the distance to the recreational areas, the respondent is faced with a trade-off between risk and travel cost. Our study indicates that ticks and the risk of tick-borne diseases significantly influence the choice of recreational area and have non-trivial welfare effects. The mean willingness to pay (WTP) per trip to avoid areas with ticks and an incidence of LB of 500 yearly cases per 100 000 inhabitants is estimated at 24 EUR. When there is also a high incidence of TBE the WTP rises to 78 EUR.

The WTP for risk reduction decreases with 'exogenous' baseline risk, defined as the prevalence of ticks and the incidence of LB and TBE in the area of residence. TBE-vaccinated respondents have a lower WTP indicating that disease risk is endogenous to behaviour. Residents in risk areas generally have better knowledge about tick-borne diseases and adapt to a higher risk through vaccination and other protective measures. Residents in emerging risk areas may have greater difficulties in assessing disease probabilities and adaptation costs. However, their risk perceptions and preferences for risk reduction should not be dismissed as being 'incorrect' as the new risk may constitute a real and sizeable loss compared to their reference point utility – a recreational area with no or few ticks. Hence, differences in WTP for risk reduction between groups with different baseline risks should be taken into account when estimating welfare costs associated with a spread of disease vectors, such as ticks, to new areas due to climate change or other environmental change.

Keywords: choice experiment, baseline risk, willingness to pay, stated preference, travel cost, climate change, adaptation, ticks, Lyme borreliosis, tick-borne encephalitis, TBE, health risk.

JEL Codes: D61, I12, Q51, Q54, Q57

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1. Introduction

The spread of vector-borne infectious diseases is one of the most tangible impacts of climate change on human health (McMichael et al., 2006; Medlock and Leach, 2015; Semenza, 2009). While the impacts of climate change on the spread of malaria through mosquitos has received considerable attention, the costs associated with the spread of ticks and infectious diseases transmitted by ticks such as tick-borne encephalitis (TBE) and Lyme borreliosis (LB)[1] are poorly covered in the scientific literature (Lindquist and Vapalahti, 2008; Stanek et al., 2012). With a warmer climate, the regions where ticks can be found have expanded to higher latitudes and altitudes, and this development is expected to continue (Gray et al., 2009; Jaenson et al., 2012; Jore et al., 2011; Lindgren et al., 2000; Ogden et al., 2010)[2] This is in line with the latest IPCC assessment report, which found examples on all continents of species and entire ecosystems moving towards both the poles and higher elevations (IPCC, 2014).

This spread of disease risk to new areas poses challenges to the standard practice in cost-benefit analysis to analyse willingness to pay (WTP) independently of baseline risk (Gerking et al., 2016). Without knowledge about the differences in WTP for risk reduction between endemic risk areas, where inhabitants are familiar with the risk, and new risk areas, where inhabitants are not familiar with the risk, it will not be possible to correctly transfer cost and benefit estimates from the endemic area to the new risk area. Understanding how changes in baseline risk influence preferences for risk reduction is hence important to be able to value the welfare effects of environmental change. However, while baseline risk is known to play an important role in estimates of WTP to reduce health risks, both theoretical and empirical studies show an ambiguous relationship between the two (Alberini and Ščasný, 2013; Finkelstein et al., 2013; Hammitt and Haninger, 2010; Liu and Neilson, 2006).

Valuing the welfare effects from a spread of vector-borne diseases to new areas is also complicated by the interlinkage between damage and adaptation. Although damage is the prime rationale for adaptation, adaptation may also lessen damage. For example, vaccination can significantly reduce the incidence of TBE (Heinz et al., 2013). Hence, risk is endogenous to behaviour (Pattanayak and Pfaff, 2009; Shogren and Crocker, 1999).

The purpose of this paper is to estimate WTP to reduce the risk of getting tick bites or contracting TBE and LB in connection with visits to recreational areas in Sweden, and to analyse the role of baseline

[1] There are several other tick-borne diseases as well, including babesiosis, Crimean-Congo haemorrhagic fever, rickettsiosis and relapsing fever.

[2] The ecology behind the spread of ticks and tick-borne diseases is complex and cannot be explained by climate change alone (Gray et al., 2009; Randolph, 2010; Šumilo et al., 2008). For example, the upsurge in TBE in the Baltics in the early 1990s was largely explained by the economic downturn following the collapse of the Soviet Union, which led to an increase in the collection of mushrooms and berries to cope with poverty and consequently to increased exposure to the TBE virus (Randolph, 2010; Šumilo et al., 2008). At the limits of the latitudinal and altitudinal distribution of ticks, climate-related factors play a more important role than in areas where ticks, TBE and LB are endemic (Jore et al., 2011).

risk and adaptive behaviour for these estimates. We conduct a survey-based choice experiment on the WTP for reducing said risks.

Our study contributes to the existing literature in several ways. First, our empirical analysis contributes to a deeper understanding of the importance of baseline risk in the valuation of vector-borne infectious disease in the context of climate change. Using data from Sweden, where there is large geographic heterogeneity in the presence of ticks, TBE virus and *Borrelia* bacteria, we study how WTP varies with 'exogenous' baseline risk, defined as the prevalence of ticks and the incidence of TBE and LB in the area of residence. We also analyse disease risk as endogenous to investments in risk reduction through vaccination against TBE.

Second, our estimates of WTP for risk reduction complement existing cost-of-illness studies for LB (Adrion et al., 2015; Henningsson et al., 2010; Joss et al., 2003; Maes et al., 1998; Magid et al., 1992; Zhang et al., 2006) and TBE (Desjeux et al., 2005; Smit, 2012). These cost-of-illness studies are based on estimates of public and private health care costs and do not fully account for the suffering related to disease or the broader welfare costs such as worries about tick bites or changes in recreational behaviour. Thus, there is a risk of underestimating the costs if estimates are limited to health care costs. In line with Berry et al. (2017), who find that LB risk has a significant negative effect on the time people in the US spend outdoors, our study indicates that an increase in ticks and the pathogens they carry can have substantial effects on recreational behaviour.

The third and final contribution is an enhanced knowledge about the heterogeneity in risk preferences and behaviour related to tick-borne diseases. While several studies have analysed risk preferences related to ticks and LB using traditional surveys (Aenishaenslin et al., 2014; Beaujean et al., 2013; Herrington, 2004; Jones et al., 2002; Shadick et al., 1997), this is the first study that we know of to use a choice experiment with an exogenous variation in the risk of both LB and TBE.

The remainder of the paper is organised as follows. The next section gives an introduction to TBE and LB and describes why Sweden is an interesting case study. Section 3 provides a theoretical background to our analysis of how WTP for risk reduction is related to baseline risk. Section 4 describes the choice experiment and the methods used to collect and analyse the data. Results are presented in Section 5. Section 6 summarizes the paper and discusses some implications.

2. Ticks and tick-borne diseases

TBE is caused by a flavivirus transmitted to humans by ticks and able to cause severe infection of the central nervous system. Around 40% of those infected by the European subtype of the virus suffer serious, long-term cognitive and neuropsychiatric impairments (Haglund and Günther, 2003). There is no treatment once infected, but the disease is preventable as effective vaccines are available (Lindquist and Vapalahti, 2008).

LB infection is caused by spirochetes belonging to the *Borrelia burgdorferi* sensu lato complex. While symptoms can be mild or absent for some individuals, they can be severe for others, especially if not treated early. There is no vaccine available on the market, but LB infections can be treated with antibiotics (Stanek et al., 2012).

Sweden provides an interesting case because of its large geographic heterogeneity in the presence of ticks, TBE virus and *Borrelia* bacteria. This geographic variation makes it possible to compare WTP for risk reduction between respondents with different baseline risk. *Ixodes ricinus* – the most common tick species in Sweden – has become more abundant and has spread farther north in recent decades, to areas where they were not previously present. *I.ricinus* have been found in 23 of Sweden's 25 counties but they are much less prevalent in the north (Jaenson et al., 2012; Jaenson et al., 1994).

Pettersson et al. (2014) report a 0.23% mean prevalence of TBE virus in ticks in southern Sweden and that TBE virus is concentrated in geographically limited areas. There has been a marked increase in the number of reported TBE cases in Sweden, from less than 50 annual cases before the mid-1980s to 200–300 cases per year since 2010. The mean incidence is three cases per 100 000 inhabitants, but the figure varies greatly across the country. In some areas, the incidence is over 40 cases per 100 000 inhabitants (Swedish Public Health Agency, 2014).

The risk of developing LB is low even if one is bitten by a tick that carries the *Borrelia* bacteria. In a study of over 2 000 ticks that had bitten people in Sweden, 26% of the ticks carried the bacteria, but only 2% of the people who were bitten by the ticks in the overall sample were diagnosed with LB (Wilhelmsson et al., 2016; Wilhelmsson et al., 2013). The same studies report large geographical variation in prevalence between different geographical locations in Sweden. As LB does not have to be officially reported in Sweden, there are no good estimates of the incidence of this disease. Estimates range from 70 to 460 cases per 100 000 inhabitants (Bennet et al., 2006; Berglund et al., 1995).

The actual risk of getting bitten by a tick is highly dependent on factors such as place of residence and summer holiday, outdoor habits and precautionary measures taken, e.g. wearing protective clothing and checking the body for ticks after being outdoors (Jones et al., 2002; Piesman and Eisen, 2008). Also the risk of getting infected by TBE virus after a tick bite depends on the geographical location and on whether the individual is vaccinated against TBE.

Outdoor recreation, not least in forest areas, is very popular in Sweden. A large survey showed that more than 90% of respondents had visited a forest area at least once in the last year and as many as 16% had engaged in recreational activities in forests or meadows more than 60 times per year (Boman et al., 2013; Fredman and Bladh, 2008; Hörnsten and Fredman, 2000). Several studies have found a considerable WTP among Swedish inhabitants for recreational trips close to their place of residence (Boman et al., 2013; Ezebilo, 2016; Ezebilo et al., 2015). Hence, the increasing prevalence of ticks and the risk of getting tick-borne diseases could have considerable behavioural and welfare-related implications in Sweden.

3. Theoretical background

To analyse how the WTP for health risk reduction can be expected to change with baseline risk – defined as the prevalence of ticks and incidence of tick-borne diseases in a geographical area – we compare a person living in an emerging risk area with few or no ticks with someone who lives in an area where ticks are endemic and there is some incidence of tick-borne diseases. The following mechanisms may influence risk perception and willingness to pay for risk reduction in relation to a recreational trip to an area with ticks and some incidence of tick-borne diseases:[3]

a) *Knowledge and fear of the unknown*: The person in the tick-endemic area will typically have more knowledge about ticks and tick-borne diseases. More knowledge should give a more evidence-based ('correct') valuation. The effect of an increase in knowledge on WTP for risk reduction could go either way. With more knowledge about tick-borne diseases, risk perceptions may increase (Aenishaenslin et al., 2014) and lead to a higher WTP for risk reduction. On the other hand, people might be particularly scared of 'new' risks they do not know much about and perceive as uncontrollable (Sjöberg, 2000; Slovic, 1987), which would make people with less knowledge have a higher WTP to reduce risk. If people are risk neutral, then the amount of information will only affect the precision and not the size of the WTP. If, however, there is risk aversion or aversion to ambiguity, then more information should reduce WTP.

b) *Overestimation of small risks*. A related point is that it is hard to correctly estimate small and poorly known risks. There is a tendency to systematically overestimate small risks and underestimate large ones (Johansson-Stenman, 2008; Kahneman and Tversky, 1979). While both our persons may overestimate the small risk of tick-borne diseases, a higher level of knowledge should reduce the size of this bias, implying a lower WTP in the endemic area.

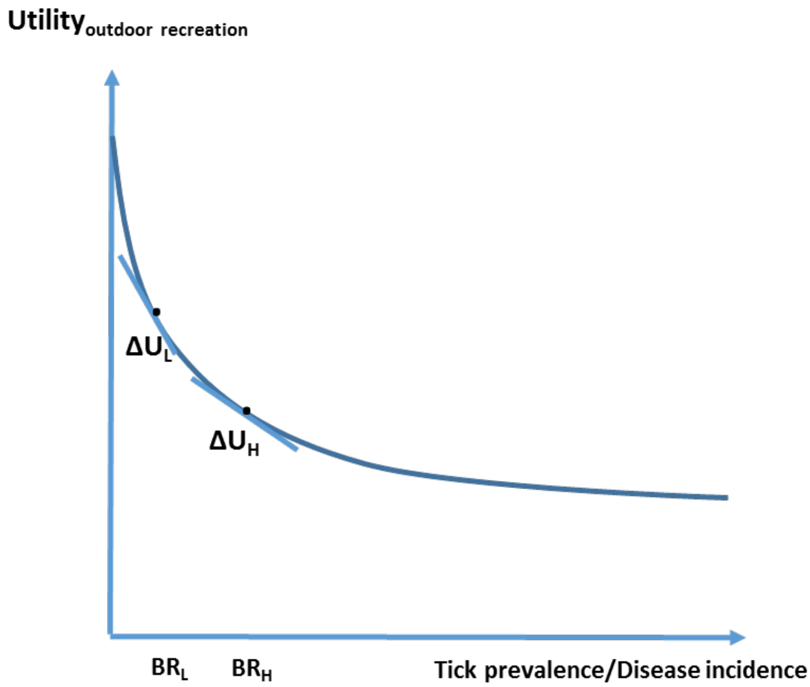
c) *Adaptive behaviour and learning*. Risks are not completely exogenous and people can learn to cope through adaptive behaviour. Examples include vaccination, wearing protective clothing, avoiding tick habitats, using repellent and learning to check one's body for ticks. If such measures are effective and not too costly, then the WTP for reducing risks associated with recreational trips should fall with experience (Gerking et al., 2016; Lloyd-Smith et al., 2016).

d*) Changing preferences*. Over a longer time period, people who are exposed to high risks may change preferences as a result of changed behaviour. If for instance an individual stops walking in forests or picking berries, she may over time forget the name and beauty of various species and lose interest in 'the nature experience'. Instead, she may discover new worlds such as that of playing chess, reading books or even watching nature films. Berry et al. (2017) find such a substitution effect between outdoor and indoor activities in the face of LB risk. If one gets used to reading books instead of going on hikes, then the presence of ticks in nature may be seen as less problematic and the WTP for risk

[3] In the choice experiment, we ask respondents to value an afternoon with lower or higher exposure to ticks and disease risk. Respondents with differing baseline risk are presented with the same hypothetical risk scenario.

reduction may be lower. This change in preferences over time is hard to evaluate with standard theoretical economic tools, which assume fixed and exogenous preferences.

e) *Change in reference point utility.* If one's preferences remain stable, there may still be differences in WTP for risk reduction due to the starting point or reference level of utility (Kahneman and Tversky, 1979). In a tick and disease risk-free environment, one has high utility from nature, and the spread of ticks to these areas may be interpreted as a loss. Because people tend to be averse to losses (Kahneman and Tversky, 1979; Knetsch, 1989; Tversky and Kahneman, 1991), we expect the WTP for risk reduction to be higher in emerging risk areas than in areas where ticks have been present for a long time. However, the disutility of ticks may well be a non-linear function, as in Figure 1.



Notes: BR_L=low baseline risk; BR_H=high baseline risk; ΔU=change in utility from one unit change in tick prevalence or disease risk; $\Delta U_L > \Delta U_H$

Figure 1. Utility from outdoor recreation at different levels of tick prevalence and disease incidence

With even a small increase in the number of ticks or disease risk, utility falls fast, but falls at a declining rate as the function is convex. If one is already frequently exposed to ticks, then an additional exposure may be less important.

f) *Rationalisation.* A related psychological mechanism is that people rationalise their choices in life. If they live next to a nuclear power plant, they tend to rationalise this choice and will often hold beliefs that this neighbouring installation does not constitute a large risk (Parkhill et al., 2010). Likewise, having lived for a long time in an area with ticks without catching a serious disease may lead to a similar rationalisation related to risks associated with tick bites. Indeed, several studies find surprisingly weak associations between exposure to ticks and protective behaviour (Jones et al., 2002; Shadick et al., 1997; Stjernberg and Berglund, 2005). This type of rationalisation of risk implies a lower WTP for risk reduction in endemic risk areas than in new risk areas.

g) *The value of money when healthy versus sick.* Finally, the value of money might change depending on the state of health in which we expect to find ourselves. If we live with a risk of TBE or LB, we are more likely to be sick in the future. If one believes that people need or value money less when ill than when healthy, then the WTP for risk reduction will increase as risk increases (Jones-Lee, 1974; Pratt and Zeckhauser, 1996). The intuition between this 'dead anyway effect' (Pratt and Zeckhauser, 1996) is that an exogenous rise in the risk of illness or death decreases the expected utility of income, implying a higher WTP for risk reduction. However, increased investments in health risk reduction may offset this effect by reducing wealth and increasing the marginal utility of income (Liu and Neilson, 2006). Hence, the effect of this mechanism on WTP is ambiguous and largely depends on whether risk is treated as exogenous or endogenous (Gerking et al., 2016).

Our review shows that it is somewhat difficult to know a priori whether the WTP will increase or decrease with baseline risk. Although mechanisms (b)–(f) should make the WTP decrease with baseline risk, mechanisms (a) and (g) have an ambiguous effect. Nevertheless, on a balance, our review suggests that the WTP for risk reduction in relation to recreational trips should decrease with an increase in baseline risk. Thus, people in areas with no or few ticks have more to lose and will be willing to pay more to avoid risks in relation to a recreational trip than those who live in endemic areas and who gradually have become accustomed to living with ticks.

It is even more difficult to say which of these values (the higher value in emerging risk areas or the lower value in the endemic area) is in some sense 'correct'. This latter question lies somewhat outside the realm of this study, but suffice it to say that it would be too simplistic to define the first, higher value as an overvaluation and the second, lower value as more 'correct', since it represents a long-run adaptation. The emergence of ticks and disease risk in an area implies a fall in the level of utility from outdoor recreation and thus a loss of welfare that is difficult to reverse. The logic of convex utility curves implies that a further marginal change will have less effect – but this is a symptom of the new situation. Thus, one could equally well say that it is the initial valuation (before risk becomes endemic) that is 'correct' and that people who have adapted to ticks will state an underestimated value.

4. The choice experiment

4.1. Design of the choice experiment

We used a choice experiment to solicit WTP for a reduction in the risk of getting tick bites, TBE and LB. Respondents were asked to imagine they were to spend 4 hours[4] outdoors during a summer weekend engaging in activities they enjoy, such as walking, picnicking and picking berries or mushrooms. Subsequently, they were asked to choose between sites based on the distance to and recreational qualities of the areas as well as the presence of ticks and risk of contracting LB and TBE. Respondents could also choose to stay home (opt out) instead of going to one of the recreational areas. The full

[4] In a study of nature recreation close to home in Sweden, Ezebilo (2016) found that the average duration of time spent in such an area was 3.5 hours.

scenario presented to the respondents, including an example of a choice set, is included in Appendix A1. Table 1 displays the choice matrix containing four attributes with three levels and one attribute with four levels.

Table 1. The choice matrix

Attributes	Levels	Comment
Area characteristics	Ordinary area Nice area Very nice area	Respondents' rating of areas based on previous visits
Presence of ticks	No ticks Some ticks Many ticks	No ticks in the recreational area Likely to get 1–2 ticks on clothes or skin during visit Likely to get 4 or more ticks on clothes or skin during visit
Risk of LB	No LB risk Some LB risk High LB risk	No LB risk in the area 25 of the 10 000 visitors get LB every year after visiting the area 50 of the 10 000 visitors get LB every year after visiting the area
Risk of TBE	No TBE risk Some TBE risk High TBE risk	No TBE risk in the area 2 of the 10 000 visitors get TBE every year after visiting the area 4 of the 10 000 visitors get TBE every year after visiting the area
Distance	1, 5, 30, 70 km	One way distance to the recreational site.

For area characteristics, respondents were asked to imagine that they had 'rated' the recreational areas after a previous visit as ordinary, nice or very nice areas for recreational purposes. *Some ticks* was defined as 'It is likely that you will get 1–2 ticks on your clothes or your skin if you walk in tall grass or in the forest during your stay in the area'. *Many ticks* signified four or more ticks.

To illustrate the risks of contracting LB or TBE in the recreational area, a grid with 10 000 squares representing annual visitors to the area was displayed. Such grids have been proved effective in explaining small probabilities to respondents (Corso et al., 2001). Coloured squares represented the number of visitors per year who contracted LB or TBE during a visit to the area (see Appendix A1). The *high LB risk* scenario, where 50 of the 10 000 yearly visitors to the area get LB, corresponds to a yearly incidence of 500 LB cases per 100 000 inhabitants in high-incidence areas (Bennet, 2005). Similarly, the *high TBE risk* scenario, where 4 of the 10 000 yearly visitors to the area get TBE, corresponds to a yearly incidence of 40 TBE cases per 100 000 inhabitants, as reported from areas in Sweden with high TBE incidence rates (Swedish Public Health Agency, 2014). *Some LB risk* and *some TBE risk* were defined as half the high risk levels. Although specific geographical areas in Sweden can have a high incidence of LB and TBE, the presented risk levels are high compared with existing estimates of the average incidence of LB and TBE in Sweden.

The final attribute in the choice experiment was the distance to the recreational site. In the analysis, we followed common practice in travel cost models and translated distance into travel cost (Adamowicz et al., 1994; Adamowicz et al., 1997; Boxall et al., 1996) using cost-per-kilometre estimates and value-of-time proxies from Swedish authorities (Swedish Tax Agency, 2014; Swedish Transport Administration, 2013).[5]

The choice sets were generated using the OPTEX procedure in SAS, which is a linear D-efficiency statistical design procedure (Kanninen, 2002; Kuhfeld, 2001).[6] Eight blocks with four choice sets in each block were generated and each block was randomly distributed to 1/8 of the respondents. Each respondent consequently answered four different statistically generated choice sets.

Because stated preference studies can be sensitive to design issues (Carson and Groves, 2007), we used several techniques to avoid potential bias. To ensure that respondents understood the information on the risk of LB and TBE, the following control question was used: *'If we state that an area has "some LB risk" and "high TBE risk", is there then a greater risk of contracting LB than TBE while visiting the area?'* The respondents who did not answer this question correctly received additional information.

To further ensure that respondents understood and reacted to the information in the choice sets, three additional choice sets containing a test of the transitivity of preferences[7] were presented to the respondents. One of these choice sets was used as a basic rationality test, where the choice of Area B strictly dominated the choice of Area A. This was achieved by letting Area B have fewer ticks, less LB risk and less TBE risk than Area A, while the area characteristics and the distance were the same. Respondents would be expected to choose Area B with lower risk.

To reduce the risk of hypothetical bias – that respondents make different choices in a survey than they would in a real-life situation – we used a 'cheap talk script' urging the respondents to answer the choice sets as if they were real-life situations. This type of script has been found to reduce hypothetical bias in previous studies (Carlsson et al., 2005; Cummings and Taylor, 1999; Morrison and Brown, 2009).

To control for potential ordering effects, we introduced several tests (see Carlsson et al. 2012 for an overview of potential ordering effects in choice experiments). The order of the four choice sets was [1,2,3,4] for 50% of the respondents and [3,4,1,2] for the other 50%. The order of the three choice sets in the transitivity test was [1,2,3], [2,3,1] and [3,1,2] for each third of the respondents, respectively. Fifty per cent of the respondents took the transitivity test before answering the four choice sets and 50% after responding to the four choice sets. Besides the choice experiment, the questionnaire

[5] The distance attribute was converted to travel cost using the following formula:
Travel Cost (TC_i) = $(2*Dist_i * 1.85) + ((INC_i/2080*0.25)*(2*DIST_i/70))$, where DIST is the distance in km to the recreational area and INC_i is each respondent's net yearly income. The first term in the expression is the direct cost of travelling back and forth to the recreational area. 1.85 SEK per km is a standard proxy for the cost per kilometre used by Swedish tax authorities (Swedish Tax Agency, 2014). The second part of the expression is the opportunity cost of the time spent travelling back and forth to the recreational area. This is estimated as one-quarter of the hourly wage and an assumed average travel speed of 70 km/hour for respondents with access to a car and half that speed for respondents without access to a car (Swedish Transport Administration, 2013).

[6] The following restrictions were imposed: All alternatives with no ticks had no LB risk and no TBE risk. All alternatives with some or many ticks had some or high LB risk. Also, we excluded choice sets in which one alternative strictly dominated the other and choice sets with identical alternatives.

[7] If Area A>Area B and Area B>Area C, then Area A>Area C

included questions about WTP for vaccines against TBE and LB. The order in which the respondents were presented these questions was also randomised. We utilise these variations and randomisations in our robustness checks, presented in Section 5.6.

4.2. Empirical strategy

We base our analysis of the choice experiment on a random utility theoretical framework (McFadden, 1974), where respondents choose between the alternatives presented to them in a way that maximises their expected utility (U). The utility that individual i derives from choosing alternative j (*j* = Area A, Area B or stay home) within choice question q can be specified as

$$U_{ijq} = \alpha_j + x_{ijq}'\beta + \varepsilon_{ijq}, \quad [1]$$

where α_j is an alternative specific constant capturing the intrinsic preferences of individual i for staying at home instead of going to recreational areas. We normalise α_j by setting the non-stay home alternatives to zero so that α becomes the utility from staying home, all else constant. x_{ijq} is a vector of the attributes describing alternative j, β is the vector of parameters for the attributes, and ε_{ijq} is a stochastic term representing unobservable factors or measurement errors. Alternative $'a'$ is chosen over alternative $'b'$ if $U_{iaq} > U_{ibq}$.

To account for heterogeneity in preferences among the respondents in relation to the different attributes and levels, we expand the basic model [1] with $(z_i\alpha)$ which is an interaction term between socio-economic variables (z_i) and a vector of parameters (α) that capture the utility of the "stay home" alternative. The interaction term captures the heterogeneity in preferences for staying home versus visiting a recreational area as a function of individual characteristics. We also include $(z_i x_{ijq})$ which is an interaction term between socio-economic variables and the attributes. δ captures the heterogeneity in preferences for the attributes that is due to individual characteristics. The expanded model can be specified as:

$$U_{ijq} = x_{ijq}'\beta + z_i\alpha + (z_i x_{ijq})'\delta + \varepsilon_{ijq}. \quad [2]$$

As a first step in our model estimation, we use a standard conditional logit model relying on the restrictive assumption of homogenous taste parameters among the respondents, i.e. the independence of irrelevant alternatives (IIA) property. For simplification we supress subscript 'q' and let β reflect both alternative specific and individual specific variables in the notation below.

$$P(choice_{ij}) = \frac{\exp(\alpha + x_{ij}'\beta)}{\sum_{j=1}^{J} \exp(\alpha + x_{ij}'\beta)} \quad [3]$$

In the next step, we relax the IIA assumption and use a use a latent class model to allow for unobserved heterogeneity in preferences among groups of respondents[8] (Boxall and Adamowicz, 2002; Greene and Hensher, 2013). In the latent class model, the parameters for the attributes, β, are represented

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[8] For comparison, we also estimated a random parameter logit model (RPL) that allows for unobserved heterogeneity in tastes across individuals (see Appendices A4 and A7).

by a discrete distribution among individuals. It is further assumed that there are a finite number of segments or classes within the population that are different from one another. The probability of belonging to a specific class can be expressed as

$$P(class = c) = \frac{\exp(z_i{'}\theta_c)}{\sum_{c=1}^{C} \exp(z_i{'}\theta_c)} \quad , \qquad [4]$$

where θ_c is the parameter vector describing class membership, which for one class is normalised to zero. Given membership in class c, the probability of choosing alternative *j* can be specified as

$$P\left(choice_{ij} | class = c\right) = \frac{\exp(\alpha + x_{ij}{'}\beta_c)}{\sum_{j=1}^{J} \exp(\alpha + x_{ij}{'}\beta_c)}. \qquad [5]$$

The latent class model requires the investigator to decide how many classes to use. The Bayesian information criterion (BIC) and the Akaike information criterion (AIC) are commonly used for this purpose, but the objectives of the study and ease of interpretation should also play a role in the choice of the number of classes (Boxall and Adamowicz, 2002; Swait, 1994)[9]. In this study, we choose a model with two classes because adding more classes does not produce improved results[10].

We estimate the marginal willingness to pay (MWTP) among the respondents for avoiding risk in connection with recreational trips following the expression in Hanemann (1984):

$$MWTP_i = \sum_{c=1}^{C} \pi_c \left(\frac{1}{\gamma_c}\left[ln\left(\sum_{j\in J} exp\left(\alpha + X_{ij}^{1}{'}\beta_c\right)\right) - ln\left(\sum_{j\in J} exp\left(\alpha + X_{ij}^{0}{'}\beta_c\right)\right)\right]\right), \quad [6]$$

where $MWTP_i$ is the marginal willingness to pay of individual i , π_c is the probability of membership in class c, γ_c is the marginal utility of income in class c. X_i^0 refers to the quality characteristics and travel cost in the base case and X_i^1 in the changed case. We calculate MWTP below as the change in a single attribute conditional on choosing an alternative, thus expression [6] collapses to the latent class probability weighted ratio of the attribute to the marginal utility of money. We use the delta method to estimate the standard error of the MWTP estimates.[11]

To analyse associations between MWTP and baseline risk, we divide the respondents into three different subsamples – emerging risk area, tick risk area and TBE risk area – according to the prevalence of ticks and the incidence of TBE in the area of residence. We define the *emerging risk area* as the geographical area of Norrland. In this area, which is situated north of the biogeographical boundary Limes Norrlandicus, there have historically been few or no ticks, but ticks have gradually spread also to this region, partly due to an increasingly warmer climate (Jaenson et al., 2012). We define *TBE risk areas* as areas with two or more reported cases of TBE in a three-digit postal code area 1986–2012.

[9] Swait 1994: '…the introduction of an additional latent segment should add to our understanding of the underlying behavioural process without bringing undesirable noise into the model.'

[10] See Appendix A2 for statistics on AIC and BIC for models with various numbers of classes. Both AIC and BIC indicate that using four classes is optimal. However, the standard errors in some of the marginal WTP estimates become very large with four classes. The MWTP results from a model with two classes are in parity with results generated when using a random parameter logit model or a conditional logit model (see Appendix A7).

[11] All models were estimated using Nlogit 5.0.

Two or more reported TBE cases in a limited geographical area is the classification of risk areas used by Swedish regional health authorities when producing TBE risk maps (Swedish Public Health Agency, 2014). Our identification of TBE risk areas is based on geographical data for the 2 687 TBE cases in Sweden 1986–2012 reported by the Swedish Public Health Agency, which we cluster in areas based on three-digit postal codes. We define *tick risk areas* as areas south of Norrland that are not classified as TBE risk areas. This classification of baseline risk corresponds to the pattern of tick bites and experience with tick-borne diseases found in our data (see Table 2 and Figure 2).

Since the sample size for the emerging risk area is relatively small to be divided up into separate classes with a latent class model, we use conditional logit models for comparing MWTP estimates between the different risk areas. To ensure that any differences in MWTP estimates between the three risk areas are not due to differences in observable individual characteristics, we run separate conditional logit models based on those observable characteristics where there are significant differences (Appendix A6).

4.3. Data

We utilised an internet panel consisting of approximately 8 000 members representative of the Swedish population and recruited in connection with telephone interviews with randomly sampled respondents (i.e. not a voluntary opt-in panel). In October 2013, the survey was distributed online to 6 000 of the panel members aged 18–85 years. The survey was carried out under informed consent and was approved by the Regional Ethical Review Board at the University of Gothenburg (decision number 544-13).

After two reminders, responses from 2 066 participants were received, corresponding to a response rate of 34%. In this paper, the 1 579 respondents (26% of the contacted panel members) who had answered all questions corresponding to the variables included in the analysis are included.

The questionnaire was developed based on focus group discussions, two pilot tests and key informant interviews with doctors and epidemiologists specialising in tick-borne diseases. In addition to the choice experiment, it included questions about exposure, risk perception, knowledge and protective behaviour related to ticks and tick-borne diseases, questions about socio-economic characteristics as well as stated preference questions about WTP for TBE and LB vaccination.

5. Results

5.1. Descriptive statistics

Figure 2a displays the area of residence of the survey respondents in the emerging risk area (n=200, 13 per cent of the respondents), tick risk area (n=915, 59%) and TBE risk area (n=464; 28%).

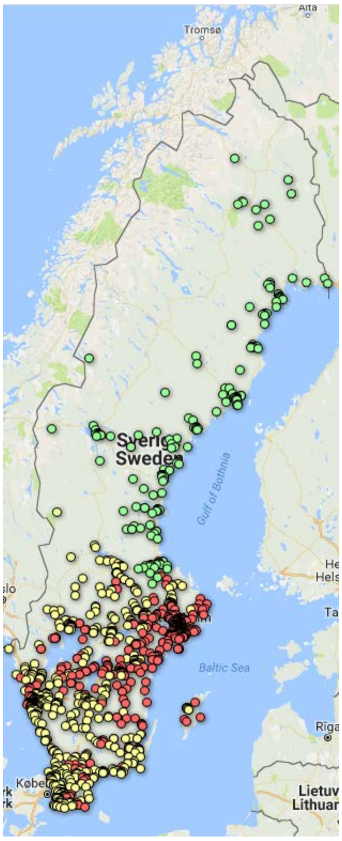

Figure 2a. Area of residence of survey respondents in the emerging risk area (n=200; green dots), tick risk areas (n=915; yellow dots) and TBE risk areas (n=464; red dots)

Figure 2b. Place of tick bite in last 12 months reported by respondents (n=615). Respondents could report several places.

Figure 2. Area of residence of respondents according to risk area and reported places of tick bites

The geographical distribution of the 1 579 respondents is largely representative of the Swedish population (Appendix A9), but we find some small but statistically significant differences in socio-economic characteristics between the population and the sample.[12] In 2013, the population mean age was 49; in the sample, it was 51 years. The mean monthly household income in the population was 40 600 SEK; in the sample, it was 43 900 SEK. The share of women in the population was 50%; in the sample, it was 53% (Statistics Sweden, 2013). The relatively low response rate raises concerns about non-response bias, which may potentially be more important than differences in gender, age and income between the sample and the population. For example, it is possible that members of a web panel spend less time outdoors than the population in general and hence are less exposed to ticks and disease risk. It is also possible that survey respondents have more experience with ticks and tick-borne

[12] Using a t-test for continuous variables and a binominal probability test for binary variables, we cannot reject the hypothesis of equal mean values between the sample and the population for age, income and gender. The significance is calculated at the 5% level.

diseases and are more concerned than the population in general. Because our survey is the first national survey of its kind in Sweden, there are only limited comparative statistics. We find similar estimates of TBE vaccination rates in the TBE-endemic Stockholm region as in a study by Askling et al. (2015), which reduces our concern about the response rate. Nevertheless, due to this potential bias, some precaution is warranted in the interpretation of our WTP estimates.

Table 2a presents descriptive statistics for the whole sample (column 1) and for the three different risk areas (columns 2-4). Comparing the socio-economic characteristics of the respondents in the three different risk areas (columns 5-7), we find that respondents in tick risk areas and TBE risk areas have a significantly higher mean income than respondents in the emerging risk area. We find no significant differences in relation to gender, age or family structure.

There is considerable variation in the incidence of TBE across the areas of residence of the respondents, from zero or just one yearly case per 100 000 inhabitants to as many as 41. The mean incidence in TBE risk areas is 3.5 yearly cases per 100 000 inhabitants, which is significantly higher than in the emerging risk areas and in tick risk areas. Twenty-four per cent of the respondents reported having been vaccinated against TBE[13], with significant differences in vaccination rates between the three risk areas.

Exposure to ticks is common among the respondents, with 67% reporting having had one or more tick bites ever and 30% reporting having had a tick bite in the last 12 months. Experience with tick-borne diseases is also rather common, with 12% reporting that they have been diagnosed with a tick-borne disease and 40% that they have a family member or a close friend who has had a tick-borne disease. Because LB is not a notifiable disease in Sweden, there are no comparative disease statistics. A study of a highly LB endemic area in Sweden found that 25% of the residents in this area had been treated for LB (Stjernberg and Berglund, 2005).

Experience with tick bites and tick-borne diseases is significantly less frequent in the emerging risk area than in the tick risk area and the TBE risk area. For example, only 4 per cent of the respondents in the emerging risk area reported a tick bite in the last 12 months, compared with over 30% in the tick risk area and the TBE risk area. This difference is also illustrated in Figure 2b, which shows the geographical locations of reported tick bites.

Table 2b reports descriptive statistics for TBE-vaccinated and -unvaccinated respondents in the whole sample (columns 2 and 3) and for respondents in TBE risk areas (columns 3 and 4). See Slunge (2015) for factors associated with TBE vaccination.

[13] Defined as having taken at least one shot of TBE vaccine ever.

Table 2a. Descriptive statistics – All respondents and split samples according to risk area (mean values)

VARIABLES	(1) **All respondents**	(2) **Emerging risk area**	(3) **Tick risk area**	(4) **TBE risk area**	(5) **P-values[e] H_0:2=3**	(6) **P-values[e] H_0:2=4**	(7) **P-values[e] H_0:3=4**
Female respondent	0.53	0.55	0.54	0.52	0.80	0.41	0.38
Age[a]	51.3	51.4	51.0	51.9	0.76	0.74	0.37
Household pre-tax income/month (1 000 SEK)[b]	43.9	40.5	44.1	45.2	0.04	0.01	0.41
Has child under 18 years	0.26	0.27	0.25	0.27	0.50	0.92	0.28
Incidence of TBE in area of residence (yearly cases/100 000 inhabitants)[c]	1.06	0.01	0.05	3.50	<0.01	<0.01	<0.01
Vaccinated against TBE	0.24	0.07	0.23	0.35	<0.01	<0.01	<0.01
Has had 1 or more tick bites in lifetime	0.67	0.24	0.72	0.77	<0.01	<0.01	0.08
Has had at least 1 tick bite in last 12 months	0.30	0.04	0.33	0.36	<0.01	<0.01	0.31
Respondent has had a tick-borne disease	0.12	0.02	0.13	0.14	<0.01	<0.01	0.60
Someone in family or close friend has had a tick-borne disease	0.40	0.18	0.43	0.43	<0.01	<0.01	0.86
Observations[d]	1579	200	915	464			

Notes:
[a] Age: The standard deviation among all respondents is 16.9 years; min=18 years; max=80 years
[b] Income: The standard deviation among all respondents is 22 800 SEK; min=5 000 SEK; max=115 000 SEK. Respondents indicated their income in intervals of 10 000 SEK. The average income is generated from the mean in each interval.
[c] Incidence of TBE: The standard deviation among all respondents is 3.97; min=0; max=41.3 cases per 100 000 inhabitants in a three-digit postal code area.
[d] The number of observations was 1 568 for lifetime tick bites and tick bites in last 12 months and 1 576 for family/close friend has had a tick-borne disease.
[e] From Chi2 test and an unpaired t-test for age, income and Incidence of TBE

Table 2b. Descriptive statistics – split samples according to TBE vaccination and TBE risk area (mean values)

VARIABLES	(1) **All respondents**	(2) **Not vaccinated**	(3) **Vaccinated**	(4) **Not vaccinated TBE risk area**	(5) **Vaccinated TBE risk area**	(6) **P-values[e] H_0:2=3**	(7) **P-values[e] H_0:4=5**
Female respondent	0.53	0.54	0.51	0.54	0.48	0.27	0.21
Age[a]	51.3	50.4	54.2	49.6	56.2	<0.01	<0.01
Household pre-tax income/month (1 000 SEK)[b]	43.9	42.0	50.0	41.8	51.4	<0.01	<0.01
Has child under 18 years	0.26	0.27	0.24	0.30	0.22	0.27	0.07
Incidence of TBE in area of residence (yearly cases/100 000 inhabitants)[c]	1.06	0.62	2.43	2.33	5.66	<0.01	<0.01
Has had 1 or more tick bites in life time	0.67	0.62	0.85	0.70	0.88	<0.01	<0.01
Has had at least 1 tick bite in last 12 months	0.30	0.25	0.47	0.31	0.45	<0.01	<0.01
Respondent has had a tick-borne disease	0.12	0.09	0.20	0.11	0.19	<0.01	0.03
Someone in family or close friend has had a tick borne disease	0.40	0.35	0.54	0.37	0.54	<0.01	<0.01
Observations[d]	1579	1198	381	302	162		

Notes:

[a] Age: The standard deviation among all respondents is 16.9 years; min=18 years; max=80 years

[b] Income: The standard deviation among all respondents is 22 800 SEK; min 5 000 SEK; max 115 000 SEK. Respondents indicated their income in intervals of 10 000 SEK. The average income is generated from the mean in each interval.

[c] Incidence: The standard deviation among all respondents is 3.97; min=0; max=41.3 cases per 100 000 inhabitants in a three-digit postal code area.

[d] The number of observations was 1 568 for lifetime tick bites and tick bites in last 12 months and 1 576 for family/close friend has had a tick-borne disease.

[e] From Chi2 test and an unpaired t-test for age, income and Incidence of TBE

5.2. Choice of recreational area at different levels of risk

As a first step in the analysis of how the risk of getting tick bites, LB or TBE influences the choice of area for recreational visits, we use a conditional logit model. Table 3 presents the results.

Table 3. Results from conditional logit model (CLM)

	CLM		**CLM and interactions with ASC**[a]		**CLM and interactions with choice attributes**[b]	
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Coefficient	S.E.[c]	Coefficient	S.E.	Coefficient	S.E.
Cost	-0.005***	0.000	-0.005***	0.000	-0.009***	0.001
Nice area	0.588***	0.053	0.589***	0.053	0.541**	0.258
Very nice area	0.699***	0.058	0.698***	0.059	0.951***	0.279
Some ticks	-0.264***	0.070	-0.276***	0.070	-0.472	0.327
Many ticks	-0.843***	0.087	-0.865***	0.088	-1.648***	0.421
Some LB risk	-0.458***	0.062	-0.464***	0.062	-0.691**	0.320
High LB risk	-0.888***	0.063	-0.894***	0.063	-1.263***	0.333
Some TBE risk	-0.426***	0.054	-0.427***	0.054	-0.071	0.284
High TBE risk	-1.252***	0.061	-1.266***	0.062	-1.091***	0.320
ASC – Stay home	-1.643***	0.078	-0.957***	0.163	-1.661***	0.079
Interactions with ASC						
ASC*Female			0.134**	0.061		
ASC*Age			- 0.001	0.002		
ASC*Income			-0.011***	0.001		
ASC*Children			0.003	0.077		
ASC*TBE risk area			-0.295***	0.099		
ASC*Tick risk area			-0.338***	0.091		
Interactions with choice attributes						
Many ticks*Income					0.006*	0.004
Many ticks*TBE risk area					0.671**	0.280
Many ticks*Tick risk area					0.835***	0.260
High LB risk*TBE risk area					0.520**	0.225
Some TBE risk*Female					-0.277**	0.110
High TBE risk*Female					-0.230*	0.124
Number of observations	6316		6316		6316	
No. of respondents	1579		1579		1579	
Log likelihood	-5816		-5771		-5703	
Pseudo R2	0.154		0.160		0.167	

*** p<0.01, ** p<0.05, * p<0.1

[a] ASC is the alternative specific constant – the 'Stay home' option.

[b] Only interactions with variables that are significantly associated with the risk attributes (ticks, LB and TBE) at the 10%, 5% or 1% level are reported. See Appendix A3 for a table showing all interaction effects.

[c] S.E.=standard error.

Columns 1 and 2 present the results from a regression where only the different attribute levels are included as explanatory variables. All coefficients of the attribute levels in column 1 are significant at the 1 per cent level, suggesting that they strongly influence respondents' choices. As expected, we find that the coefficients for area characteristics are positive while those for travel cost, the presence of ticks, LB risk and TBE risk are negative. We also find that coefficients have larger values for higher attribute levels, indicating that the magnitude of the risk or benefit also influences the respondents' choices. Comparing the different types of risk, we find that respondents on average rate high TBE risk as the most negative attribute, followed by high LB risk and presence of many ticks in a recreational area. The negative sign of the alternative specific constant (ASC), i.e. the stay at home (or opt out) alternative, suggests that most respondents chose to visit one of the recreational areas presented to them in the choice sets instead of staying at home.

Interacting socio-economic variables with the ASC, in columns 3 and 4 in Table 3, we find that females are significantly more likely to choose the stay at home alternative and that respondents with higher income are less likely to do so. We also find that respondents living in a tick risk area or TBE risk area are less likely than those living in the emerging risk area to choose the stay at home option.

The results of the conditional logit model where we interact the choice attributes with socio-economic variables are reported in columns 5 and 6. In line with the results from the interactions with the alternative specific constant, we find a significant positive association between living in a tick risk or TBE risk area and visiting areas with 'many ticks' and between living in a TBE risk area and choosing to visit areas with 'high LB risk'. In addition, income is positively associated with visiting areas with many ticks. There is a negative association between being female and choosing to visit areas with TBE risk.

In order to allow for heterogeneity in preferences among groups of respondents, we use a latent class model as described in Section 4.2. The model assigned 60% of the respondents to class 1 and 40% of the respondents to class 2. Results are reported in Table 4, where columns 1–4 include results from a model with the choice attributes only and columns 5–8 include results when choice attributes are interacted with socio-economic variables. Including socio-economic variables in the model only marginally changes coefficients and does not change the level of significance.[14] This reinforces the finding from the conditional logit model that the attribute levels influence the choices made by the respondents.

[14] Except for the attribute 'some LB risk', which changes from no significant association with the choices of respondents in class 2 to an association significant at the 10 % level.

Table 4. Results from latent class model

	Model 1 – choice attributes only				Model 2 – interactions with socio-economic variables			
	Class 1		Class 2		Class 1		Class 2	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Utility function	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Cost	-0.006***	0.000	-0.006***	0.001	-0.006***	0.000	-0.006***	0.001
Nice area	0.741***	0.073	0.510***	0.129	0.743***	0.073	0.507***	0.129
Very nice area	0.892***	0.083	0.694***	0.138	0.899***	0.083	0.662***	0.138
Some ticks	0.325***	0.101	-1.064***	0.142	0.334***	0.101	-1.079***	0.144
Many ticks	0.040	0.127	-3.112***	0.222	0.042	0.127	-3.137***	0.225
Some LB risk	-0.517***	0.096	-0.200	0.134	-0.502***	0.096	-0.230*	0.134
High LB risk	-0.858***	0.086	-1.641***	0.233	-0.851***	0.086	-1.699***	0.239
Some TBE risk	-0.255***	0.079	-1.138***	0.139	-0.265***	0.079	-1.126***	0.141
High TBE risk	-1.115***	0.081	-2.246***	0.172	-1.133***	0.081	-2.203***	0.171
ASC – Stay home	-2.746***	0.139	-1.670***	0.153	-2.709***	0.138	-1.707***	0.156
Class membership function								
Constant					-0.498	0.307		
Female					-0.293**	0.122		
Age					0.001	0.004		
Income					0.0132***	0.003		
Children					-0.038	0.152		
Lives in tick risk area					0.580***	0.181		
Lives in TBE risk area					0.499**	0.198		
Latent class probability	0.599		0.401		0.601		0.399	
No. of observations	6316				6316			
No. of respondents	1579				1579			
Log likelihood	-5138				-5116			
Pseudo R2	0.260				0.263			

*** p<0.01, ** p<0.05, * p<0.1

While both classes show similar preferences in relation to travel costs, the respondents in class 2 are more averse to the presence of ticks, LB risk and TBE risk. Whereas the presence of 'some ticks' and 'many ticks' has a significant negative influence on the choices of respondents in class 2, the presence of 'some ticks' has an unexpected significant positive influence on the choices of respondents in class 1 and the presence of 'many ticks' is not significantly associated with the choices in this class. The presence of LB or TBE risk has a significant negative influence on the choices of both classes (i.e. significantly reduces the probability that respondents would visit the area). The effect is stronger in class 2, except for 'some LB risk', where it is weaker. Respondents in class 1 are also less likely to choose the stay at home alternative.

Interacting the choice attributes with socio-economic variables (Table 4, columns 5–8), we find that higher income and living in a tick risk or TBE risk area is significantly and positively associated with belonging to class 1. Females are significantly more likely to belong to class 2. The associations found relating to income and gender are in line with findings from earlier studies on risk perception: that women are generally more risk averse and that risks are perceived as lower among groups with high income (Sjöberg, 2000; Slovic, 1987).

The distinct preference classes that emerge in the latent class analysis suggest that there is considerable unobserved heterogeneity in preferences for risk reduction.[15]

5.3. Marginal WTP to avoid risk associated with recreational visits

Based on the results from the latent class model (Table 4), we calculate the respondents´ marginal willingness to pay (MWTP) to avoid ticks or disease risk in connection with one recreational trip. Results for the two classes and for the whole sample are reported in Table 5.

Table 5. Marginal willingness to pay to avoid ticks or disease risk associated with one recreational trip (SEK)[a b]

	Class 1		**Class 2**		**Average**	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Some ticks	-57.1***	18.1	180***	27.9	38.1**	15.3
Many ticks	-7.09	22.4	528***	53.7	207***	25.6
Some LB risk	91.0***	17.7	33.9	22.7	68.1***	13.1
High LB risk	151***	16.6	278***	44.9	202***	19.2
Some TBE risk	44.9***	13.9	193***	26.3	104***	12.4
High TBE risk	196***	15.1	381***	39.4	270***	17.0
Class probability	0.599		0.401			

*** p<0.01, ** p<0.05, * p<0.1

[a]MWTP is calculated by dividing the coefficient of the risk attribute by the coefficient of the cost attribute in columns 1 and 3 in Table 4. The average MWTP for the two classes is calculated as the sum of MWTP for each class multiplied by the class probabilities.

[b]MWTP in SEK for round trip to recreational area

The average MWTP among all respondents in the sample is largest for 'high TBE risk', at 270 SEK (approximately 31 EUR[16]), followed by 'many ticks' (207 SEK) and 'high LB risk' (202 SEK). If, instead of travel cost, we use distance to the recreational site as the cost attribute, we find that respondents would be willing to travel around 45 kilometres (one-way distance to a recreational site) to avoid areas with 'many ticks' or 'high LB risk' and 58 kilometres to avoid areas with 'high TBE risk'.[17]

There are large differences between MWTP estimates of respondents in class 1 and class 2, especially in the valuation of the presence of ticks in recreational areas. Respondents in class 2 are willing to pay

[15] Results from using a random parameter logit model (RPL) that allows for unobserved heterogeneity in tastes across individuals were similar to those of the conditional logit model and the latent class model, except for a significant negative association between age and visiting areas with 'high TBE risk'. The significant variance parameters further indicate that there is considerable unobserved heterogeneity in preferences for risk reduction (see Appendix A4 and A7).

[16] The exchange rate was 1 EUR = 8.7 SEK in October 2013 when the survey was conducted.

[17] See Appendix A5 for an estimate of how many kilometres respondents state they would travel to avoid ticks or risk in association with recreational trips. The calculation is based on the same latent class model as in Table 4 but with distance instead of travel cost as the cost attribute.

180 SEK and 528 SEK for avoiding areas with some ticks and many ticks respectively, but respondents in class 1 are not willing to pay for travelling to a tick-free area for recreational activities. There are also differences in the ranking of risk preferences between the two classes of respondents. While respondents in class 1 rate 'high TBE risk' as most negative, followed by 'high LB risk' and 'some LB risk', respondents in class 2 rank 'many ticks' as most negative, followed by 'high TBE risk and 'high LB risk'. MWTP for avoiding an area with high risk of TBE or high risk of LB among respondents in class 2 is almost two times higher than the corresponding MWTP of respondents in class 1.

5.4. Baseline risk, vaccination and WTP for risk reduction

Table 6 reports mean marginal WTP for risk reduction for respondents living in the emerging risk area, tick risk areas and TBE risk areas. We find that mean marginal WTP is considerably higher among respondents living in the emerging risk area than among respondents in the other two risk areas. These differences are statistically significant at the 5 or 10 per cent level for the 'many ticks' and the 'high LB risk' attributes[18]. Except for the LB risk attributes, we find no significant differences in estimates between respondents in tick risk areas and those in TBE risk areas.

By comparing MWTP of different income groups, we find that the differences in MWTP between respondents in the emerging risk area and TBE risk areas are not due to the observed significant difference in mean income between the respondents in these risk areas (Appendix A6).

As discussed above, people can adapt to risks in various ways, including reducing the risk of TBE by getting vaccinated, and such adaptation measures may in turn affect their WTP for risk reduction in relation to recreational trips. Table 7 reports MWTP for vaccinated and unvaccinated respondents among all respondents and respondents in TBE risk areas, respectively.

Respondents vaccinated against TBE have a significantly lower marginal WTP to avoid areas with many ticks and/or high TBE risk compared with unvaccinated respondents. In fact, their MWTP to avoid areas with high TBE risk is 54% of the MWTP of unvaccinated respondents. Also in TBE risk areas, the MWTP to avoid areas with high TBE risk among vaccinated respondents is 54% of the MWTP of unvaccinated respondents. This indicates that TBE vaccination can have a significant impact on recreational choices and that the benefits from vaccination may exceed just a reduced cost of illness.

[18] The imprecise estimates, especially for the relatively small subsample in the emerging risk area, for some of the attributes, explain why the seemingly large differences in MWTP for some choice attributes are not significant at the 5 or 10 per cent level.

Table 6. Marginal willingness to pay to avoid ticks or disease risk associated with one recreational trip among respondents residing in areas with different baseline risks (SEK) [a] [b]

	(1)		(2)		(3)		(4)	(5)	(6)
	Emerging risk area		**Tick risk area**		**TBE risk area**		**P-values[c] H_0:(1)=(2)**	**P-values[c] H_0:(1)=(3)**	**P-values[c] H_0:(2)=(3)**
	Mean	S.E.	Mean	S.E.	Mean	S.E.			
Some ticks	141**	55.5	37.4**	18.8	56.3**	24.9	0.078	0.165	0.545
Many ticks	410***	87.9	144***	23.6	162***	31.6	0.004	0.008	0.657
Some LB risk	153***	51.9	107***	17.8	50.7**	22.8	0.403	0.073	0.052
High LB risk	321***	70.8	189***	19.4	134***	24.1	0.073	0.013	0.076
Some TBE risk	118***	44.5	95.8***	14.6	65.4***	19.1	0.636	0.278	0.205
High TBE risk	344***	65.4	259***	18.0	232***	23.6	0.212	0.109	0.363
No. of individuals	200		915		464				
Log likelihood	-691		-3360		-1733				
R2	0.212		0.155		0.142				

*** p<0.01, ** p<0.05, * p<0.1

[a] Average MWTP values from conditional logit models for three different sub-samples of the respondents

[b] MWTP in SEK for round trip to recreational area

[c] p-values of unpaired t-tests of equal marginal WTP between subsamples

Table 7 Marginal willingness to pay to avoid ticks and disease risk associated with one recreational trip among TBE-vaccinated and -unvaccinated respondents[a b]

	(1)		(2)		(3)		(4)		(5)	(6)
	All respondents				**Respondents in TBE risk areas**				**P-values[c]**	**P-values[c]**
	Not vaccinated		**Vaccinated**		**Not vaccinated**		**Vaccinated**		**H_0:(1)=(2)**	**H_0:(3)=(4)**
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.		
Some ticks	62.7***	16.6	24.1	28.4	95.0***	29.6	-31.0	45.6	0.241	0.021
Many ticks	195***	21.5	110***	34.9	226***	39.0	31.8	55.2	0.038	0.004
Some LB risk	99.6***	15.5	79.8***	26.9	40.8	26.3	66.3	43.0	0.524	0.613
High LB risk	196***	17.5	141***	27.6	126***	28.3	138***	43.4	0.093	0.893
Some TBE risk	104***	13.0	38.7*	22.1	84.8***	22.5	29.0	34.8	0.011	0.180
High TBE risk	294***	17.3	158***	23.9	278***	30.6	149***	37.3	0.000	0.008
No. of individuals	1198		381		302		162			
Log likelihood	-4359		-1400		-1096		-594			
R2	0.169		0.128		0.173		0.114			

*** p<0.01, ** p<0.05, * p<0.1

[a] Average MWTP values from conditional logit models for different sub-samples of the respondents

[b] MWTP in SEK for round trip to recreational area

[c] p-values of unpaired t-tests of equal marginal WTP between subsamples

5.5. Willingness to pay for risk reduction under different risk scenarios

The incidence of LB and TBE presented for the recreational sites in the choice experiment are relatively high compared with the levels of risk found in most geographical areas in Sweden. [19] In order to analyse how a possible increase in incidence to these levels would affect recreational choices and people's demand for risk reduction, we identify four scenarios with different combinations of risks:

- Scenario 1: Some ticks and some LB risk (no TBE risk);
- Scenario 2: Some ticks, some LB risk and some TBE risk;
- Scenario 3: Many ticks and high LB risk (no TBE risk);
- Scenario 4: Many ticks, high LB risk and high TBE risk.

In contrast to the marginal WTP estimates for one attribute at a time, presented in Sections 5.2 and 5.3, Table 8 reports WTP estimates for avoiding a combination of ticks and some level of LB and/or TBE risk for each of the four scenarios.

Table 8 Willingness to pay to avoid combinations of ticks and disease risk associated with one recreational trip (SEK)[a b]

	Mean	S.E.	95% Confidence interval	
Scenario 1: Some ticks and some LB risk	106***	16.5	74	138
Scenario 2: Some ticks, some LB risk and some TBE risk	409***	33.2	344	474
Scenario 3: Many ticks and high LB risk	210***	20.1	171	250
Scenario 4: Many ticks, high LB risk and high TBE risk	679***	43.2	595	764
	n=1 579			

*** p<0.01, ** p<0.05, * p<0.1

[a] Calculation based on latent class models with two classes

[b] WTP in SEK for round trip to recreational area

On average, respondents' WTP for avoiding risk in association with one recreational trip ranges from 106 (CI95:74–138) SEK (approximately 12 EUR) in scenario 1 with lowest risk to 679 (CI95:595–764) SEK (78 EUR) in scenario 4 with highest risk. The WTP to avoid areas with some ticks combined with some LB risk and some TBE risk (scenario 2) is 409 (CI95:344–474) SEK (47 EUR) per recreational trip. This is higher than the WTP to avoid areas with no TBE risk but many ticks and high LB risk (scenario 3), which is estimated at 210 (CI95: 171–250) SEK (24 EUR) per recreational trip.

As shown by Berry et al. (2017), the risk of tick-borne disease can affect recreational demand so that people living in risk areas spend less time outdoors. As an illustration of how recreational demand may change in relation to our four scenarios, we use a hypothetical model where a person can choose between going to one of three identical 'very nice recreational areas' for a four hour visit (as defined in the choice experiment) at a distance of 10 km from the area of residence. The person can also choose

[19] Some LB risk and high LB risk correspond to an incidence of 250 and 500 cases per 100 000 inhabitants, respectively. Some TBE risk and high TBE risk correspond to an incidence of 20 cases and 40 cases per 100 000 inhabitants, respectively.

to stay home (opt out). The assumed distance to the sites is based on a study of recreational nature travel in Sweden, which found that 12 km was the average distance travelled (Ezebilo, 2016). We use parameter values estimated with conditional logit models for the different subsamples as an input to our illustration.

Figure 3a and 3b display the share of respondents who would choose to stay home instead of visiting recreational areas when we vary the risk of getting tick bites and the incidence of LB and TBE in the recreational areas. The risk levels are defined in the four risk scenarios. Estimated opt-out rates for the emerging risk area, tick risk areas and TBE risk areas are reported in Figure 3a. Estimated opt-out rates among TBE vaccinated and unvaccinated respondents as well as among TBE vaccinated and unvaccinated respondents in TBE risk areas are reported in Figure 3b.

When there are no ticks and no disease risk at the recreational sites, around 3% of the respondents would prefer to stay home instead of going to a 'very nice recreational site' at a distance of 10 km. With increasing risk of LB and TBE, the share choosing to stay home increases for the whole sample of respondents as well as for the different sub-samples. However, there is a large difference between respondents in the emerging risk area on the one hand and respondents in tick risk areas and TBE risk areas on the other. In Scenario 4, with a combination of high risk of LB and TBE, 33% of those living in a TBE risk area would opt out, compared with 37% of those living in tick risk areas and 57% of those living in the emerging risk area. This difference indicates that respondents in TBE risk areas and tick risk areas have adjusted to living with risk to a larger degree than respondents in the emerging risk area. The high share that would choose to stay home in the highest risk scenario – also among respondents in TBE risk areas – may be due to the relatively high risk levels presented in the scenario compared with the current level of risks.

Among all TBE-vaccinated respondents, 19% would choose to stay home in the highest risk scenario, compared to 45% among unvaccinated respondents. Fourteen per cent of the TBE–vaccinated respondents in TBE risk areas would choose to stay home in the highest risk scenario, compared to 47% of the unvaccinated respondents in TBE risk areas. The simulation indicates that vaccination can have a substantial effect on recreational demand and that the effect is larger in high-risk environments.

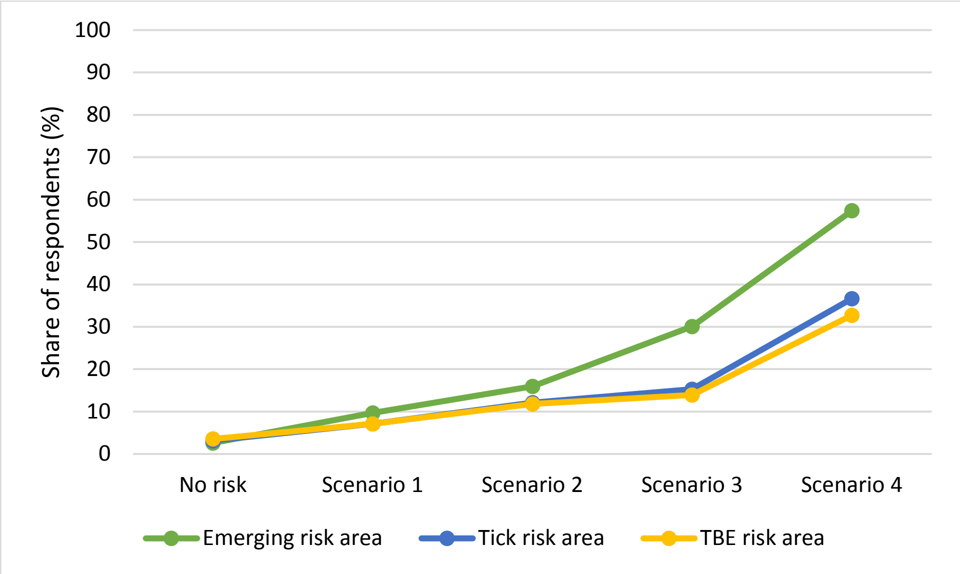

Figure 3a. Estimated opt-out rates in emerging risk area, tick risk area and TBE risk area

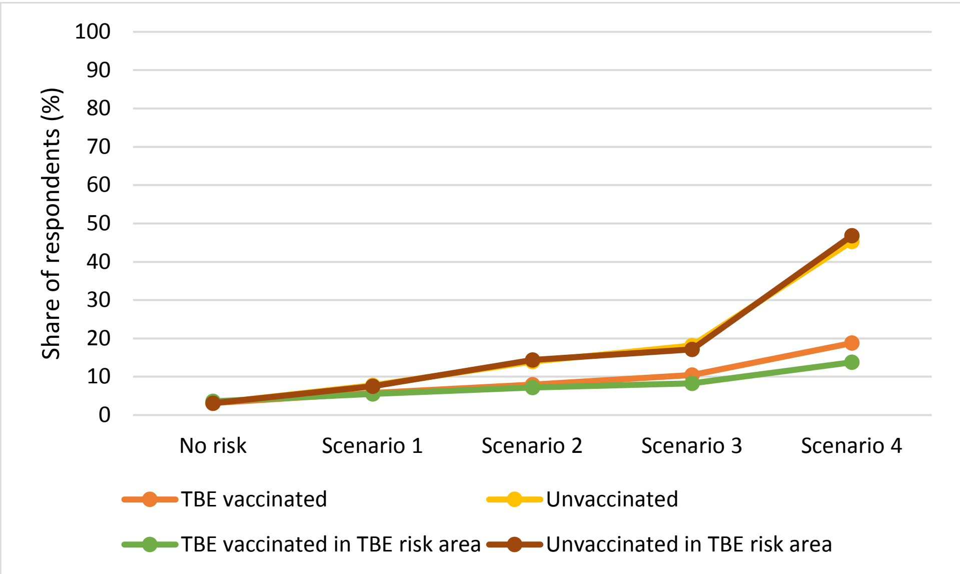

Figure 3b. Estimated opt-out rates among TBE vaccinated and unvaccinated[d] *as well as among TBE vaccinated and unvaccinated in TBE risk areas*

[a] Average opt-out rates in a situation with no risk of TBE or LB and for four different risk scenarios. Scenario 1: Some ticks and some LB risk; Scenario 2: Some ticks, some LB risk and some TBE risk; Scenario 3: Many ticks and high LB risk; Scenario 4: Many ticks, high LB risk and high TBE risk.

[b] The results are based on a simulation using parameter values estimated with a conditional logit model from the data generated in the choice experiment. We assume that a person can choose between going to one of three identical 'very nice recreational areas' (as defined in the choice experiment) situated 10 km from the respondent's home or staying at home (opt out).

[c] Emerging risk area (n=200); tick risk areas (n=915); TBE risk areas (n=464);
TBE-vaccinated respondents (n=381); Unvaccinated respondents (n=1198); TBE vaccinated respondents in TBE risk areas (n=162); Unvaccinated respondents in TBE risk areas (n=302)

[d] The opt out rates for unvaccinated respondents in TBE risk areas are almost identical to those of all unvaccinated, which makes it difficult to see the opt out shares for the 'unvaccinated' in Figure 3b.

Figure 3. Share of respondents choosing not to visit a recreational area at different levels of risk[a], simulation[b] for different sub-samples[c]

5.6. Robustness

We find no statistically significant differences in our estimated results due to the order in which respondents answered the different choice sets and stated preference questions or to whether they performed the transitivity test before or after responding to the statistically generated choice sets.[20] Only a few respondents did not pass the basic rationality test or the transitivity test, or had lexicographic preferences (i.e. chose the same alternative in all choice sets).[21] Twenty-one per cent of the respondents gave the wrong answer to the control question about risk levels presented to them before answering the choice sets. These respondents were given additional information in order to improve their understanding. We find no significant differences when we compare MWTP estimates for the whole sample with MWTP estimates when the respondents not passing these tests or the control question are excluded.[22]

Results could also be sensitive to the choice of econometric model used. Comparing average MWTP estimates from a latent class model with 2 classes, a conditional logit model and a random parameter logit model, we find no significant differences. A latent class model with 3 classes yields higher average MWTP estimates than the other models.[23]

We also test whether our results are sensitive to how we have defined the different risk areas. First, we assess whether there are unobserved risk factors associated with the geographic location by interacting the alternative specific constant with dummy variables for each of the 21 counties in Sweden. Unobserved risk factors associated with geographic location should be identified with this test. Second, we reproduce our results using an alternative classification of TBE risk area that is based on the average TBE incidence in each county. Both these tests reinforce the result that the WTP for risk reduction in relation to recreational visits decreases with baseline risk (Appendix A8).

6. Discussion

Understanding how changes in baseline risk influence preferences for risk reduction is important when valuing the welfare effects of environmental change, including the spread of disease. We conduct a survey-based choice experiment in Sweden to estimate willingness to pay to reduce the risk of tick

[20] We conduct unpaired t-tests of MWTP estimates where we compare estimates for groups of respondents answering the choice sets or stated preference questions, as well as the transitivity test in different orders. Statistical significance is determined at the 5 per cent level.

[21] Fifty respondents (3%) failed the basic rationality test in which one alternative strictly dominated the other on all choice attributes. Twenty-five respondents (1.6%) did not pass the transitivity test. Seventeen (1.1%) chose alternative 1 in all choice sets or alternative 2 in all choice sets (i.e. lexicographic preferences). Forty-three respondents (2.7%) chose the stay home alternative (opted out) in all seven choice sets. However, this may not necessarily be due to poor understanding of the information presented but rather to risk aversion or other reasons for not going on recreational trips.

[22] These robustness test were conducted with unpaired t-tests comparing MWTP estimates for the different samples. Statistical significance is determined at the 5 per cent level.

[23] The average MWTP estimates for TBE risk generated with a latent class model with 3 classes is significantly higher than the corresponding estimate using a conditional logit model (Appendix A7).

bites, Lyme borreliosis (LB) and tick-borne encephalitis (TBE) in connection with recreational trips. We analyse the role of baseline risk for these estimates by combining our survey data with data on exogenous disease risk in different geographical regions. Unlike cost of illness studies, our focus on how the presence of ticks and related disease risks affect recreational behaviour allows us to include broader welfare costs in the analysis. We discuss six main conclusions from this study.

First, we find that the marginal WTP for risk reduction in relation to recreational visits decreases with baseline risk, defined as the prevalence of ticks and the incidence of TBE and LB in the area of residence. Respondents living in the emerging risk area have a significantly higher WTP for risk reduction in connection with recreational trips than respondents in tick risk areas and TBE risk areas. Respondents in the emerging risk area are also more likely to choose to stay at home if faced with a choice between staying home or visiting recreational areas with ticks and disease risk.

There are several possible explanations for why marginal WTP for risk reduction decreases with baseline risk. Respondents in the emerging risk area generally have less experience with ticks and tick-borne diseases. Given the common difficulties involved in assessing low-probability events, it is likely that respondents in the emerging risk area have greater difficulties assessing the low probability of getting a tick-borne disease than respondents with more experience with ticks. Reference point bias is also a plausible explanation for why the WTP for risk reduction decreases with baseline risk. Respondents living in areas with no or few ticks may interpret the presented hypothetical risk scenario as a relatively greater loss compared with respondents in tick risk or TBE risk areas, who have a lower reference point utility from outdoor recreation. There may also be a ‘learning to live with ticks’ effect, where residents in risk areas adapt their behaviour through vaccination or other measures to a higher baseline risk. While respondents with little experience with ticks are averse not only to disease risk but also to ticks per se, vaccinated respondents in TBE risk areas are only averse to visiting an area with ticks if it is associated with a high incidence of LB or TBE.

Second, TBE-vaccinated respondents have a significantly lower WTP for risk reduction in connection with recreational trips than unvaccinated respondents. The MWTP for avoiding areas with TBE risk is around 50% lower among vaccinated respondents than unvaccinated respondents. This indicates that vaccination against TBE may have positive side effects in terms of recreational benefits. Such benefits should be included in cost-benefit analyses of public vaccination programmes against TBE (Askling et al., 2015; Desjeux et al., 2005; Slunge, 2015; Šmit and Postma, 2015).

Third, our study indicates that the welfare costs associated with ticks, LB and TBE are non-trivial. Respondents were on average willing to pay 210 SEK (24 EUR) (CI95: 171–250 SEK) per recreational trip to avoid areas with ticks and an incidence of LB of 500 cases per 100 000 inhabitants. The WTP to avoid recreational areas where there is also a high incidence of TBE (40 cases per 100 000 inhabitants) was on average 679 SEK (78 EUR) (CI95: 595–764 SEK) per recreational trip.

Fourth, we find considerable unobserved heterogeneity in preferences for risk reduction, as illustrated by the distinct preference classes that emerge in the latent class analysis and the significant variance parameters in the random parameters models. The associations between observable socio-economic characteristics and class membership are in line with common findings regarding risk perception, e.g. that women generally perceive risks as greater and that risks are perceived as lower with higher income.

Fifth, in line with a recent paper by Gerking et al. (2016), our study raises questions about the appropriateness of the standard practice of analysing marginal WTP independently of baseline risk in cost-benefit analysis. Our study illustrates that there can be a risk of overestimating or underestimating the welfare costs associated with a spread of disease vectors to new areas. For example, Simon et al. (2014) predict that, partly due to climate change, ticks and the associated LB risk will expand approximately 250–500 km further north in North America by 2050. Welfare costs related to such projections may be underestimated if the differences in WTP for risk reduction between inhabitants in existing risk areas and emerging or new risk areas are not taken into account. Welfare costs may be overestimated if human adaptation to increased risk by means of vaccination, other types of protective behaviour and/or changes in preferences is not taken into account. Hence, differences in WTP for risk reduction between groups with different baseline risks should be taken into account when estimating welfare costs associated with a spread of disease vectors, such as ticks, to new areas due to climate change or other environmental change.

Finally, our study also points to the difficulties involved in valuing welfare effects of climate change and other environmental change over time. When new risks emerge people have difficulties assessing risks and the adaptation costs they may infer. However, their risk perceptions and preferences for risk reduction should not be dismissed as being 'incorrect', as the new risk may constitute a real and sizeable loss compared with their reference point utility. In areas where risks from environmental change have become endemic, people's risk perceptions are generally more informed and welfare estimates derived from stated preference studies will in some sense be more 'correct'. However, these values reflect an adaptation of behaviour and preferences to a lower reference point utility and may in some sense reflect an underestimation of the costs of environmental change.

Three key policy recommendations emanate from this study. The choice experiment indicates that recreational choice is sensitive to information about risk in different recreational areas. Risk maps where LB or TBE hotspots are indicated could hence have an effect on recreational choices and reduce exposure to risk. However, our study also illustrates that understanding information about risk can be cognitively challenging. Experimental research on how people react to various kinds of geographically oriented risk information could be a way to improve risk communication. Second, providing information in emerging risk areas about ticks, tick-borne diseases and protective measures can potentially lower damage costs by facilitating the process of adaptation to living in a new risk context. Third, subsidised vaccination programmes or other measures that increase TBE vaccination could have positive effects on recreational behaviour. Such programmes could be especially important in endemic TBE risk areas where the disease incidence among the unvaccinated population is high (Askling et al., 2015).

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Appendix

A1. Choice experiment scenario

Choice between recreational areas

Imagine that it is late summer and that you have decided to spend four hours during the weekend outdoors engaging in activities such as walking, picking berries or mushrooms, picnicking, or other things you enjoy doing. Imagine that you are to choose between spending the four hours outdoors in one of two areas (area A or B).

We will now describe areas A and B and then ask you to **select the area in which you would prefer to spend the four hours**:

The following things distinguish areas A and B from each other:

Area characteristics
Imagine that you have rated the area after a previous visit. This can include how beautiful the area is, its natural values or the presence of mushrooms and berries. You have divided the areas into the following categories:
- ordinary area,
- nice area,
- very nice area.

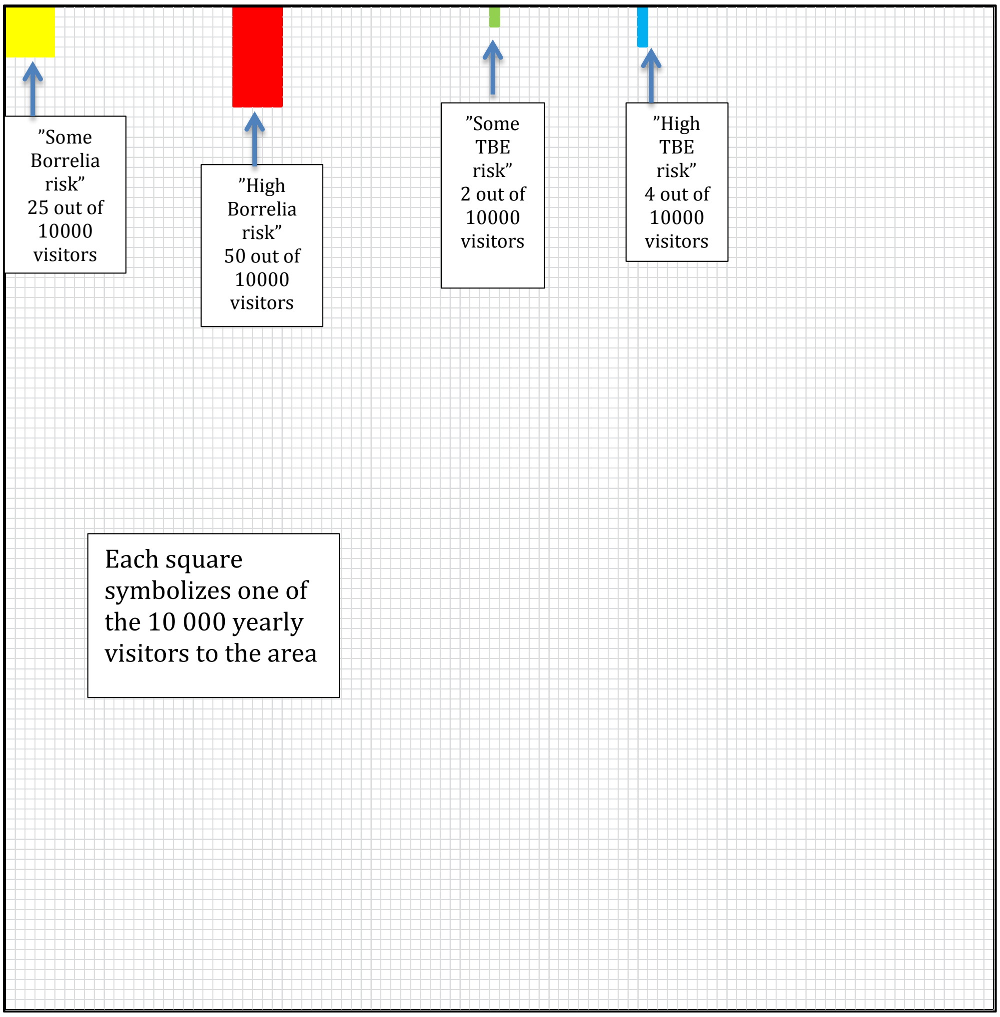
The presence of ticks:

- **no ticks**
- **some ticks –** it is likely that you will get 1–2 ticks on your clothes or your skin if you walk in tall grass or in the forest during your stay in the area
- **many ticks –** it is likely that you will get 4 or more ticks on your clothes or your skin if you walk in tall grass or in the forest during your stay in the area

The distance to the area

- 1 km
- 5 km
- 30 km
- 70 km

The risk of contracting Lyme borreliosis and TBE
Both Areas A and B are about 10 square kilometres and are visited by about 10 000 people per year. The figure below contains 10 000 squares. Each square symbolises 1 person who visits the area.



- **Some Borrelia risk** – means that 25 of the 10 000 visitors get Lyme borreliosis every year after visiting the area. This is symbolised by the 25 yellow-coloured squares in the figure.
- **High Borrelia risk** – means that 50 people get Lyme borreliosis every year after visiting the area. This is symbolised by 50 red-coloured squares in the figure.
- **Some TBE risk** – means that 2 people get TBE every year after visiting the area. This is symbolised by the 2 green-coloured squares in the figure.
- **High TBE risk**– means that 4 people get TBE every year after visiting the area. This is symbolised by the 4 blue-coloured squares in the figure.

This means that *only a very small share of the visitors become infected with Lyme borreliosis or TBE every year.*

To be sure that you understand the information, we ask you to answer the following question:
If we state that an area has some Borrelia risk and high TBE risk, is there then a greater risk of contracting Borrelia than TBE while visiting the area? [compulsory question]
Select just one of the following:

☐ Yes
☐ No

[If yes, the following text is shown:) Correct answer!

[If no, the following text is shown:]
- Some Borrelia risk – means that 25 of the 10 000 visitors contract Lyme borreliosis each year in conjunction with visits to the area.
- High TBE risk – means that 4 of the 10 000 visitors get infected with TBE each year in conjunction with visits to the area.
Thus, there is a greater risk of contracting Lyme borreliosis than TBE while visiting the area.

Read about what characterises areas A and B in the table below. Select whether you would choose to go to area A or B to spend the four hours outdoors. If, under the given circumstances, you would choose not to visit either of the areas, mark alternative C, 'Not go'.

Read the text in the box before making your choice:

Experiences from other similar surveys show that it is common that people make other choices in a survey than they would in real life. Some may state that they would travel 70 km to visit an area while in real life they would only be willing to travel 30 km. We want you to state the choice you would make if this was a real situation.

(*Example of a choice set:)*

	Area A	**Area B**	**Not go (C)**
Area characteristics	Nice area	Nice area	
Presence of ticks	No ticks	Some ticks	
Risk of Borrelia	No Borrelia risk	Some Borrelia risk	
Risk of TBE	No TBE risk	Some TBE risk	
Distance	5 km	1 km	
Mark if you would choose A, B or C:	[ ]	[ ]	[ ]

A2. Statistics for latent class model with different number of classes

Table A2. Statistics for latent class model with different number of classes*

No. of classes	LogL	PseudoR2	AIC[a]	BIC[b]	No. of Parameters (P)	Class Probabilities 1	2	3	4	5
2	-5138	0.26	10 318	5215	21	60%	40%			
3	-5069	0.27	10 203	5187	32	56%	34%	11%		
4	-4999	0.28	10 083	5157	43	54%	25%	6%	16%	
5	-4996	0.28	10 100	5195	54	28%	6%	35%	21%	11%

* Models estimated without interactions with socio-economic variables. N=1 579 for all estimations. BIC indicates 4 classes; AIC indicates 4 classes.

[a] AIC (Akaike information criterion) is calculated using $\{-2(LogL - P)\}$.

[b] BIC (Bayesian information criterion) is calculated using $\left\{-LogL + \frac{P}{2} * \ln(N)\right\}$.

A3. Results from conditional logit model (CLM) – interactions between choice attributes and socio-economic variables

	CLM with interactions	
Variable	Coefficient	S.E.
Cost	-0.009***	0.001
Nice area	0.541**	0.258
Very nice area	0.951***	0.279
Some ticks	-0.472	0.327
Many ticks	-1.648***	0.421
Some LB risk	-0.691**	0.320
High LB risk	-1.263***	0.333
Some TBE risk	-0.071	0.284
High TBE risk	-1.091***	0.320
Stay home (opt out)	-1.661***	0.079
Interactions		
Nice area*Female	-0.099	0.102
Nice area*Age	-0.002	0.003
Nice area*Income	0.005**	0.002
Nice area*Children	0.038	0.129
Nice area*TBE risk area	-0.044	0.172
Nice area*Tick risk area	0.036	0.160
Very nice area*Female	-0.068	0.110
Very nice area*Age	-0.007*	0.003
Very nice area*Income	0.009***	0.003
Very nice area*Children	-0.076	0.139
Very nice area*TBE risk area	-0.211	0.186
Very nice area*Tick risk area	-0.237	0.172
Some ticks*Female	0.020	0.127
Some ticks*Age	-0.004	0.004
Some ticks*Income	0.004	0.003
Some ticks*Children	-0.168	0.161
Some ticks*TBE risk area	0.180	0.214
Some ticks*Tick risk area	0.318	0.199
Many ticks*Female	-0.061	0.165
Many ticks*Age	-0.002	0.005
Many ticks*Income	0.006*	0.004
Many ticks*Children	-0.072	0.208
Many ticks*TBE risk area	0.671**	0.280
Many ticks*Tick risk area	0.835***	0.260
Some LB risk*Female	-0.009	0.127
Some LB risk*Age	0.003	0.004
Some LB risk*Income	-0.001	0.003
Some LB risk*Children	-0.063	0.159
Some LB risk*TBE risk area	0.286	0.209
Some LB risk*Tick risk area	0.056	0.193
High LB risk*Female	0.019	0.129

	CLM with interactions	
Variable	Coefficient	S.E.
High LB risk*Age	0.000	0.004
High LB risk*Income	0.000	0.003
High LB risk*Children	0.074	0.161
High LB risk*TBE risk area	0.520**	0.225
High LB risk*Tick risk area	0.325	0.211
Some TBE risk*Female	-0.277**	0.110
Some TBE risk*Age	-0.004	0.004
Some TBE risk*Income	-0.001	0.002
Some TBE risk*Children	-0.057	0.138
Some TBE risk*TBE risk area	0.102	0.191
Some TBE risk*Tick risk area	-0.027	0.179
High TBE risk*Female	-0.230*	0.124
High TBE risk*Age	-0.004	0.004
High TBE risk*Income	0.002	0.003
High TBE risk*Children	-0.020	0.155
High TBE risk*TBE risk area	0.098	0.216
High TBE risk*Tick risk area	0.048	0.202
Cost*Female	0.000	0.000
Cost*Age	0.000***	0.000
Cost*Income	0.000**	0.000
Cost*Children	0.001*	0.000
Cost*TBE risk area	-0.002**	0.001
Cost*Tick risk area	-0.001*	0.001
Number of observations	6316	
Number of respondents	1579	
Log likelihood	-5703	
PseudoR2	0.167	

*** p<0.01, ** p<0.05, * p<0.1

A4. Results from random parameter logit model (RPL) – with and without interactions between choice attributes and socio-economic variables

	RPL without interactions[a]		**RPL - interactions with socio-economic variables**[a]	
Variables	Coefficient	S.E.	Coefficient	S.E.
Cost	-0.008***	0.000	-0.008***	0.000
Nice area	1.061***	0.099	0.114	0.460
Very nice area	1.240***	0.110	0.601	0.488
Some ticks	-0.260**	0.115	-1.253**	0.576
Many ticks	-1.334***	0.155	-2.754***	0.799
Some LB risk	-0.737***	0.120	-2.592***	0.663
High LB risk	-1.689***	0.134	-2.832***	0.692
Some TBE risk	-0.730***	0.098	0.010	0.540
High TBE risk	-2.225***	0.130	-0.976*	0.581
Stay home (opt out)	-2.548***	0.125	-2.613***	0.129
Interactions				
Nice area*Female			-0.110	0.178
Nice area*Age			0.006	0.006
Nice area*Income			0.011***	0.004
Nice area*Children			0.296	0.223
Nice area*TBE risk area			-0.085	0.293
Nice area*Tick risk area			0.086	0.272
Very nice area*Female			-0.091	0.186
Very nice area*Age			-0.005	0.006
Very nice area*Income			0.018***	0.004
Very nice area*Children			-0.031	0.233
Very nice area*TBE risk area			-0.391	0.311
Very nice area*Tick risk area			-0.409	0.290
Some ticks*Female			0.034	0.220
Some ticks*Age			0.000	0.007
Some ticks*Income			0.007	0.005
Some ticks*Children			-0.248	0.277
Some ticks*TBE risk area			0.052	0.369
Some ticks*Tick risk area			0.392	0.344
Many ticks*Female			-0.055	0.299
Many ticks*Age			-0.002	0.009
Many ticks*Income			0.005	0.007
Many ticks*Children			-0.236	0.377
Many ticks*TBE risk area			0.979*	0.504
Many ticks*Tick risk area			1.291***	0.472
Some LB risk*Female			0.013	0.242
Some LB risk*Age			0.015*	0.008
Some LB risk*Income			0.005	0.006
Some LB risk*Children			0.066	0.304
Some LB risk*TBE risk area			0.675*	0.401
Some LB risk*Tick risk area			0.261	0.372

	RPL without interactions[a]		RPL - interactions with socio-economic variables[a]	
Variables	Coefficient	S.E.	Coefficient	S.E.
High LB risk*Female			0.073	0.251
High LB risk*Age			0.001	0.008
High LB risk*Income			0.004	0.006
High LB risk*Children			0.165	0.311
High LB risk*TBE risk area			1.078**	0.434
High LB risk*Tick risk area			0.777*	0.408
Some TBE risk*Female			-0.507**	0.202
Some TBE risk*Age			-0.009	0.006
Some TBE risk*Income			0.001	0.005
Some TBE risk*Children			-0.243	0.251
Some TBE risk*TBE risk area			0.169	0.344
Some TBE risk*Tick risk area			-0.126	0.321
High TBE risk*Female			-0.412*	0.215
High TBE risk*Age			-0.016**	0.007
High TBE risk*Income			0.000	0.005
High TBE risk*Children			-0.082	0.264
High TBE risk*TBE risk area			0.364	0.371
High TBE risk*Tick risk area			0.137	0.346
Standard deviations of Random Parameters				
St.Dev. Nice area	1.519***	0.130	1.576***	0.131
St.Dev. Very nice area	1.519***	0.130	1.576***	0.131
St.Dev. Some ticks	1.841***	0.118	1.837***	0.117
St.Dev. Many ticks	1.841***	0.118	1.837***	0.117
St.Dev. Some LB risk	1.883***	0.166	1.892***	0.159
St.Dev. High LB risk	1.883***	0.166	1.892***	0.159
St.Dev. Some TBE risk	0.070**	0.307	0.929***	0.251
St.Dev. High TBE risk	1.042***	0.209	1.101***	0.195
Number of observations	6316		6316	
Number of respondents	1579		1579	
Log likelihood	-5415		-5340	
Pseudo R2	0.220		0.230	

*** p<0.01, ** p<0.05, * p<0.1

[a] All parameters of the choice attributes, except the cost parameter, are assumed to be normally distributed. The models are estimated using 500 Halton draws.

A5. Results from latent class model with distance instead of travel cost as choice attribute

Table A5.1 Latent class model with distance instead of travel cost as choice attribute[a]

	Class 1		**Class 2**	
Utility function	Coefficient	S.E.	Coefficient	S.E.
Distance	-0.027***	0.001	-0.006***	0.001
Nice area	0.741***	0.073	0.510***	0.129
Very nice area	0.890***	0.083	0.694***	0.138
Some ticks	0.322***	0.101	-1.064***	0.142
Many ticks	0.039	0.127	-3.112***	0.222
Some LB risk	-0.526***	0.096	-0.200	0.134
High LB risk	-0.861***	0.086	-1.641***	0.233
Some TBE risk	-0.250***	0.079	-1.138***	0.139
High TBE risk	-1.111***	0.081	-2.246***	0.172
Stay home	-2.753***	0.140	-1.670***	0.153
Latent class probability	0.599		0.401	
Number of observations	6316			
No. of respondents	1579			
Log likelihood	-5135			
Psudo R2	0.260			

*** p<0.01. ** p<0.05. * p<0.1

[a] The model is estimated with choice attributes only.

Table A5.2 Distance that respondents state they would travel to avoid ticks or disease risk associated with one recreational trip (km) [a b]

	Class 1		Class 2		Average	
	Mean	S.E.	Mean	S.E.	Mean	S.E.
Some ticks	-11.9***	3.82	38.7***	5.97	8.37**	3.25
Many ticks	-1.43	4.73	114***	11.5	44.8***	5.44
Some LB risk	19.5***	3.72	6.91	4.90	14.4***	2.79
High LB risk	31.9***	3.50	59.5***	9.57	43.0***	4.09
Some TBE risk	9.27***	2.94	42.1***	5.64	22.4***	2.66
High TBE risk	41.1***	3.17	83.0***	8.45	57.9***	3.66
Class probability	0.599		0.401			

*** p<0.01. ** p<0.05. * p<0.1

[a] Calculation based on latent class model in Table A5.1.

[b] One way distance to the recreational site in kilometres

A6. Marginal WTP for respondents with ‘low’ and ‘high’ income in emerging risk areas and TBE risk areas [a b]

	(1) **Emerging risk area low income**		(2) **TBE risk area low income**		(3) **Emerging risk area high income**		(4) **TBE risk area high income**		(5) **P-values H_0:(1)=(2)**	(6) **P-values H_0:(3)=(4)**
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.		
Some ticks	158**	67.3	35.8	25.8	125	93.0	86.8*	46.7	0.093	0.716
Many ticks	396***	104.1	84.8**	33.5	419***	149	255***	59.6	0.005	0.308
Some LB risk	61.9	53.8	68.4***	24.4	306***	117	31.5	41.7	0.919	0.030
High LB risk	223***	71.6	113***	24.3	461***	150	173***	46.8	0.149	0.068
Some TBE risk	58.1	49.5	66.0***	20.3	214**	88.4	63.7*	34.7	0.881	0.117
High TBE risk	280***	71.4	197***	24.6	420***	123	284***	45.4	0.274	0.303
No. of individuals	106		206		94		258			
Log likelihood	-367		-750		-319		-962			
R2	0.212		0.161		0.224		0.145			

*** p<0.01. ** p<0.05. * p<0.1

[a] Average MWTP values from conditional logit models in SEK for round trip to a recreational area

[b] ‘Low income’ = monthly household income <40 000 SEK; ‘High income’ = monthly household income >=40 000 SEK

Note: We test whether the differences in MWTP between emerging risk and TBE risk areas are due to the observed significant difference in mean income between the groups of respondents. We find that there are significant differences in MWTP to avoid areas with ticks among respondents with monthly household incomes below 40 000 SEK in emerging risk areas and TBE risk areas, respectively. Similarly, we find significant differences in MWTP to avoid areas with LB risk among respondents with household income above 40 000 SEK. We conclude that while income is positively associated with MWTP for risk reduction, differences in average income between the emerging risk area and TBE risk areas cannot explain the differences in MWTP estimates between the groups of respondents.

A7. Marginal WTP estimates from different econometric models and p-values for tests of equal means [a] [b]

	(1) Latent class model 2 classes		(2) Latent class model 3 classes		(3) Latent class model 4 classes		(4) Random parameter logit model		(5) Conditional logit model		(6) Latent class model 2 classes with interactions	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
Some ticks	38.1**	15.3	45.7**	20.6	37.8**	15.4	31.9**	14.1	54.4***	14.4	36.6**	15.3
Many ticks	207***	25.6	236***	36.3	243	171482	164***	18.8	174***	18.4	205***	25.5
Some LB risk	68.1***	13.1	68.8***	17.3	193	0.00	90.4***	15.1	94.5***	13.5	68.5***	13.0
High LB risk	202***	19.2	230***	25.9	214***	27.4	207***	17.0	183***	14.9	203***	19.4
Some TBE risk	104***	12.4	137***	19.9	82.7***	13.8	89.6***	12.2	87.9***	11.2	103***	12.3
High TBE risk	270***	17.0	322***	31.7	268***	25.0	273***	15.2	258***	14.1	267***	16.6
n=	1579		1579		1579		1579		1579		1579	
Log likelihood	-5138		-5069		-4999		-5415		-5816		-5116	
Pseudo R2/R2	0.260		0.269		0.280		0.220		0.155		0.263	
No. of classes	2		3		4						2	

*** $p<0.01$. ** $p<0.05$. * $p<0.1$

[a] Models 1–5 include choice attributes only. In model 6 choice attributes are interacted with female, age, income, children, tick risk area and TBE risk area.

	P-values H_0:(1)=(2)	P-values H_0:(1)=(4)	P-values H_0:(1)=(5)	P-values H_0:(2)=(5)
Some ticks	0.755	0.773	0.446	0.750
Many ticks	0.514	0.176	0.295	0.128
Some LB risk	0.963	0.271	0.159	0.245
High LB risk	0.368	0.815	0.459	0.116
Some TBE risk	0.160	0.421	0.338	0.032
High TBE risk	0.148	0.895	0.587	0.065

[b] p-values from unpaired t-tests

A8. Geographic specific effects and county-based risk classification

1. Control for geographic specific effects

We assess whether there are unobserved risk factors associated with the geographic location by interacting the alternative specific constant with dummy variables for each of the 21 counties in Sweden. We use the counties Norrbotten and Västerbotten (the counties furthest north) as reference category. Results from a conditional logit model are reported in Table A8.1. We find that the coefficients of the interaction variables are significant at the 5 per cent level and negative for most counties classified as tick risk areas and TBE risk areas. In the counties Gävleborg, Jämtland and Västernorrland, which also form part of the emerging risk area, we find no significant interaction effects. A negative coefficient indicates that respondents in the county are less likely to stay home instead of going to a recreational area with risk compared with respondents in Norrbotten and Västerbotten.

Table A8.1 Control for geographic specific effects – interaction of the alternative specific constant with county dummies. Results from a conditional logit model

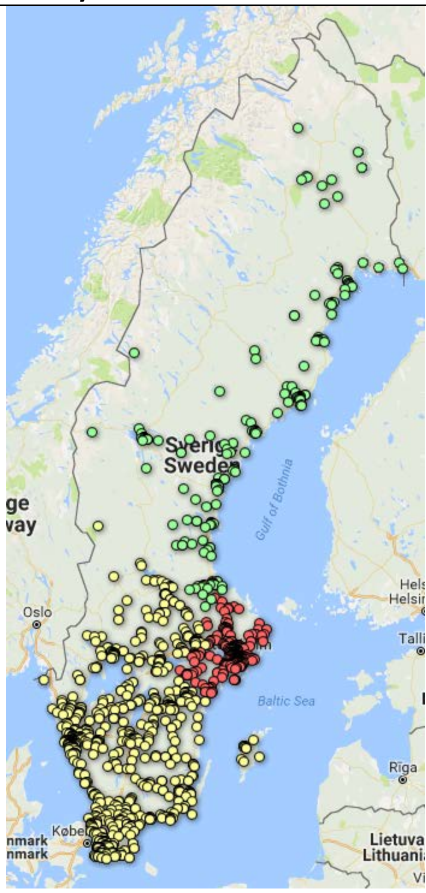
	CLM with ASC interactions	
Variables	Coefficient	S.E.
Cost	-0.005***	0.000
Nice area	0.590***	0.053
Very nice area	0.701***	0.058
Some ticks	-0.274***	0.070
Many ticks	-0.857***	0.087
Some LB risk	-0.456***	0.062
High LB risk	-0.884***	0.063
Some TBE risk	-0.424***	0.054
High TBE risk	-1.253***	0.061
ASC – Stay home (opt out)	-1.270***	0.144
Interactions with ASC		
ASC*Blekinge	-0.807***	0.280
ASC*Dalarna	-0.422**	0.214
ASC*Gavleborg	0.029	0.203
ASC*Gotland	-0.468	0.306
ASC*Halland	-0.508**	0.226
ASC*Jamtland	-0.302	0.253
ASC*Jonkoping	-0.258	0.196
ASC*Kalmar	-0.878***	0.248
ASC*Kronoberg	-0.815***	0.282
ASC*Orebro	-0.570**	0.241
ASC*Ostergotland	-0.310*	0.170
ASC*Skane	-0.239	0.151
ASC*Sodermanland	-0.856***	0.227
ASC*Stockholm	-0.497***	0.142
ASC*Uppsala	-0.449**	0.224
ASC*Varmland	-0.359	0.224
ASC*Vasternorrland	-0.207	0.227
ASC*Vastmanland	-0.306	0.214
ASC*Vgotaland	-0.350**	0.146
Number of observations	6316	
No. of respondents	1579	
Log likelihood	-5793	
R2	0.156	

*** p<0.01. ** p<0.05. * p<0.1

2. MWTP estimates using an alternative risk classification

We analyse whether our results are sensitive to our classification of TBE risk clustered at the three-digit postal code level by using a classification of TBE risk based on the average incidence of TBE at the county level. The risk classification is presented in table A8.2. Descriptive statistics for the three risk areas using the county incidence-based risk classification are presented in Table A8.3. Marginal WTP estimates for the three different risk areas are presented in table A8.4. We find that MWTP for risk reduction decreases with baseline risk also when using this alternative risk classification.

Table A8.2.

<table>
<tr><th>County</th><th>TBE Incidence[a]</th><th>Map of Sweden</th><th>Risk classification based on county TBE incidence[b]</th></tr>
<tr><td>Västerbotten</td><td>0.12</td><td rowspan="21">
</td><td rowspan="21">
</td></tr>
<tr><td>Västernorrland</td><td>0.21</td></tr>
<tr><td>Halland</td><td>0.24</td></tr>
<tr><td>Norrbotten</td><td>0.32</td></tr>
<tr><td>Jämtland</td><td>0.39</td></tr>
<tr><td>Gävleborg</td><td>0.43</td></tr>
<tr><td>Kronoberg</td><td>0.43</td></tr>
<tr><td>Dalarna</td><td>0.47</td></tr>
<tr><td>Skåne</td><td>0.47</td></tr>
<tr><td>Blekinge</td><td>0.66</td></tr>
<tr><td>Värmland</td><td>0.77</td></tr>
<tr><td>Örebro</td><td>0.82</td></tr>
<tr><td>Kalmar</td><td>0.90</td></tr>
<tr><td>Jönköping</td><td>1.01</td></tr>
<tr><td>Västra Götaland</td><td>1.24</td></tr>
<tr><td>Västmanland</td><td>1.57</td></tr>
<tr><td>Gotland</td><td>1.75</td></tr>
<tr><td>Östergötland</td><td>2.39</td></tr>
<tr><td>Stockholm</td><td>5.00</td></tr>
<tr><td>Södermanland</td><td>7.61</td></tr>
<tr><td>Uppsala</td><td>8.18</td></tr>
</table>

[a] Mean incidence of TBE per county 2004–2013 (reported TBE cases per 100 000 inhabitants) (Swedish Public Health Agency, 2017).

[b] Area of residence of survey respondents in the emerging risk area (n=200; green dots), tick risk area (n=936; yellow dots) and TBE risk areas (n=442; red dots). TBE risk areas comprise the three counties with an average TBE incidence >= 5 per 100 000 inhabitants.

Table A8.3.Descriptive statistics with county-based risk classification

VARIABLES	(1) All respondents	(2) Emerging risk area	(3) Tick risk area	(4) TBE risk area	(5) n (all resp.)
Female respondent	0.53	0.55	0.54	0.51	1579
Age[a]	51.3	51.4	50.0 [µ]	54.1	1579
Household pre-tax income/month (SEK 1 000)[b]	43.9	40.5	42.8	47.8[#]	1579
Has child under 18 years	0.26	0.27	0.27	0.23	1579
Vaccinated against TBE	0.24	0.07*	0.17*	0.48*	1579
Has had 1 or more tick bites in lifetime	0.67	0.24[#]	0.73	0.74	1 568
Has had at least 1 tick bite in last 12 months	0.30	0.04[#]	0.34	0.34	1 568
Respondent has had a tick-borne disease	0.12	0.02*	0.12*	0.16*	1 579
Someone in family or close friend has had a tick borne disease	0.40	0.18[#]	0.42	0.44	1 576
Observations	1579	200	937	442	

Notes:

[a] Age: The standard deviation among all respondents is 16.9 years; min 18 years; max 80 years

[b] Income: the standard deviation among all respondents is 22 800 SEK; min 5 000 SEK; max 115 000 SEK

*Mean estimates for the different risk areas are significantly different from each other. p<0.05

[#] Mean estimate is significantly different from other risk areas. p<0.05

[µ] Mean estimate is significantly different from TBE risk area. p<0.05

Table A8.4. Marginal WTP estimates for different subsamples using county TBE incidence classification

Marginal willingness to pay to avoid ticks or disease risk associated with one recreational trip among respondents residing in areas with different baseline risks (SEK). p-values of unpaired t-tests of equal marginal WTP between subsamples. Results from conditional logit model. [a b]

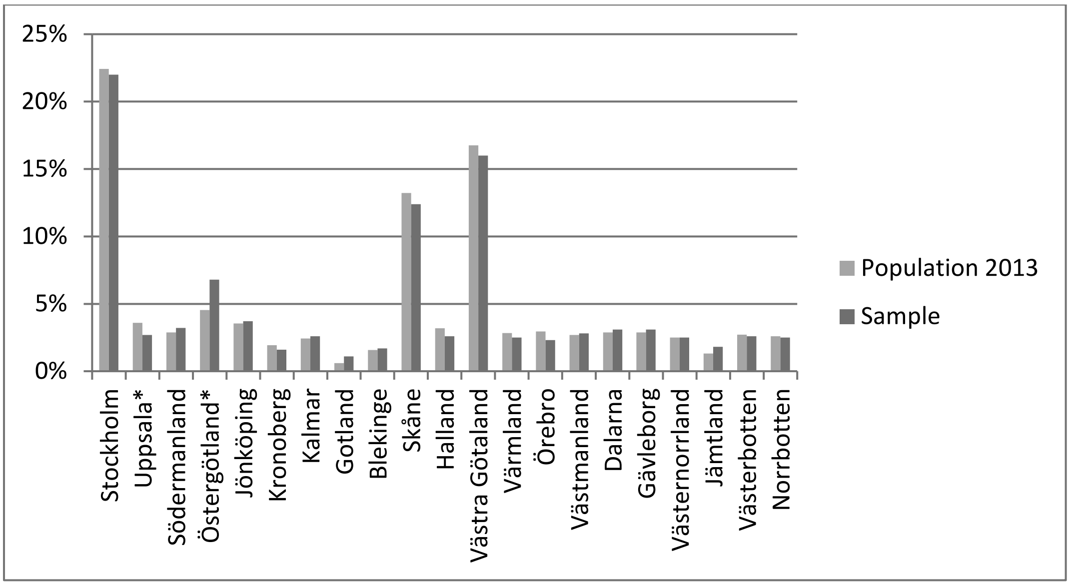
	(1) Emerging risk area		(2) Tick risk area		(3) TBE risk area		(4) P-values H_0:(1)=(2)	(5) P-values H_0:(1)=(3)	(6) P-values H_0:(2)=(3)
	Mean	S.E.	Mean	S.E.	Mean	S.E.			
Some ticks	141**	55.5	53.7***	18.3	21.7	25.9	0.137	0.052	0.313
Many ticks	410***	87.9	165***	23.2	117***	32.4	0.008	0.002	0.228
Some LB risk	153***	51.9	106***	17.2	46.7*	24.0	0.392	0.064	0.045
High LB risk	321***	70.8	197***	19.2	111***	24.3	0.092	0.005	0.006
Some TBE risk	118***	44.5	95.1***	14.1	63.4***	20.0	0.624	0.264	0.196
High TBE risk	344***	65.4	262***	17.7	223***	23.8	0.228	0.081	0.178
No. of individuals	200		937		442				
Log likelihood	-691		-3420		-1659				
R2	0.212		0.163		0.131				

*** p<0.01. ** p<0.05. * p<0.1

[a] Average MWTP values from conditional logit models for three different sub-samples of the respondents.

[b] MWTP in SEK for round trip to recreational area.

A9. Area of residence of survey respondents compared to the Swedish population



*Significant differences between the population share and the sample share at the 5% level for the counties of Uppsala and Östergötland

[a] Population data for the 21 counties from Statistics Sweden, 2013.

Figure A9. County of residence among the Swedish population 2013[a] compared with 1 579 survey respondents

Paper III

RESEARCH ARTICLE

The Willingness to Pay for Vaccination against Tick-Borne Encephalitis and Implications for Public Health Policy: Evidence from Sweden

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Abstract

The increasing incidence of tick-borne encephalitis (TBE) in Sweden and several other European countries has sparked a discussion about the need for a public vaccination strategy. However, TBE vaccination coverage is incomplete and there is little knowledge about the factors influencing vaccination behavior. Based on a survey of 1,500 randomly selected respondents in Sweden, we estimate vaccination coverage in areas with different TBE risk levels and analyze the role of vaccine price and other factors influencing the demand for vaccination. First, we find that the average rate of TBE vaccination in Sweden is 33% in TBE risk areas and 18% elsewhere. Income, age and risk-related factors such as incidence of TBE in the area of residence, frequency of visits to areas with TBE risk, and experience with tick bites are positively associated with demand for TBE vaccine. Next, using contingent valuation methodology, we estimate the willingness to pay for TBE vaccination among the unvaccinated respondents and the effect of a possible subsidy. Among the unvaccinated respondents in TBE risk areas, we estimate the mean willingness to pay for the recommended three doses of TBE vaccine to be 465 SEK (approximately 46 euros or 40% of the current market price). We project that a subsidy making TBE vaccines free of charge could increase the vaccination rate in TBE risk areas to around 78%, with a larger effect on low-income households, whose current vaccination rate is only 15% in risk areas. However, price is not the only factor affecting demand. We find significant effects on vaccination behavior associated with trust in vaccine recommendations, perceptions about tick bite-related health risks and knowledge about ticks and tick-borne diseases. Hence, increasing knowledge and trust, as well as ease of access to vaccinations, can also be important measures for public health agencies that want to increase the vaccination rate.

Competing Interests: The authors have declared that no competing interests exist.

Introduction

An increasing number of tick-borne encephalitis (TBE) cases have initiated a discussion about the need for a public vaccination strategy, potentially including a vaccine subsidy, in Sweden and other European countries [1–4]. This study estimates the willingness to pay (WTP) for TBE vaccination and the effect of a possible TBE vaccine subsidy on vaccination rates in Sweden. We also estimate the current vaccination coverage in areas differing in TBE incidence and analyze the role of income, risk behavior and other factors influencing vaccine demand.

TBE is caused by the TBE virus, a flavivirus transmitted to humans by ticks, which can cause severe infection of the central nervous system. Around 40% of those infected by the European subtype of the virus suffer from serious long-term or permanent sequelae [5]. Elderly people tend to get the most serious sequelae, but lately it has been recognized that young children also can get serious and long-term sequelae from TBE [6]. In Sweden and several other European countries, risk areas are expanding and incidence is increasing [7, 8]. There is no treatment, but effective vaccines are available [9].

WHO recommends that vaccination should be offered to all age groups in areas with an incidence higher than 5 annual cases per 100,000 persons [9]. Austria is the only country that has implemented a TBE vaccination program targeting the whole population. As a result, vaccination coverage in Austria increased from 6% in 1980 to 85% in 2011 and the number of TBE cases decreased from almost 700 in 1979 to less than 100 per year in the period 2000–2005 [10–12]. Several countries, including Slovenia, Latvia, and Finland, have experimented with targeted vaccination campaigns in which the price of the vaccine has been reduced for specific target groups and areas [13–15].

In Sweden, there has been a marked increase in the number of reported TBE cases during the last two decades and, subsequently, an increase in the number of TBE vaccine doses sold in Sweden, from below 100,000 doses a year in the early 1990s to 500,000–600,000 doses a year since 2006 (S1 Fig). TBE vaccination is recommended by Swedish health authorities for people spending time outdoors in TBE risk areas. However, it is not included in the national vaccination program [4].

While there are numerous studies on the willingness to pay for other vaccines [16–20], there are to our knowledge no published studies on the WTP for TBE vaccination. Hence, this study makes an important contribution to the few existing health economics studies on TBE vaccination [1–3, 21, 22]. Our analysis of the demand for TBE vaccination at current market prices complements a recent study, which estimated TBE vaccination coverage in the county of Stockholm [4]. Based on a survey of the Swedish population, we estimate vaccination coverage in areas differing in TBE incidence. Besides the variables that previously have been identified to be associated with TBE vaccination–outdoor activities in high-risk areas, age, income and country of birth [4]–we identify the role of knowledge, risk perception and trust in vaccine recommendations.

Methodology

2.1. Survey instrument development and data collection

To elicit respondents' willingness to pay for TBE vaccination, we used established contingent valuation survey methodology [23, 24]. A questionnaire was developed based on focus group discussions, two pilot tests, and key informant interviews with doctors and epidemiologists specializing in tick-borne diseases. The survey was performed under informed consent and approved by the Regional Ethical Review Board at the University of Gothenburg (decision number 544–13).

The questionnaire asked about exposure, risk perception, knowledge, and protective behavior related to ticks and tick-borne diseases, as well as socioeconomic information about the respondent and his/her household. To quantify the effect of a possible vaccine subsidy, the unvaccinated respondents were asked about their (WTP) for TBE vaccination using the following question: "*Would you vaccinate yourself or someone in your household against TBE if it cost a total of [100, 250, 500, 750, 1000] SEK for the three doses of the vaccine that protect ONE person for at least three years*?" Each respondent was presented with one of the five different prices shown in the brackets. The prices were randomly assigned to respondents so that each hypothetical price was presented to one-fifth of the unvaccinated respondents.

Because stated preference studies can be sensitive to design issues [23, 24], we used several techniques to avoid potential bias. The risk that respondents make different choices in a survey than they would in a real-life situation is usually lower for goods purchased for individual use than for goods that benefit the general public [25]. Nevertheless, we urged the respondents to answer the question as if it were a real-life situation [26, 27] and respondents were asked how certain they were about their answers [28]. We find no significant differences in results between those stating they were certain about their answer and those stating they were uncertain about their answer to the question about WTP for TBE vaccination (See Table C in S1 Text).

The survey (S2 Text) was distributed online in October 2013 to 6,000 respondents aged 18–85 years in a national internet panel representative of the Swedish population. The internet panel consists of approximately 8,000 members recruited in connection with telephone interviews with randomly sampled respondents (i.e., this is not a voluntary opt-in survey). Respondents were reminded twice to complete the questionnaire. 1,526 respondents completed the questionnaire and an additional 540 respondents answered several but not all questions, corresponding to a response rate of 25% for the whole questionnaire and 25%–34% for selected questions. Thirty-one percent of the respondents answered the questions about whether they were vaccinated against TBE.

A crucial question related to the relatively low response rate is whether those responding are more interested than the general population in TBE vaccination. Ideally, we would compare the share of TBE vaccinated respondents in our sample with the vaccination rate among the Swedish population. However, because there is no TBE vaccine register in Sweden, there are no comparative statistics on vaccination rates. A recent study of TBE vaccination rates in Stockholm County [4] finds that 53% of the population had ever received a TBE vaccine shot. Among the 415 respondents in our survey living in Stockholm County, 50% had received a TBE vaccine shot, signifying that our survey found approximately the same vaccination rate. This reduces our concerns about the response rate.

We find some statistically significant differences in socioeconomic characteristics between our survey respondents and the Swedish population. While the differences are small in magnitude, we control for their potential impact on the estimated effects of a possible vaccine subsidy by using population mean instead of sample mean values in the model used for the predictions (S4 Text).

2.2. Data analysis

We model the demand for a TBE vaccine as derived from the individual's demand for health, subject to a budget constraint [29]. We propose that the demand for a TBE vaccine is a function of the price of the vaccine; the incidence of TBE in the area of residence; the behavioral risk associated with outdoor habits; experience with ticks and tick-borne diseases; knowledge about tick-borne diseases; risk perceptions related to tick bites; trust in vaccine recommendations; and socioeconomic characteristics (age, gender, income, and education). We use a binary logit regression model to study what *actually* made people get vaccinated against TBE. The dependent variable *Vaccinated* equals 1 if the respondent is vaccinated and 0 if not.

To study the *hypothetical* WTP for TBE vaccination, we also use a binary logit regression model. The dependent variable *Buy* equals 1 if the respondent states he/she would buy the vaccine at the offered price and 0 if he/she would not. Using a utility difference framework [30], we assume that respondents would buy the vaccine if it led to greater utility (welfare) relative to not buying the vaccine. With a random utility model containing a linear utility function, we calculate unvaccinated respondents' mean WTP ($E[WTP]$) for a TBE vaccine as:

$$E[WTP] = \frac{\alpha + \beta\bar{z}}{\mu}$$

where α is the intercept, β is the estimated coefficient of each explanatory variable in the regression model, $\bar{z}$ is the vector of the explanatory variables, and μ is the estimated coefficient of the bid variable, or the marginal utility of income.

We use the delta method to estimate the standard error of the expected WTP. The estimated median WTP is equal to mean WTP due to the assumption of symmetric distribution in the parametric estimate. We also estimate a non-parametric mean WTP with the Turnbull estimator [31] (S1 Text).

As an objective indicator of TBE risk in different areas of residence, we use an incidence-based risk classification of Swedish postal code areas based on geographical data for the 2,687 reported TBE cases in Sweden for 1986–2012 from the Swedish Public Health Agency and population data from Statistics Sweden. We calculate TBE incidence as the average number of TBE cases per 100,000 inhabitants in each three-digit postal code area during the 27-year period. Following the classification of risk areas used by many Swedish regional health authorities when producing TBE risk maps, we define "TBE risk areas" as areas where there is positive TBE incidence and there have been two or more reported cases of TBE in a three-digit postal code area during 1986–2012. We divide this broad category into "TBE low-risk areas," defined as TBE risk areas with an incidence lower than 5, and "TBE high-risk areas," defined as TBE risk areas with an incidence of 5 annual TBE cases or more per 100,000 inhabitants [9].

Results

3.1. Descriptive statistics

The incidence of TBE varies greatly with location. For instance, 32% of our respondents live in a low-risk area and 6.5% live in a high-risk area. Among respondents' areas of residence, we found the highest TBE incidence to be 41 TBE cases per 100,000 inhabitants, substantially exceeding the rate at which WHO recommends vaccination.

However, living in an area with high TBE risk does not necessarily imply that a respondent has a high risk of getting TBE. The variable *Outdoor in TBE risk areas* captures behavioral risk, with 37% of respondents reporting spending time in forests or other areas where there are ticks and where they know or think there is also TBE.

Tick bites are common, with 68% of the respondents reporting that they had been bitten at least once. Tick-borne disease is common as well: 45% had either had a tick-borne disease (13%) and/or a family member or close friend who had had a tick-borne disease (41%). Eight respondents (0.5%) had had TBE and 51 respondents (3%) had a family member or close friend who had had TBE.

Perceptions about health risks and trust in vaccinations also varied, with 42% of the respondents answering that tick bites constitute a rather large or very large risk to his/her health or the health of his/her family. However, 18% had low or very low trust in vaccine

Table 1. Variable definitions and summary statistics.

Variable	Obs	Mean	S.D.	Min	Max	Definition
Socioeconomic						
Female	1526	0.53	0.50	0	1	1 = female respondent
Age	1526	51.4	17.0	18	80	Years
Income	1526	44.1	23.0	5	115	Household pre-tax income/month(1,000 SEK)[a]
University	1526	0.52	0.50	0	1	1 = has studied at university
Urban	1526	0.47	0.50	0	1	1 = lives in city with>50,000 inhabitants
TBE Vaccination						
TBE vaccinated	1526	0.24	0.43	0	1	1 = vaccinated
TBE risk in residence area and summerhouse area						
TBE incidence in area of residence	1526	1.11	4.05	0	41.3	TBE incidence in respondents' residence area
TBE risk summerhouse	1526	0.17	0.37	0	1	1 = spends time in summerhouse in area with $\geq$2 documented TBE cases
Behavioral risk						
Outdoor in TBE risk area	1526	0.37	0.48	0	1	1 = spends time outdoor in TBE risk areas[b]
Risk of tick bite at work	1526	0.10	0.29	0	1	1 = risk of getting tick bite while working
Experience with ticks						
Tick bite ever	1526	0.68	0.47	0	1	1 = has had at least 1 tick bite in lifetime
Tick-disease experience	1526	0.45	0.50	0	1	1 = the respondent or his/her family or friend has had tick-borne disease
Knowledge about ticks and tick-borne diseases						
Knowledge	1526	3.81	1.79	0	7	No. of correct answers to the 7 knowledge questions
Risk perception						
Health risk of tick-bites	1526	0.42	0.49	0	1	1 = tick bites perceived as very or rather large risk to respondent or his/her family's health
Low trust in vaccine recommendations	1526	0.18	0.38	0	1	1 = rather low or very low trust in vaccine recommendations from healthcare institutions

[a] Respondents indicated their income in intervals of 10,000 SEK. The midpoint of the scale is used in the data. E.g., if 10–20,000 SEK was indicated, then 15,000 SEK is used.

[b] Daily, weekly or 1–2 visits per month to areas where the respondent knows or thinks there is TBE.

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recommendations from health care institutions. As we will show, distrust can offset some of the effect of a subsidy on vaccination behavior.

We also identified gaps in respondents' knowledge about TBE. The average score on the seven knowledge questions (S2 Text) was 3.8. For example, 61% of the respondents knew there is vaccine that can prevent TBE, but only 32% knew that the disease cannot be treated with antibiotics. As with trust, knowledge can affect demand for vaccination.

Table 1 provides definitions and summary statistics of the variables included in the analysis.

3.2. Vaccination rate

We find incomplete vaccination coverage throughout Sweden, with 24% of the respondents reporting they were vaccinated against TBE. Almost 90% of these respondents indicated they had received their last shot in the last five years, but this does not necessarily imply that they were fully protected. Hence, "vaccinated" should be interpreted here as a person who has ever received a dose of TBE vaccine.

We find a vaccination rate of about 33% in TBE risk areas and 18% elsewhere. In TBE high risk areas (i.e., areas with an incidence of 5 annual TBE cases or more per 100,000 inhabitants), the vaccination rate was 55%, compared with 30% in TBE low risk areas (i.e., areas with an incidence between 0 and 5). In areas without TBE risk, i.e., areas with zero TBE incidence or where there has been only one reported TBE case ever, there is a large difference in vaccination rates between respondents living north (5%) and south (22%) of the biogeographical boundary Limes Norrlandicus. Although ticks have spread further north in Sweden in recent decades, the prevalence of ticks and tick-borne diseases north of this boundary is considerably lower than in southern Sweden [32].

3.3. Who gets vaccinated against TBE?

Using a binary logit regression model, we identify variables that have a statistically significant association with the probability of TBE vaccination (Table A in S3 Text). Similarly, to a previous study [4], we find that income, age and frequency of visits to forests or other areas with TBE risk are positively associated with higher vaccination probability. Having a low household income (less than 20,000 SEK pre-tax/month) is associated with a 7 percentage point lower vaccination probability compared to households with higher incomes. Being older than 65 years is associated with a 7 percentage point higher vaccination probability compared to individuals aged 31–65 years. Frequent visits to forests or other areas with TBE risk are associated with a 20 percentage point higher vaccination probability. We find no gender differences in vaccination probability. In contrast to a previous study [4], we do not find a statistically significant association between being born outside Europe and vaccination probability.

We also find that knowledge about ticks and tick-borne diseases, risk perceptions related to tick bites, and trust in vaccine recommendations are associated with the probability of being vaccinated. The vaccination probability is around 6 percentage points higher for individuals perceiving that tick bites constitute a very serious or rather serious risk to their own or their family members' health. Very low or rather low trust in vaccine recommendations in general, not specifically linked to TBE, is associated with a 6 percentage point decrease in the vaccination probability.

In addition, vaccination behavior is positively correlated with the TBE incidence level in the respondents' area of residence. Living in an area with a one-unit higher incidence is associated with a 1.3 percentage point higher vaccination probability. Having access to a summerhouse in a TBE risk area is associated with an 11 percentage point higher vaccination probability.

3.4. Willingness to pay for TBE vaccination

Fig 1 displays the share of unvaccinated respondents stating they would get vaccinated if the total price of the recommended three doses of vaccine was the bid price presented to them in the survey. As expected, an increasing share of the respondents state they would buy the TBE vaccine when the price of the vaccine decreases.

A rather large share (35%) of the unvaccinated respondents in TBE risk areas say they would get vaccinated at the price of 1,000 SEK, i.e., only 50 SEK (approximately 5 euros) less than the current market price. There is also a substantial share (36%) of the respondents in TBE risk areas stating they would not get vaccinated even if the price was only 100 SEK for the three doses of vaccine. In fact, 13% of the unvaccinated respondents in areas with TBE risk state that they would not get vaccinated even if the vaccine was free of charge.

This reflects that many factors besides vaccine price influence vaccination behavior. Inertia can be such a factor. When unvaccinated respondents in risk areas were asked why they were not vaccinated, 25% said they intended to get vaccinated but had not yet gotten to it and 6% responded that it was complicated and took too much time to get vaccinated. Thus, reducing the time and search costs associated with finding a vaccination provider may be more important for increasing the vaccination rate in this group than lowering the vaccine price.

Other reasons for not being vaccinated among respondents living in risk areas included: rarely visiting areas with ticks or TBE risk (24–25%), low perceived risk (15%), afraid of vaccine side effects (18%) and the vaccine costing too much (15%). As many as 26% of the respondents in risk areas state that they have never thought about getting vaccinated and 11% were not aware that a vaccine existed. This indicates that increasing the knowledge and trust about TBE risk and vaccination can be important measures for increasing the vaccination rate.

Next, we estimate mean willingness to pay among the unvaccinated respondents. Using a binary logit regression model (see Section 2.2), we find that the mean WTP for three doses of TBE vaccine is 464 SEK (95% CI 331–597 SEK) among respondents living in TBE risk areas. Among all unvaccinated respondents, mean WTP is 402 SEK (95% CI 331–474 SEK).

The parameter values for the WTP estimates are derived from the logit regression with *BUY* (respondents stating they would get vaccinated at the offered bid price) as the dependent variable (Table 2).

Columns 1–3 show results for all unvaccinated respondents and Column 4 shows results for unvaccinated respondents living in TBE risk areas. The marginal probabilities represent the marginal change in the probability of buying TBE vaccination due to a marginal change in the explanatory variable, or in the case of binary explanatory variables, a change from 0 to 1.

Here, we report on variables with a statistically significant association with vaccination probabilities among unvaccinated respondents living in TBE risk areas. As expected, WTP for TBE vaccination is negatively associated with the price of the vaccine and positively associated with income. A 100 SEK price reduction increases the vaccination probability by 4 percentage points and 1000 SEK higher income increases the vaccination probability by 0.2 percentage points. We also find that the vaccination probability among women is 12 percentage points higher than among men.

Similar to the findings about who gets vaccinated at current market prices, we find a higher vaccination probability for those with frequent visits to forests or other areas with TBE risk (18 percentage points), among respondents with experience of tick-borne diseases (13 percentage points), and among those who believe that tick bites constitute a very serious or rather serious risk to their own or their family's health (15 percentage points). The vaccination probability is 14 percentage points lower among respondents with low trust in vaccine recommendations compared to respondents with higher trust.

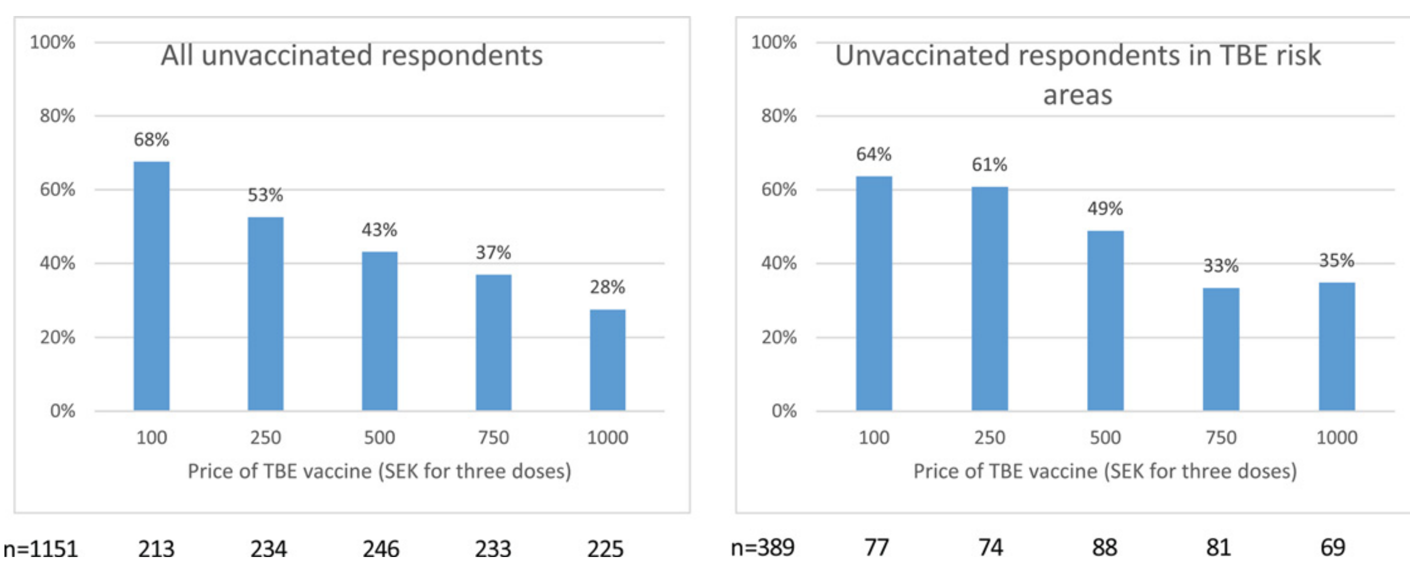

Fig 1. Share of unvaccinated respondents stating they would get vaccinated against TBE at different prices (SEK).

doi:10.1371/journal.pone.0143875.g001

Table 2. Determinants of willingness to pay for TBE vaccination; Marginal probabilities after logit evaluated at sample means[a].

VARIABLES	Not vaccinated respondents (1) Buy	Not vaccinated respondents (2) Buy	Not vaccinated respondents (3) Buy	Not vaccinated respondents in TBE risk- areas (4) Buy
Price	-0.042***	-0.043***	-0.046***	-0.042***
	(0.005)	(0.005)	(0.005)	(0.009)
Female		0.089***	0.059*	0.119**
		(0.031)	(0.034)	(0.059)
Age		0.003***	0.002**	0.002
		(0.001)	(0.001)	(0.002)
Income		0.003***	0.003***	0.002*
		(0.001)	(0.001)	(0.001)
University		-0.006	-0.026	0.030
		(0.032)	(0.033)	(0.058)
Urban		-0.052	-0.047	0.017
		(0.031)	(0.034)	(0.062)
TBE incidence in area of residence			0.001	0.002
			(0.009)	(0.011)
TBE risk summerhouse			0.039	0.026
			(0.053)	(0.076)
Outdoor in TBE risk area			0.107***	0.183***
			(0.037)	(0.060)
Risk of tick bite at work			0.101*	-0.044
			(0.059)	(0.091)
Knowledge			0.025**	-0.003
			(0.010)	(0.017)
Tick bite ever			-0.055	0.012
			(0.036)	(0.065)
Tick-disease experience			0.034	0.134**
			(0.036)	(0.060)
Health risk tick bite			0.159***	0.149**
			(0.035)	(0.058)
Low trust in vaccine recommendations			-0.161***	-0.137**
			(0.037)	(0.065)
Constant	0.688***	-0.441	-0.763**	-1.031*
	(0.116)	(0.289)	(0.329)	(0.596)
Observations	1,151	1,151	1,151	389
Pseudo R2	0,05	0,07	0,12	0,12

Robust standard errors in parentheses

*** p<0.01

** p<0.05

* p<0.1

[a] Table B in S1 Text contains descriptive statistics of the variables included in the model.

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We also include several variables which we find are not significantly associated with vaccination probability. These are age, level of education, knowledge about tick-borne diseases, TBE incidence in the area of residence, having access to a summerhouse in a TBE risk area and living in a larger urban area (S1 Text).

3.5. The effects of a possible TBE vaccine subsidy

Using the regression model on WTP for TBE vaccination, we predict the demand for TBE vaccination at different prices among the unvaccinated respondents living in TBE risk areas (S4 Text; S2 Fig). The price considered is for the three doses of TBE vaccine recommended for disease protection.

Demand increases with reduced prices; the average marginal effect per SEK of subsidy is 0.065 percentage points. We predict that, with a full subsidy (i.e., making the TBE vaccination free of charge), 68% (CI95 59–77%) of the currently unvaccinated respondents in TBE risk areas would get vaccinated. With the estimated current vaccination rate of 33% in TBE risk areas, such a subsidy could increase the vaccination rate by an additional 45 percentage points to 78%. Similarly, a 50% subsidy reducing the price of three vaccine doses to 525 SEK is predicted to increase the vaccination rate among unvaccinated respondents in TBE risk areas to 46% (CI95 41–52%), resulting in a total vaccination rate of approximately 64% in TBE risk areas.

We also find that a subsidy would have a relatively larger effect on the vaccination rate among low-income households than among mid- and high-income households. In TBE risk areas, there is a large difference in vaccination rates across households with different income levels. While high-income households (with a monthly pre-tax income above 60,000 SEK) have a vaccination rate of 50%, mid-income households (20,000–60,000 SEK) have a vaccination rate of 31%, and low-income households (earning less than 20,000 SEK per month) have a vaccination rate of only 15%. We predict that a full subsidy would increase the vaccination rates in TBE risk areas to approximately 68% among low-income households, 78% among mid-income households, and 87% among high-income households. A 50% subsidy would also have a relatively larger effect on the vaccination rates among low-income households than among households with higher incomes (Fig 2).

Discussion

Our results have several implications. First, the current TBE vaccination strategy has resulted in a vaccination rate of about 33% in TBE risk areas and 18% elsewhere. This rate is considerably higher than in TBE endemic countries such as the Czech Republic (16%) and Slovenia (12%) but lower than in Austria (85%), which is the only country that has implemented a TBE vaccination program targeting the whole population, thus substantially reducing the incidence of the disease [11]. The possibility that those responding to our survey may be more concerned about ticks and TBE than survey non-responders and the general population could imply that the actual vaccination rate in Sweden is lower than our estimates. Hence, our results suggest that the rate of vaccination, especially in areas with high TBE risk, needs to increase in order to substantially reduce the incidence of TBE in Sweden.

Second, the demand for vaccination is only partly explained by risk-related factors such as incidence of TBE in the respondent's area of residence, experience with tick bites, and frequency of visits to forests or other areas with TBE risk. Trust in vaccination recommendations, perceptions about the health risks associated with tick bites, knowledge, and ease of access to vaccination services also matter. Hence, increasing knowledge, trust and access can be important measures for public health agencies.

Third, in line with findings from studies on adoption of other types of vaccines, we find that income matters. The current market price of the TBE vaccine deters a substantial share of at-risk people with low incomes from getting vaccinated. Respondents with household pre-tax

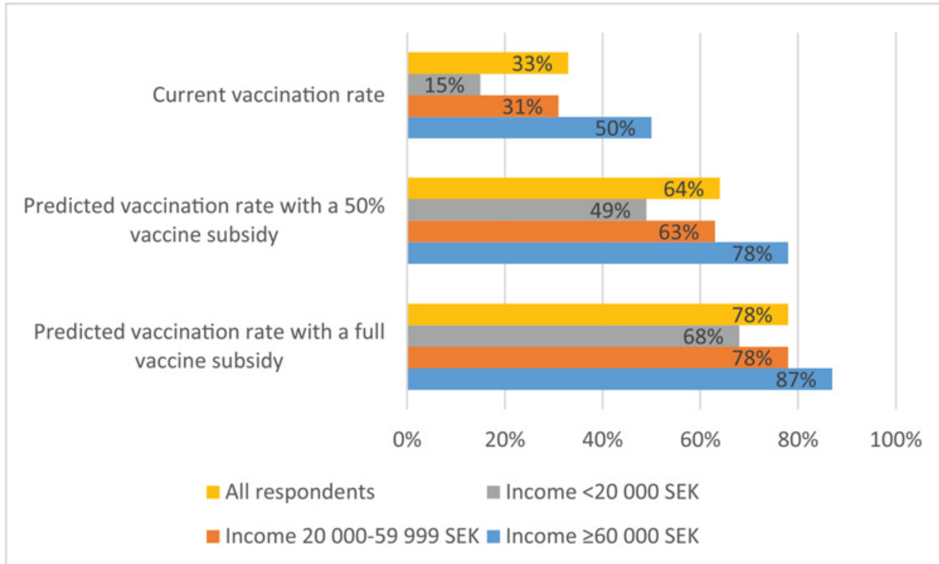

Fig 2. Predicted vaccination rates with a TBE vaccine subsidy in TBE risk areas (%). All respondents and respondents in different income groups (pre-tax monthly household income in SEK).

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incomes below 20,000 SEK/month in TBE risk areas have a vaccination rate of only 15% and are 18 percentage points less likely to get vaccinated than those with higher incomes.

Fourth, our results indicate that a subsidy that reduces the price of TBE vaccines could substantially increase the demand. Unvaccinated respondents in TBE risk areas have a mean willingness to pay for TBE vaccination of 465 SEK (approximately 40% of the current market price). This indicates that even a partial subsidy could have a substantial effect on vaccination rates. We estimate that introducing a 50% subsidy (i.e., reducing the price from 1,050 SEK to 525 SEK) would cause almost 50% of the unvaccinated population in TBE risk areas to get vaccinated; this would increase the vaccination rate from around 33% to 64% in TBE risk areas. A full vaccine subsidy (i.e., providing vaccines for free) could increase the vaccination rate by an additional 14 percentage points. However, given that 13% of the unvaccinated respondents in TBE risk areas state they would not get vaccinated even if the vaccine were free of charge, while many respondents state other reasons for not getting vaccinated, we conclude that there is a diminishing marginal effect of a price subsidy. In order to increase the vaccination rate to above 70%, including TBE vaccination in the general vaccination program would most likely be necessary. Besides making TBE vaccination free of charge, such a measure would send a clear signal to the population living in TBE risk areas about how public health agencies value TBE risk.

Supporting Information

S1 Fig. Reported TBE cases 1956–2014 and number of TBE vaccine doses sold 1992–2012 in Sweden.
(EPS)

S2 Fig. Predicted demand for TBE vaccination at different prices among unvaccinated respondents in TBE risk areas in Sweden.
(EPS)

S1 Text. Willingness To Pay (WTP) estimation.
(DOCX)

S2 Text. Survey.
(PDF)

S3 Text. TBE vaccination probability estimation.
(DOCX)

S4 Text. Prediction of the effects of a TBE vaccine subsidy.
(DOCX)

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Author Contributions

Conceived and designed the experiments: DS. Performed the experiments: DS. Analyzed the data: DS. Contributed reagents/materials/analysis tools: DS. Wrote the paper: DS.

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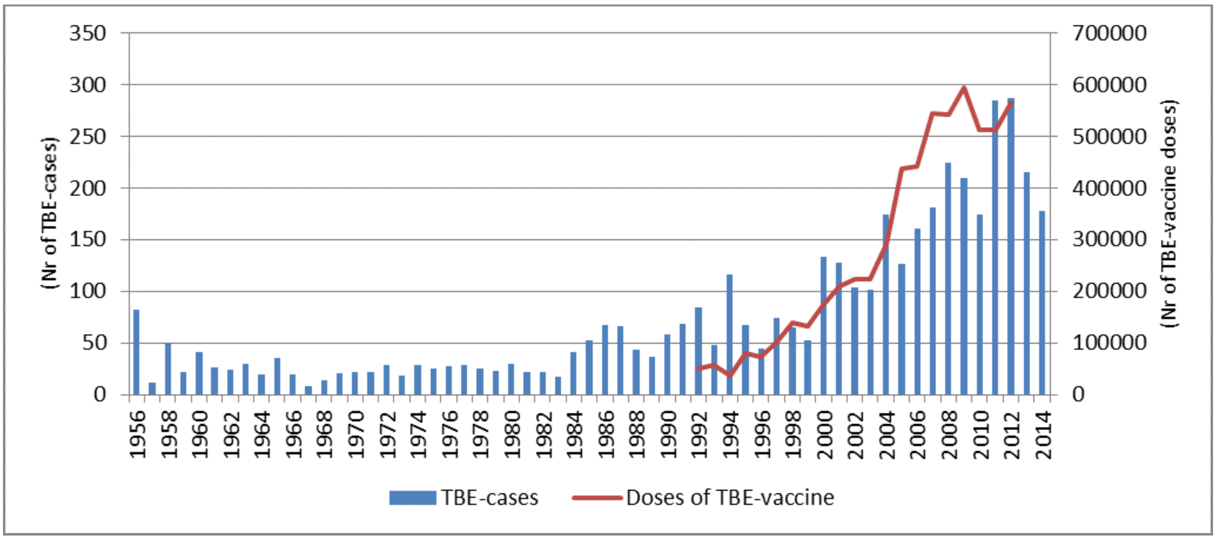
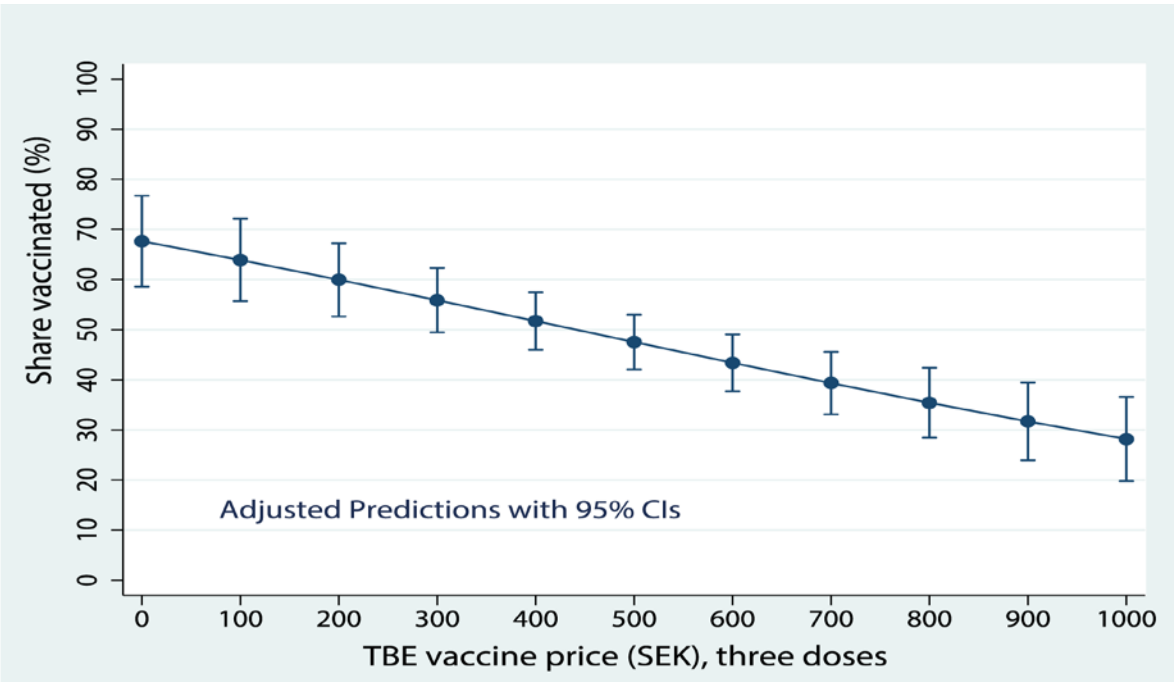
Supporting Information: Slunge (2015). The Willingness to Pay for Vaccination against Tick-Borne Encephalitis and Implications for Public Health Policy: Evidence from Sweden



Sources: TBE cases: Swedish Public Health Agency. Reported TBE Cases in Sweden 1954 - 2014. 2015. Vaccine doses: 1992-2004: Anell A, Glenngård AH. Vacciner i Sverige: ett hälsoekonomiskt perspektiv. Lund: Institutet för hälso- och sjukvårdsekonomi (IHE). 2007. 2005-2012: Baxter. TBE vaccine doses sold in Sweden 2005-2012. Market data obtained via email from the company in February 2013. 2013.

S1 Fig. Reported TBE cases 1956–2014 and number of TBE vaccine doses sold 1992–2012 in Sweden



S2 Fig. Predicted demand for TBE vaccination at different prices among unvaccinated respondents in TBE risk areas (prices in SEK for three doses of vaccine)

S1 Text Willingness To Pay (WTP) estimation

Estimation of non-parametric WTP

We estimate a non-parametric mean WTP ($E[WTP_n]$) with the Turnbull estimator as:

$E(WTP_n) = \sum_{j=1}^{J} \frac{n_j}{N_j}[B_j - B_{j-1}]$,

where J is the number of bids, B is the bid level, N_j is the number of respondents in the sample responding to bid B_j , and n_j is the number of respondents answering yes to bid B_j among N_j respondents. The non-parametric median WTP is the value of the bid that makes the respondents indifferent between accepting and rejecting the bid, i.e., the bid with a 0.5 probability of being accepted.

Table A displays parametric and non-parametric estimates of mean and median WTP for the three doses of TBE vaccine recommended for disease protection. The first estimate is for the whole sample of unvaccinated respondents (n=1,151) and the second for the unvaccinated respondents in TBE risk areas (n=389).

Table A. Estimated mean and median willingness to pay for TBE vaccination in SEK among unvaccinated respondents. 95% confidence intervals in parentheses.

	All Unvaccinated Respondents (n=1,151)		**Unvaccinated respondents in TBE risk areas** (n=389)	
	Mean	*Median*	*Mean*	*Median*
Parametric estimate	401 SEK (330 - 473)	401 SEK	465 SEK (334 - 595)	465 SEK
Non-parametric estimate	416 SEK	250 SEK	451 SEK	250 SEK

The median WTP non-parametric estimates are considerably lower than the estimated mean WTP. This is due to the relatively large share of respondents accepting the highest bid of 1,000 SEK for the vaccine.

Descriptive statistics for WTP estimates

Table B includes descriptive statistics for variables in the model presented in *Table 2 Determinants of Willingness to Pay for TBE vaccination* in the main article.

Table B Descriptive statistics for WTP estimates

	All Unvaccinated Respondents		Unvaccinated Respondents in TBE risk areas				
Variable	**Mean**	**S.D**	**Mean**	**S.D.**	**Min**	**Max**	**Definition**
Dependent variable							
Buy	0.45	0.50	0.48	0.50	0	1	1=states he/she would buy vaccine at stated price
Socioeconomic							
Female	0.54	0.50	0.55	0.50	0	1	1=female respondent
Age	50.44	16.81	49.62	16.55	18	80	Years
Income	42.03	22.04	41.81	20.98	5	115	Monthly household pre-tax income (1000 SEK)
University	0.50	0.50	0.44	0.50	0	1	1=has university degree
Urban	0.45	0.50	0.37	0.48	0	1	1=lives in city with>50 000 inhabitants
TBE risk in area of residence and summerhouse area							
TBE-incidence in area of residence	0.65	2.47	1.90	3.97	0	41.30	TBE-incidence in respondents living area
TBE risk summerhouse	0.12	0.32	0.16	0.37	0	1	1=spends time in summerhouse in area with >1 documented TBE cases
Behavioral risk							
Outdoor in TBE risk area	0.27	0.45	0.38	0.48	0	1	1=spends time in forests in areas with TBE risk
Risk of tick bite at work	0.08	0.27	0.10	0.30	0	1	1=risk to get tickbite while working
Knowledge and experience with ticks							
Knowledge	3.52	1.78	3.67	1.74	0	7	Nr of correct answers on the 7 knowledge questions
Tick bite ever	0.63	0.48	0.70	0.46	0	1	1=has had at least 1 tick bite
Tick-disease experience	0.40	0.49	0.46	0.50	0	1	1=the respondent or his/her family or friend has had tick-borne disease
Risk perception							
Health risk tick bite	0.36	0.48	0.43	0.50	0	1	1=tick bite perceived as very large/rather large risk to respondent or his/her family
Low trust in vaccine recommendations	0.20	0.40	0.22	0.41	0	1	1=low/very low trust in vaccine recommendations from health care institutions
Observations	1151		389				

Control for uncertainty of answers

To control for a potential hypothetical bias, respondents were asked how certain they were about their answers to the WTP question. Here, in Table C, we add a dummy variable ("Certainanswers") to the model presented in Table 2 in the main article; we find no significant differences in results for those stating they are rather certain or very certain about their answer to the question about WTP for TBE vaccination, compared to those stating they are rather uncertain or very uncertain about their answer.

Table C Control for uncertainty of answers

VARIABLES	(1) Not vaccinated respondents	(2) Not vaccinated respondents	(3) Not vaccinated respondents in TBE-risk areas	(4) Not vaccinated respondents in TBE-risk areas
Price	-0.046***	-0.046***	-0.042***	-0.043***
	(0.005)	(0.005)	(0.009)	(0.009)
Female	0.056*	0.056*	0.119**	0.122**
	(0.034)	(0.034)	(0.060)	(0.060)
Age	0.002**	0.002**	0.002	0.002
	(0.001)	(0.001)	(0.002)	(0.002)
Income	0.003***	0.003***	0.002	0.002
	(0.001)	(0.001)	(0.001)	(0.001)
University	-0.026	-0.026	0.038	0.042
	(0.034)	(0.034)	(0.060)	(0.060)
Urban	-0.050	-0.049	0.017	0.018
	(0.033)	(0.034)	(0.063)	(0.063)
TBE-incidence in area of residence	-0.000	-0.000	0.000	0.001
	(0.007)	(0.007)	(0.001)	(0.008)
TBE risk summerhouse	0.038	0.038	0.027	0.030
	(0.052)	(0.052)	(0.079)	(0.079)
Outdoor in TBE risk area	0.106***	0.106***	0.176***	0.168***
	(0.037)	(0.037)	(0.058)	(0.059)
Risk of tick bite at work	0.112*	0.112*	-0.053	-0.067
	(0.061)	(0.061)	(0.095)	(0.094)
Knowledge	0.027***	0.027***	-0.004	-0.004
	(0.010)	(0.010)	(0.018)	(0.018)
Tick bite ever	-0.060	-0.060	0.007	0.002
	(0.037)	(0.037)	(0.067)	(0.067)
Tick-disease experience	0.031	0.032	0.139**	0.138**
	(0.037)	(0.037)	(0.061)	(0.061)
Health risk tick bite	0.156***	0.156***	0.143**	0.157***
	(0.035)	(0.035)	(0.060)	(0.060)
Low trust in vaccine recommendations	-0.157***	-0.157***	-0.127*	-0.125*
	(0.038)	(0.038)	(0.067)	(0.067)
Certainanswers		0.011		-0.122
		(0.047)		(0.078)
Observations	1,132	1,132	381	381
PseudoR2	0,12	0,12	0,12	0,12

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Control for ordering effects

Besides the WTP for TBE vaccination question, the survey also included questions about WTP for a hypothetical vaccine against Lyme borreliosis as well as a choice experiment where respondents were asked to choose between recreational areas with different risks of being exposed to ticks and tick-borne diseases. In order to control for potential ordering effects, the three different stated preference questions were introduced to respondents in different choice orders. Each choice order was presented to one-quarter of the respondents (Table D).

Table D. Order of stated preference questions as presented to the respondents

Choice orders	Key
Order 1: CE. WTP Borrelia. WTP TBE	CE= Choice experiment
Order 2: WTP Borrelia. WTP TBE. CE	WTP Borrelia - soliciting WTP for hypothetical vaccine against Lyme borreliosis
Order 3: CE. WTP TBE. WTP Borrelia	
Order4: WTP TBE. WTP Borrelia. CE	WTP TBE - soliciting WTP for vaccine against TBE

When introducing a dummy variable for each choice order, we find a small ordering effect, significant at the 10% level among all respondents, but not among respondents in TBE risk areas (Table E). We conclude that the order in which the respondents answered the different choice questions does not significantly affect our estimated results.

Table E. Control for ordering effects in WTP TBE vaccination estimates

	(1) Not vaccinated respondents	(2) Not vaccinated respondents	(3) Not vaccinated respondents in TBE-risk areas	(4) Not vaccinated respondents in TBE-risk areas
VARIABLES	*BUY*	*BUY*	*BUY*	*BUY*
Price	-0.046***	-0.047***	-0.042***	-0.042***
	(0.005)	(0.005)	(0.009)	(0.009)
Female	0.059*	0.058*	0.119**	0.117**
	(0.033)	(0.033)	(0.059)	(0.059)
Age	0.002**	0.002**	0.002	0.002
	(0.001)	(0.001)	(0.002)	(0.002)
Income	0.003***	0.003***	0.002*	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
University	-0.026	-0.022	0.030	0.023
	(0.033)	(0.033)	(0.059)	(0.060)
Urban	-0.047	-0.049	0.017	0.021
	(0.033)	(0.033)	(0.063)	(0.063)
TBE incidence in area of residence	0.001	0.002	0.002	0.002
	(0.007)	(0.007)	(0.008)	(0.008)
TBE risk summerhouse	0.039	0.043	0.026	0.024
	(0.051)	(0.052)	(0.078)	(0.078)
Outdoor in TBE risk area	0.107***	0.110***	0.183***	0.179***
	(0.036)	(0.036)	(0.057)	(0.058)
Risk of tick bite at work	0.101*	0.105*	-0.044	-0.044
	(0.060)	(0.060)	(0.092)	(0.093)
Knowledge	0.025**	0.025**	-0.003	-0.003
	(0.010)	(0.010)	(0.018)	(0.018)
Tick bite ever	-0.055	-0.056	0.012	0.010
	(0.036)	(0.036)	(0.066)	(0.067)
Tick-disease experience	0.034	0.034	0.134**	0.136**
	(0.036)	(0.036)	(0.060)	(0.060)
Health risk tick bite	0.159***	0.156***	0.149**	0.149**
	(0.035)	(0.035)	(0.059)	(0.059)
Low trust in vaccine recommendations	-0.161***	-0.159***	-0.137**	-0.138**
	(0.038)	(0.038)	(0.066)	(0.066)
order2		0.067		-0.083
		(0.045)		(0.080)
order3		0.034		-0.015
		(0.044)		(0.074)
order4		0.085*		-0.027
		(0.045)		(0.077)
Observations	1.151	1.151	389	389

Standard errors in parentheses; *** p<0.01. ** p<0.05. * p<0.1

S2 Text Survey – *see Appendix B to thesis paper 1*

S3 Text TBE vaccination probability estimation

In this document, we provide background information for Section *3.3.* (*Who gets vaccinated against TBE?*) in the main article. First, we display tables with the regression models and summary statistics for the variables included. Next, we show that the results do not change when age and income are coded as continuous variables. Finally, we control for possible omitted variable bias.

TBE vaccination probability

Table A shows the results from the logit regression with *Vaccinated* as the dependent variable. The first and second columns include the results for respondents in the whole sample (n=1,526). The first column includes only the explanatory variables that are arguably exogenous to the decision to get vaccinated against TBE. The third and fourth columns include the results for respondents living in areas with low TBE risk (n=485) and high TBE risk (n=100), respectively. The fifth column shows the results for respondents who live outside areas with TBE risk (n=941). All explanatory variables in the model are binary, except for the continuous variables *TBE incidence in area of residence* and *Knowledge*. The marginal probabilities displayed show the marginal change in the probability of choosing to be vaccinated due to a marginal change in the explanatory variables at the sample mean. For the binary explanatory variables, this represents a change from 0 to 1. For example, the probability that a person in a low-income household in a TBE low-risk area (column 3) is vaccinated against TBE is 11.5 percentage points lower than for somebody in a household with higher income in the same area. The standard error of the presented marginal probabilities is in parentheses. Summary statistics is presented in Table B.

Table A. TBE vaccination – marginal probabilities after logit evaluated at sample means

	All respondents	All respondents	Respondents living in TBE-low risk areas	Respondents living in TBE-high risk areas	Respondents NOT living in TBE-risk areas
	(1)	(2)	(3)	(4)	(5)
VARIABLES	Vaccinated	Vaccinated	Vaccinated	Vaccinated	Vaccinated
Female	0.009	-0.014	-0.038	0.086	-0.004
	(0.022)	(0.022)	(0.043)	(0.153)	(0.021)
Age1830	0.001	0.036	0.176**	0.273	-0.020
	(0.034)	(0.036)	(0.080)	(0.200)	(0.028)
Age>65	0.104***	0.072***	0.177***	0.218	0.021
	(0.027)	(0.026)	(0.055)	(0.150)	(0.025)
Low income	-0.104***	-0.070***	-0.115*	-0.472***	-0.023
	(0.027)	(0.026)	(0.059)	(0.117)	(0.026)
University	0.061***	0.021	0.033	0.030	0.010
	(0.022)	(0.021)	(0.044)	(0.140)	(0.021)
Urban	0.070***	0.074***	0.020	0.148	0.098***
	(0.023)	(0.022)	(0.044)	(0.210)	(0.021)
TBE incidence in area or residence		0.013***	0.032	0.006	-0.056
		(0.004)	(0.024)	(0.010)	(0.455)
TBE risk summerhouse		0.112***	0.140**	-0.015	0.099***
		(0.031)	(0.055)	(0.171)	(0.036)
Outdoor in TBE risk area		0.195***	0.197***	0.570***	0.122***
		(0.024)	(0.043)	(0.106)	(0.028)
Risk of tick bite at work		0.098**	0.120	0.167	0.075
		(0.043)	(0.076)	(0.175)	(0.049)
Knowledge		0.048***	0.064***	0.052	0.036***
		(0.007)	(0.014)	(0.051)	(0.007)
Tick bite ever		0.071***	0.037	0.255	0.060***
		(0.024)	(0.052)	(0.191)	(0.023)
Tick-disease experience		0.030	0.079*	-0.004	0.008
		(0.023)	(0.045)	(0.173)	(0.023)
Health risk tick bite		0.063***	0.023	0.003	0.078***
		(0.023)	(0.043)	(0.158)	(0.025)
Low trust in vaccine recommendations		-0.058**	-0.118**	0.080	-0.032
		(0.025)	(0.047)	(0.197)	(0.025)
Constant	-1.649***	-4.410***	-4.193***	-4.268***	-4.832***
	(0.141)	(0.289)	(0.504)	(1.277)	(0.407)
Observations	1,526	1,526	485	100	941
Pseudo R2	0,03	0,24	0,21	0,36	0,23

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table B Extended summary statistics

	All respondents (1526 obs.)		Respondents in low risk areas (485 obs.)		Respondents in high risk areas (100 obs.)		Respondents NOT in risk areas (941 obs)			
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Min	Max
TBE vaccinated	0.24	0.43	0.29	0.45	0.55	0.50	0.18	0.39	0	1
Socioeconomic										
Female	0.53	0.50	0.52	0.50	0.58	0.50	0.53	0.50	0	1
Age	51.36	16.95	51.00	17.11	55.05	15.46	51.15	16.99	18	80
Age1830	0.14	0.35	0.14	0.34	0.06	0.24	0.15	0.36	0	1
Age>65	0.30	0.46	0.29	0.45	0.40	0.49	0.29	0.45	0	1
Income	44.1	23.0	45.1	22.4	46.5	23.5	43.4	23.2	5	115
Lowincome	0.14	0.34	0.11	0.31	0.14	0.35	0.15	0.36	0	1
University	0.52	0.50	0.50	0.50	0.44	0.50	0.55	0.50	0	1
Urban	0.47	0.50	0.41	0.49	0.15	0.36	0.54	0.50	0	1
TBE risk										
TBE incidence in residence area	1.11	4.05	0.84	0.87	12.80	9.95	0.01	0.02	0*	41
TBE risk residence area	0.38	0.49	1.00	0.00	1.00	0.00	0.00	0.00	0	1
High TBE risk residence area	0.07	0.25	0.00	0.00	1.00	0.00	0.00	0.00	0	1
TBE risk summerhouse	0.17	0.37	0.22	0.42	0.20	0.40	0.14	0.34	0	1
Behavioral risk										
Outdoor in TBErisk area	0.37	0.48	0.46	0.50	0.67	0.47	0.29	0.45	0	1
Risk of tick bite at work	0.10	0.29	0.11	0.32	0.17	0.38	0.08	0.27	0	1
Experience with ticks										
Tick bite ever	0.68	0.47	0.74	0.44	0.85	0.36	0.63	0.48	0	1
Tick disease experience	0.45	0.50	0.51	0.50	0.55	0.50	0.41	0.49	0	1
Knowledge and risk perceptions										
Knowledge	3.81	1.79	4.03	1.72	3.98	1.78	3.67	1.81	0	7
Health risk tick bite	0.42	0.49	0.45	0.50	0.62	0.49	0.38	0.48	0	1
Low trust vaccine recommendations	0.18	0.38	0.19	0.39	0.17	0.38	0.18	0.38	0	1

*In TBE-low risk areas, the minimum incidence is 0.11. In TBE-high risk areas, the minimum incidence is 5.1

Age and Income coded as continuous variables

Table C shows that age and income also are significantly associated with vaccination probability when coded as continuous variables

Table C. Age and Income coded as continuous variables

VARIABLES	(1) tbevaccinated	(2) tbevaccinated	(3) tbevaccinated	(4) tbevaccinated	(5) tbevaccinated
Female	0.016	-0.009	-0.016	0.057	-0.003
	(0.022)	(0.021)	(0.044)	(0.155)	(0.021)
Age	-0.011**	-0.014***	-0.024***	-0.036	-0.006
	(0.005)	(0.004)	(0.009)	(0.036)	(0.004)
Agesq	0.000***	0.000***	0.000***	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Income	0.003***	0.002***	0.003***	0.012***	0.001
	(0.000)	(0.000)	(0.001)	(0.004)	(0.000)
University	0.042*	0.010	0.013	-0.099	0.006
	(0.022)	(0.021)	(0.043)	(0.163)	(0.021)
Urban	0.061***	0.066***	-0.004	0.225	0.094***
	(0.022)	(0.022)	(0.044)	(0.194)	(0.022)
TBE incidence in residence area		0.012***	0.029	0.005	-0.066
		(0.003)	(0.024)	(0.009)	(0.425)
TBE risk summerhouse		0.108***	0.145**	0.109	0.091**
		(0.032)	(0.058)	(0.197)	(0.038)
Outdoor in TBE risk area		0.195***	0.203***	0.583***	0.125***
		(0.025)	(0.043)	(0.114)	(0.029)
Risk of tick bite at work		0.115***	0.153*	0.250	0.078
		(0.043)	(0.081)	(0.155)	(0.048)
Knowledge		0.046***	0.063***	0.056	0.035***
		(0.007)	(0.014)	(0.048)	(0.007)
Tick bite ever		0.068***	0.039	0.098	0.059**
		(0.024)	(0.053)	(0.232)	(0.023)
Tick disease experience		0.029	0.074*	-0.019	0.009
		(0.022)	(0.043)	(0.178)	(0.022)
Health risk tick bite		0.064***	0.023	0.080	0.079***
		(0.022)	(0.044)	(0.171)	(0.025)
Low trust in vaccine recommendations		-0.053**	-0.111**	0.131	-0.031
		(0.024)	(0.046)	(0.170)	(0.024)
Observations	1.526	1.526	485	100	941

Standard errors in parentheses; *** p<0.01. ** p<0.05. * p<0.1

Control for omitted variable bias

We control for potential omitted variable bias in our estimation of TBE vaccine adoption (Table D). Columns 1-4 are identical with Table A above (but with a slightly smaller sample size). In Columns 5-8, we include four additional dichotomous variables: Swedishborn (=1 if born in Sweden); Health (=1 if respondent rates his/her health status as good or very good on a 1-5 scale); Hightrusthealthcare (=1 if respondent has rather or very high trust in Swedish health care); and Outdoorpet (=1 if respondent has a cat, dog or other pet which is not only inside the house). When including these variables, the levels of significance for the variables included in Table A do not change.

Table D. Control for omitted variable bias

VARIABLES	(1) All respondents	(2) Respondents living in TBE-risk areas	(3) Respondents living in TBE-high risk areas	(4) Respondents NOT living in TBE-risk areas	(5) All respondents	(6) Respondents living in TBE-risk areas	(7) Respondents living in TBE-high risk areas	(8) Respondents NOT living in TBE-risk areas
Female	-0.014	-0.037	0.076	-0.005	-0.013	-0.043	0.072	-0.002
	(0.022)	(0.044)	(0.150)	(0.022)	(0.022)	(0.044)	(0.156)	(0.021)
Age1830	0.027	0.154*	0.279	-0.021	0.023	0.147*	0.218	-0.024
	(0.035)	(0.082)	(0.234)	(0.029)	(0.035)	(0.082)	(0.263)	(0.028)
Age>65	0.068***	0.165***	0.184	0.022	0.068***	0.175***	0.113	0.019
	(0.026)	(0.056)	(0.158)	(0.026)	(0.026)	(0.057)	(0.177)	(0.025)
Low income	-0.070***	-0.106*	-0.523***	-0.023	-0.064**	-0.095	-0.581***	-0.014
	(0.026)	(0.058)	(0.117)	(0.027)	(0.027)	(0.060)	(0.107)	(0.028)
University	0.027	0.042	0.051	0.012	0.024	0.042	0.114	0.002
	(0.021)	(0.043)	(0.146)	(0.021)	(0.021)	(0.042)	(0.156)	(0.022)
Urban	0.071***	0.013	0.174	0.097***	0.070***	0.023	0.119	0.088***
	(0.022)	(0.044)	(0.211)	(0.022)	(0.023)	(0.045)	(0.224)	(0.023)
TBE-incidence residence area	0.013***	0.033	0.007	-0.061	0.013***	0.034	0.007	-0.016
	(0.003)	(0.024)	(0.009)	(0.435)	(0.003)	(0.024)	(0.010)	(0.434)
TBE-risk summerhouse	0.117***	0.139**	0.004	0.108***	0.114***	0.142**	-0.058	0.099**
	(0.033)	(0.056)	(0.196)	(0.040)	(0.033)	(0.057)	(0.203)	(0.039)
Outdoor in TBE-risk area	0.194***	0.197***	0.543***	0.126***	0.192***	0.192***	0.562***	0.123***

VARIABLES	(1) All respondents	(2) Respondents living in TBE-risk areas	(3) Respondents living in TBE-high risk areas	(4) Respondents NOT living in TBE-risk areas	(5) All respondents	(6) Respondents living in TBE-risk areas	(7) Respondents living in TBE-high risk areas	(8) Respondents NOT living in TBE-risk areas
	(0.025)	(0.043)	(0.116)	(0.029)	(0.025)	(0.043)	(0.124)	(0.029)
Risk of tick bite at work	0.091**	0.108	0.195	0.073	0.092**	0.097	0.100	0.074
	(0.041)	(0.077)	(0.167)	(0.048)	(0.041)	(0.076)	(0.196)	(0.047)
Knowledge	0.047***	0.063***	0.050	0.036***	0.047***	0.065***	0.0447	0.034***
	(0.007)	(0.014)	(0.047)	(0.007)	(0.007)	(0.014)	(0.050)	(0.007)
Tick bite ever	0.067***	0.030	0.261	0.058**	0.070***	0.030	0.337*	0.059**
	(0.024)	(0.054)	(0.193)	(0.024)	(0.024)	(0.054)	(0.191)	(0.023)
Tick disease experience	0.030	0.083*	-0.023	0.006	0.029	0.087**	-0.035	0.006
	(0.022)	(0.044)	(0.172)	(0.023)	(0.022)	(0.044)	(0.180)	(0.023)
Healt risk tick bite	0.066***	0.031	0.005	0.080***	0.070***	0.032	-0.002	0.087***
	(0.023)	(0.044)	(0.160)	(0.025)	(0.023)	(0.043)	(0.173)	(0.025)
Low trust in vaccine recommendations	-0.060**	-0.124***	0.091	-0.033	-0.055**	-0.128***	0.130	-0.017
	(0.024)	(0.045)	(0.180)	(0.025)	(0.025)	(0.045)	(0.190)	(0.028)
Swedishborn					0.019	-0.058	0.0721	0.050
					(0.044)	(0.108)	(0.245)	(0.036)
Health					0.020	0.028	-0.149	0.022
					(0.014)	(0.026)	(0.106)	(0.014)
High trust in health care					0.009	-0.017	0.272*	0.019
					(0.023)	(0.046)	(0.155)	(0.023)
Outdoor pet					-0.004	0.078*	0.026	-0.036
					(0.023)	(0.047)	(0.172)	(0.023)
Observations	1,504	476	98	930	1,504	476	8	930

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

S4 Text Prediction of the effects of a TBE vaccine subsidy

In this document, we describe how we calculate the effects on vaccination rates of a possible TBE vaccine subsidy. Next, we control for potential hypothetical bias by only including those who state they were rather certain or very certain in their response to the WTP question. Finally, we separate those with a positive WTP from those with zero WTP in our calculations of predicted vaccination rates.

Estimation of the effect of a possible subsidy

The current vaccination rate is derived from our survey. In TBE risk areas, the vaccination rate is 33% (CI95 30-37%).

We use the margins command in STATA to predict the effects of a possible subsidy on the demand for TBE vaccination in TBE risk areas.

We use *population mean* instead of sample mean for age (=49) female (=0.5) and income (=40600). For the other variables, we use sample means (S1 Text Willingness To Pay (WTP) estimation). We first make predictions for respondents in TBE risk areas and then for all unvaccinated respondents.

. quietly logit yesbidtbe bidtbe female age income university urban tberisk summerhouserisk outTBEarea worktickrisk knowledge tickbiteever diseaseexperience healthrisktickbite lowtrustvaccine if tberiskhome==1

. margins, at (bidtbe=(0 5.25)age=49 female=0.5 income=40.6) atmeans post

Adjusted predictions Number of obs = 389

	Margin	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
_at						
1	.6766442	.0462551	14.63	0.000	.5859859	.7673025
2	.4649515	.0279448	16.64	0.000	.4101807	.5197224

1. The predicted vaccination rate among the unvaccinated in TBE risk areas at full subsidy, price zero = 68% (CI95 59-77%)
2. The predicted vaccination rate among the unvaccinated in TBE risk areas at 50% subsidy, price 525 = 46% (CI95 41-52%)

Based on our estimated vaccination rate of 33% among all respondents, we find the following predicted total vaccination rates, with a full subsidy and a 50% subsidy respectively, in TBE risk areas:

<u>Full subsidy:</u> Out of the 584 respondents in TBE risk areas, 389 are unvaccinated. With a full subsidy, 68% (0.68*389=265 respondents) of the unvaccinated would get vaccinated. This corresponds to 45% (265/584) of the total number of respondents in TBE risk areas. The new vaccination rate with the full subsidy would be 33%+45%=78%.

<u>50% subsidy:</u> With a 50% subsidy, 46.5% (0.465*389=181 respondents) of the unvaccinated respondents would get vaccinated. This corresponds to 31% (181/584) of the total number of respondents in TBE risk areas. The new vaccination rate with the 50% subsidy would be 33%+31%=64%.

This information is displayed in Table 3 in the paper.

Predictions for all unvaccinated respondents

. quietly logit yesbidtbe bidtbe female age income university urban tberisk summerhouserisk outTBEarea worktickrisk knowledge tickbiteever diseaseexperience healthrisktickbite lowtrustvaccine

. margins, at (bidtbe=(0 5.25)age=49 female=0.5 income=40.6) atmeans post

Adjusted predictions Number of obs = 1151

	Margin	Delta-method Std. Err.	z	P>|z|	[95% Conf. Interval]	
_at						
1	.6698401	.0271847	24.64	0.000	.6165591	.723121
2	.4329932	.0161237	26.85	0.000	.4013914	.464595

1. The predicted vaccination rate among all unvaccinated respondents at full subsidy, price zero = 67% (CI95 62-72%)
2. The predicted vaccination rate among the unvaccinated in TBE risk areas at 50% subsidy, price 525 = 43% (CI95 40-46%)

Based on our estimated vaccination rate of 25% among all respondents, we find the following predicted total vaccination rates with a full subsidy and a 50% subsidy:

<u>Full subsidy:</u> Out of the 1526 respondents in our sample, 1151 are unvaccinated (75%). With a full subsidy, 67% (771 respondents) of the unvaccinated would get vaccinated. This corresponds to 51% (771/1526) of the total number of respondents in TBE risk areas. The new vaccination rate with the full subsidy would be 25+51=76%.

<u>50% subsidy:</u> With a 50% subsidy, 43% of the unvaccinated (495) respondents would get vaccinated. 495/1526=32%. The new vaccination rate would be 25%+32%=57%.

These predicted vaccination rates are not included in the paper.

Control for uncertainty of answer

We control for potential hypothetical bias in our estimates of effects of a vaccine subsidy in TBE risk areas by including only those who state they were rather certain or very certain in their response to the WTP question. When excluding the 56 respondents (out of 389) who were rather or very uncertain about their responses to the WTP question, we find:

- the same effect of a full subsidy on vaccination rates – 68%
- a 2 percentage point lower predicted vaccination rate – 44% compared to 46% - with a 50% subsidy

We conclude that our ex post control does not raise a concern that our estimates are influenced by hypothetical bias.

Respondents with Zero WTP for a TBE vaccine

13% of the unvaccinated respondents living in areas with TBE risk state that they would not get vaccinated even if the vaccine was free of charge.

We separate these respondents from those respondents with a positive willingness to pay in an estimate of the predicted vaccination rate with a subsidized vaccine, using the same model as above.

We find that the predicted vaccination rate with a full subsidy in TBE risk areas increases by 1 percentage point to 79% and that the predicted vaccination rate with a 50% subsidy increases by 1 percentage point to 65%.

We conclude that analyzing those with zero WTP separately from those with positive WTP, compared to analyzing them jointly, gives similar predicted vaccination rates.

Paper IV

PUBLIC ADMINISTRATION AND DEVELOPMENT

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GREENING GROWTH THROUGH STRATEGIC ENVIRONMENTAL ASSESSMENT OF SECTOR REFORMS

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SUMMARY

Climate change and escalating degradation of ecosystem services place the need for greening economic growth on the international policy agenda. To make growth greener and more inclusive, it is crucial to change the institutions and incentive structures in national sector reforms and to involve poor and vulnerable groups in decision making. The article analyses the role that strategic environmental assessment (SEA) of sector reforms can play in greening growth in developing countries and discusses implications for public administrations. We suggest that SEA can contribute to greening growth if it draws attention to environmental priorities when the sector reform agenda is set, fosters policy learning processes through repeated and sustained stakeholder interaction and facilitates access to information and empowerment of environmental constituencies. The empirical basis for the article is drawn from a recent World Bank pilot programme involving SEAs of different sector reforms (mining, forestry, urban planning, infrastructure) in Africa (Kenya, Malawi, Sierra Leone, Guinea, Liberia) and Asia (China, Bangladesh and Pakistan).

KEY WORDS—strategic environmental assessment; green growth; governance; institutions; sector reform; World Bank

INTRODUCTION

The need for greening economic growth[1] is receiving increasing recognition in international policy discourse. This interest comes from a better understanding of the economic costs associated with climate change and loss of ecosystem services and the opportunities of a greener growth process such as green jobs creation and the fostering of technological change (World Bank, 2010a; OECD, 2011; UNEP, 2011). However, despite the pressing need for greening growth, there are several reasons why the quest for ‘getting the prices right’ and other measures for greening growth suggested by international organisations may not translate into practical action at the national and sector level in developing countries.[2]

First, the *information* on the state and economic value of ecosystem services and environmental assets is typically very limited in developing countries. It is hence difficult for decision makers interested in greening growth to know how to design optimal taxes or other policy instruments that obtain ‘the prices right’ so that environmental costs are internalised in public and private decision making. Although national statistics bureaus closely monitor economic indicators such as gross domestic product growth, inflation and exports, most developing countries lack even rudimentary data on important environmental assets, and regular monitoring and reporting is rare.

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[1]There is no unanimous definition of green growth. The World Bank states that it is about ‘making growth processes resource-efficient, cleaner and more resilient without necessarily slowing them’ (Hallegatte *et al*., 2011). Organisation for Economic Co-operation and Development states that ‘green growth is about fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. It is also about fostering investment and innovation, which will underpin sustained growth and give rise to new economic opportunities (OECD, 2011).

[2]Low and middle income countries.

Second, the *institutions* shaping national and sector decision making often favour business as usual and vested interests rather than green growth.[3] Because greening sector reforms (e.g. mining, infrastructure, forestry) typically would need to bring about significant changes in institutions and policies, they are sensitive political processes that often are resisted by strong economic interests.[4] Weak institutions are increasingly put forward as a key explanation behind the failure of many developing countries to translate natural resources wealth into sustained economic growth and poverty reduction (Mehlum *et al*., 2006; Collier, 2010). This echoes the mounting attention within social science research during the last decades to the fundamental role of institutions and good governance for economic growth and poverty reduction (World Bank, 2003; Acemoglu *et al*., 2001; Rodrik *et al*., 2004; Ostrom, 2005). A troubling finding from this research is that institutions tend to be persistent to change because of the slow changing nature of norms and other informal rules (North, 1990; Williamson, 2000) and because economically and politically powerful groups benefitting from the current institutional settings effectively can block reform processes (Acemoglu *et al*., 2004; Acemoglu and Robinson, 2008). The absence of well-defined and enforced property rights are often highlighted as a crucial institutional constraint to economic growth as well as environmental management (Ostrom, 1990; Rodrik, 2000). However, obstacles to greening growth may encompass a variety of other institutional constraints, such as badly designed environmental protection laws or dysfunctional participatory and coordinating institutions, which constrain the possibilities of weaker stakeholders to make their voices heard and promote political and institutional change (Bardhan, 2005). As Rodrik (2006) has pointed out, the institutional constraints to growth vary between different countries and sectors and need to be identified in a context specific analysis.

Third, the *incentives* for key decision makers to promote a greener growth are often weak. Although the economic and social benefits of sector growth in terms of employment, exports and tax revenue are often tangible in the short term, the environmental costs or benefits tend to be more long term and elusive. Moreover, environmental costs of degrading open access type environmental assets such as the climate, oceans and forests can be transferred to other stakeholders, distant in time or space or weakly organised to represent their interests (Hardin, 1968; Ostrom, 2005; Sterner and Coria, 2012). As a result, the costs in terms of health effects from industrial pollution or environmental degradation are often disproportionally carried by the poor and weaker stakeholders (Baumol and Oates, 1975; World Bank, 2005; Sterner and Coria, 2012). Although greening growth can have positive social outcomes on citizens who benefit from reduced pollution or environmental degradation, in some situations, there is a clear trade-off between greening growth and social objectives. For example, meeting growing energy demands with renewable energy sources instead of cheap coal can lead to increased energy costs for poor households. Because the climate is a public good, the incentives for individual countries to switch into a less carbon intensive growth path are weak.[5]

For many developing countries, greening growth is hence very challenging because it entails addressing the poor level of information on environmental assets, resisting political pressure from powerful interests as well as strengthening institutions and incentives for environmental management and balancing environmental and social priorities. The political attention to greening growth may in some contexts prove to create a window of opportunity for integrating environmental concerns in sector reforms, but generally, the expectations on rapid change should be modest. In order to green growth, public administrations in developing countries will need to work systematically and in a sustained effort making use of a range of approaches and policy instruments.

There are, in principle, many policy instruments available for making growth greener, including the creation of property rights, environmental laws and funds for innovation as well as instruments that help set right the price signals related to resource use and pollution. However, politics also has its failures and policy makers often have a hard time enacting and enforcing appropriate policies such as pollution and resource taxes. The key question of this article is

[3]Following North (1990), we interpret institutions broadly as the humanly designed constraints that structure human interaction. They are made up of formal constraints (e.g. rules, laws, constitutions), informal constraints (e.g. norms of behaviour, conventions, self-imposed codes of conduct), and their enforcement characteristics. Together they define the incentive structure of societies and specifically economies.
[4]Removal of subsidies to fossil fuels is an example of a green growth policy initiative that is frequently blocked by interest groups benefitting from status quo, although the reform would be beneficial from both an environmental and social point of view (Coady *et al*., 2006; Sterner, 2012).
[5]One should thus not overstate the possibilities to pursue low carbon development strategies without the presence of an international agreement on climate change (Sterner and Damon, 2011).

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whether subjecting policy processes to extended analysis and stakeholder engagement—through strategic environmental assessment (SEA)—can help in addressing the challenges relating to information, institutions and incentives discussed above and facilitate implementation of policy instruments that would make growth greener.

The rationale for focusing on SEA is that a growing number of public administrations are using SEA to enhance environmental integration in strategic planning and decision making. We focus on sector reforms because this is arguably where the institutions, policies and budgets that matter most for economic growth are shaped, where vested interests are most clearly manifested and where it is particularly difficult to integrate environmental concerns in decision making.[6] The article builds mainly on the findings from an evaluation of a recent World Bank pilot programme involving seven SEAs. While these cases do not constitute a representative sample in a statistical sense they represent a variety of sector reforms (mining, forestry, urban planning, infrastructure) and national contexts in Africa (Kenya, Malawi, Sierra Leone, Guinea, Liberia) and Asia (China, Bangladesh and Pakistan) (Loayza *et al*., 2011, World Bank *et al*., 2011). Based on the findings from the evaluation, experiences from the use of SEA in other reform processes in developing countries (e.g. OECD, 2012) and an extensive literature review (Slunge *et al*., 2011a) we discuss key implications for developing country public administrations intending to use SEA for greening growth.

The article continues as follows. The next section describes the origin and rapid development of SEA. It then discusses mechanisms through which SEA potentially can contribute to greening growth and contrasts this with the findings from the World Bank pilot programme on the actual influence SEAs have had in specific cases of sector reform and the role of context for this influence. The article proceeds with a discussion of key implications for the introduction and use of SEA by public administrations in developing countries. The last section concludes.

WHAT IS STRATEGIC ENVIRONMENTAL ASSESSMENT?

Rather than being a specific tool or methodology, the OECD describes SEA as '*...analytical and participatory approaches to strategic decision-making that aim to integrate environmental considerations into policies, plans and programmes, and evaluate the inter linkages with economic and social considerations*' (OECD, 2006). Originally, SEA was designed as an extension of environmental impact assessment (EIA) of projects to plans, programmes and policies. Most countries' SEA legislation fall under and extends existing EIA legislation to programmes and plans but in most cases not to the policy level. For example, the European Union SEA directive[7] requires that environmental assessments are conducted for plans and programmes. Many developing countries have recently adopted legislations or regulations on SEA, and the use of SEA is increasing rapidly (Ahmed and Fiadjoe, 2006; OECD, 2012). Most SEAs have been undertaken in support of programmes and land use plans. Application of SEA in policies has been sparse but recently its use in developing countries has increased mainly to incorporate environmental considerations in environmentally sensitive sectors such as mining, transports and forestry. Several development agencies and banks use SEA to enhance the integration of environmental considerations in reform processes they support (OECD, 2012). For example, the World Bank has experience from supporting SEAs of sector reforms in a diverse set of countries since the early 1990s (Kjorven and Lindhjem, 2002; World Bank, 2005). Climate change may further encourage the use of SEA in policy and sector reform. For example, the Forestry Carbon Partnership Facility and UN REDD[8] use policy SEA approaches in the preparation of country strategies for the reduction of deforestation and forest degradation (FCPF, 2011; Slunge *et al*., 2011a).

HOW CAN STRATEGIC ENVIRONMENTAL ASSESSMENT CONTRIBUTE TO GREENING OF SECTOR REFORMS?

Since the late 1990s, there has been a transition in the scholarly debate about the role of environmental assessment. This debate was earlier heavily influenced by technically oriented approaches, and a conviction that improved

[6]Already the Brundtland commission noted that 'those responsible for managing natural resources and protecting the environment are institutionally separated from those responsible for managing the economy. The real world of interlocked economic and ecological systems will not change; the policies and institutions concerned must' (WCED, 1987).
[7]Directive 2001/42/EC.
[8]The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries.

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information would lead to better decisions by rational decision makers. The failure of assessment procedures to live up to these expectations resulted in a growing interest in political science and policy formulations models (e.g. those developed by Simon, 1957; Lindblom, 1959; Cohen *et al*., 1972; Sabatier, 1988; Kingdon, 1984) to explain the influence of assessments on policy making. The role of institutions and governance conditions, the non-linearity of public decision making and the potential role that participation, deliberation and learning could have for improving outcomes is highlighted in more recent analyses of the links between environmental assessments and policy making. Instead of directly influencing the plan or policy being subject to an assessment through technically oriented recommendations, the effectiveness of the assessment process would also depend on its ability to contribute to policy learning and to foster institutional and governance change (Kornov and Thissen, 2000; Owens *et al*., 2004; Ahmed and Sánchez-Triana, 2008; Bina, 2008; Nilsson and Nykvist, 2009).

Building on these new views on environmental assessment and the growing recognition of the central role of institutions for sustainable development, the World Bank (2005) suggested that SEA needs to primarily focus on influencing institutional and governance conditions framing policy and sector reform processes rather than on detailed assessments of environmental impacts. SEA would have the potential to influence strategic decision making through focusing on four intermediary outcomes as follows: (World Bank, 2005; Ahmed and Sánchez-Triana, 2008) (i) raised attention to environmental priorities; (ii) strengthened environmental constituencies; (iii) enhanced social accountability; and (iv) policy learning. Figure 1 contains a conceptual model describing how SEA, involving substantive analytical work and stakeholder engagement (1) can result in the four intermediary outcomes (2) By, on the one hand, facilitating the agglomeration of dispersed environmental interests and concerns into a coherent demand for enhanced environmental stewardship and, on the other hand, by expanding the policy capacity and broadening the policy horizons of decision makers (3) conditions for improved integration of key environmental concerns in policy formulation and implementation (4), and ultimately greener growth (5) can be created. Contextual factors (6), which facilitate or hinder the contribution of SEA to greening of growth are discussed in the next section.

Raising attention to environmental priorities

Typically an SEA includes a careful compilation of data and analysis of current and potential environmental impacts of different development alternatives (Therivél, 2010; Sadler *et al*., 2011). Given the weak knowledge base on environmental assets in many developing countries, an improvement in the knowledge base can be of great importance for green growth. But, just providing documents with technical information on environmental impacts to policy makers

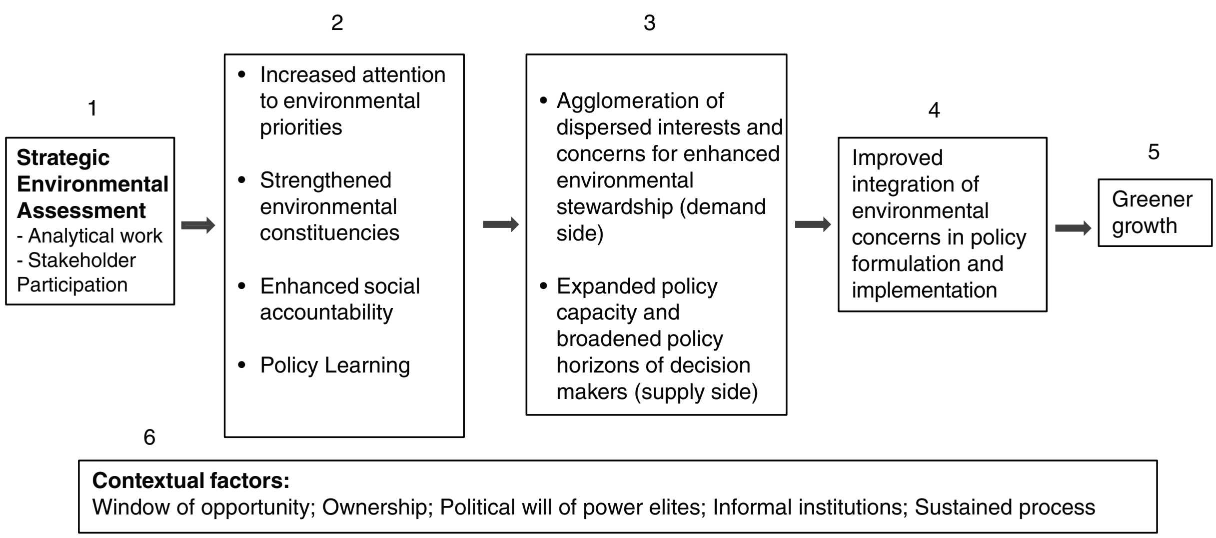

Figure 1. Conceptual model linking strategic environmental assessment and green growth.

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is rarely sufficient to make them play a role in the policy-making process. In order to put environmental issues on the sector reform agenda, it is important to make them politically attractive through linking them to economic growth, poverty reduction and other development priorities issues (World Bank, 2005; Ahmed and Sánchez-Triana, 2008).

Strengthening environmental constituencies

Through opening up the policy process to a broader set of stakeholders and creating space for interaction and deliberation about environmental risks and opportunities related to the sector reform, SEA can empower constituencies with environmental stakes in the policy process. Such groups or networks organised around a common environmental concern affected by the policy process constitute a critical force for integrating environmental considerations in policy reform. Civil society and community-based organisations, the media and the legislature are examples of actors that may form important parts of constituencies for environmental change (World Bank, 2005; Blair, 2008; Feldman and Khademian, 2008). Without strengthened constituencies that can demand accountability with regard to environmental priorities, integration of these concerns in policy reform risk being short-lived. Poor communities, indigenous groups or other marginalized stakeholders are typically not involved in or listened to in policy making processes. The dispersion of these groups creates constraints for their collective organization, and they are thus easily sidelined in policy dialogue by more powerful stakeholders. Through engaging these stakeholders, SEA can potentially contribute to both a greener and more inclusive growth process (World Bank, 2005; Feldman and Khademian, 2008; Kende-Robb and Van Wicklin, 2008).

Enhancing social accountability

By facilitating a more inclusive policy process and providing stakeholders with access to information about environmental and social risks related to the sector reform, SEA can enable stakeholders to hold decision makers as well as implementing agencies to account (Blair, 2008). SEA processes can also highlight underlying legislation and implementation practices that obstruct information disclosure, public participation and access to justice on environmental matters (Ahmed and Sánchez-Triana, 2008).

Policy learning

Taking into account that a specific SEA is a rather limited intervention in scope and time, its ability to induce a policy learning process is crucial for catalysing a broader and more long-term change process. Through providing a forum for repeated interaction and deliberation, SEA can create communities of participation, which facilitate trust building and sharing of problem perceptions among stakeholders. Under the right conditions, stakeholders can start to deal with the complex problems and responses to environmental issues related to the sector reform and share policy dilemmas and trade-offs (Feldman and Khademian, 2008; Loayza & Albarracin-Jordan, 2010; World Bank *et al*., 2011). Constituency strengthening and improved social accountability constitute important mechanisms for facilitating policy learning beyond the completion of the SEA. SEA can also contribute to policy learning through setting up publicly available systems for monitoring and evaluation of environmental and social aspects related to sector reform implementation (World Bank, 2005; Ebrahim, 2008). Although the effect of a single SEA on policy learning is usually limited, the cumulative effect of repeatedly using SEA in policy reform may be considerable (Nooteboom, 2007; Ahmed and Sánchez-Triana, 2008).

FINDINGS FROM THE WORLD BANK PILOT PROGRAMME ON STRATEGIC ENVIRONMENTAL ASSESSMENT OF SECTOR REFORMS

The World Bank initiated in 2005 a pilot programme on SEA to test, learn and promote SEA approaches in policies, high level planning and sector reforms. The first phase of the pilot programme involved undertaking seven SEAs in various developing countries. As can be seen in Table 1, the SEAs were conducted in a variety of sectors and in partnership with national counterparts. In several cases, notably the three mining sector reform cases, the assessments explicitly included both environmental and social issues. This was mainly because the national counterparts favoured such integrated assessments.

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Table 1. Strategic environmental assessments conducted as part of the World Bank pilot programme

SEA	Country and national counterpart	Sector	SEA undertaken	Evaluation finalised
SEA of Kenya Forests Act	Kenya; Forest Reform Committee	Forestry	2005–2007	March 2010
West Africa Minerals Sector Strategic Assessment	Guinea, Liberia, Sierra Leone; Mano River Union, Economic Community of West African States, West African Monetary Union	Minerals	2008–2010	February 2010
Strategic Environmental and Social Assessment of the Sierra Leone Mining Sector Reform	Sierra Leone; Environmental Protection Agency	Minerals	2006–2007	June 2009
Strategic Environmental and Social Assessment of Malawi Minerals sector reform	Malawi; Ministry of Energy and Mines	Minerals	2009	January 2010
SEA of Dhaka Metropolitan Development Plan	Bangladesh; Capital Development Authority	Urban planning	2006–2007	November 2009
SEA of Hubei Road Transport Sector	China; Hubei Provincial Communication Department	Transport	2007–2009	January 2010
The Pakistan Strategic Environmental, Poverty and Social Assessment of the Trade and Transport Sector	Pakistan; the Pakistan Planning Commission	Transport Infrastructure Trade	2009–2011	Not evaluated*

SEA, strategic environmental assessments.
*Because of political instability, it was not possible to conduct a formal evaluation of the SEA in Pakistan.

All SEAs involved substantive analytical work and stakeholder engagement with a special focus on analysing and strengthening institutions and governance frameworks for the management of environmental concerns in sector reforms. For example, the analytical work in the SEA of the forest sector reform in Kenya included a situation analysis identifying crucial social, environmental and governance factors for the implementation of the new Forests Act. In a special political economy analysis, potential winners and losers and hurdles to reform implementation were identified. Stakeholders were involved mainly through interviews, focus groups and three large workshops were representatives from government, private sector, academia, civil society and community-based organisation were asked to discuss and identify environmental policy priorities for the reform process. The final stage of the SEA involved the preparation of a Policy Action Matrix with priority action areas which were discussed at the final workshop, with the intention of obtaining commitments from key stakeholders to taking the priority actions forward (World Bank, 2007).

One of the other SEAs in the pilot programme, the West Africa Minerals Sector Strategic Assessment (WAMSSA), looked at mining sector reform from a regional perspective. WAMSSA was a regional SEA that comprised the Manu River Union countries of Guinea, Liberia and Sierra Leone. Its main objective was to assist these countries in using their large untapped mineral wealth for promoting sustainable development taking advantage of economies of scale associated to mining development. WAMSSA identified three large potential 'mining-infrastructure clusters' and assessed the common environmental, social, and sector governance issues critical for the development of these clusters. The strategic assessment involved an extensive and detailed consultation process that consisted of focus group meetings in all three national capitals; community surveys and meetings undertaken in 10 mining communities in the three countries; national workshops to select and rank environmental and social priorities, as well as to identify key policy and institutional adjustments to be incorporated in mining reform; and a final validation workshop. The assessment included an institutional

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analysis to examine the institutional, legal and governance gaps that needed to be overcome in order for the regional cluster approach to be able to address the priorities identified by stakeholders (World Bank, 2010c).

In the second phase of the pilot programme, each of the SEAs was evaluated (World Bank *et al*., 2011).[9] Evaluating the influence of an SEA on a sector reform is complicated by the many different influencing factors and the difficulties in attributing an observed change to the SEA. When the evaluations took place, it was too early to draw definite conclusions about the extent to which the SEAs had contributed to deeper policy learning around environmental issues and to broader changes in institutions and governance conditions. Such effects can take years to become apparent and are best studied over a decade or so (Sabatier, 1988). Taking these difficulties into consideration, the evaluation focused on identifying the influence of the SEAs on the intermediary outcomes as defined previously (item two in Figure 1) and on identifying contextual factors, which facilitated or hindered the influence of the SEAs on these outcomes.

The evaluation found that SEAs involving substantial analytical work and stakeholder engagement can contribute to the integration of environmental—and in some cases also social—concerns in sector policy formulation and implementation. The relevance of focusing on the four intermediary outcomes was largely validated by the evaluation, but not surprisingly, there were large variations in the influence of the different SEAs. Table 2 summarises the influence of the SEAs on these outcomes.

The level of attention paid to environmental priorities in the reform process

All SEAs included elaborate analytical work and stakeholder participation to identify, rank and attract attention to environmental priorities. This contributed to improved dialogue over environmental and social issues in all sector reform processes, although to various extent. In some cases, notably the SEAs in West Africa (WAMSSA) and Malawi, the strategic environmental and social assessments provided a new opportunity for environmental and social concerns related to mining sector activities to be openly discussed and placed on the policy reform agenda. WAMSSA created support for a multi country mining development process by showing the benefits of developing mining-infrastructure clusters that can also help in addressing critical environmental risks such as the fragmentation and degradation of the Upper Guinea forest (World Bank, 2010c). The pilot in Dhaka was less successful because marginalised groups were not duly represented in the priority setting process. This may explain why important issues such as vulnerability to climate change were neglected.

Strengthening of constituencies with environmental concerns

There are several examples where the SEAs contributed to strengthening constituencies (primarily civil society organisations) through improving their access to information and providing opportunities to engage in policy dialogues on environmental concerns. However, the scope of the SEAs was generally too limited to be able to empower environmental constituencies in a substantial way. A lesson learned is that properly involving marginalised stakeholders and constituency-building require substantial time and resources as well as culturally sensitive practices to be effective. An SEA can have some empowering effect on environmental constituencies, but continuous support after SEA completion is required.

The level of social accountability surrounding the reform process

The information generated by the SEAs through the analysis of environmental priorities and engagement with stakeholders generally led to improved accountability but again, to various extent. Several of the SEAs led to the establishment of monitoring frameworks for how environmental and social concerns are managed during sector reform implementation. These were agreed upon in multi-stakeholder dialogues and provided stakeholders, mainly

[9]The Swedish EIA Centre at the Swedish University of Agricultural Sciences, the Environmental Economics Unit at the University of Gothenburg and the Netherlands Commission for Environmental Assessment were invited by the World Bank to join in the evaluation of the SEAs. The evaluations were undertaken using a joint analytical framework (Slunge *et al*., 2011b) and included semi-structured interviews with stakeholders and policy makers involved in the respective SEAs and sector reform processes.

Table 2. Outcomes of SEAs on sector reform processes

SEA Pilot	Attention to environmental priorities	Stakeholder involvement and strengthening of constituencies	Social accountability	Policy learning
Kenya ForestsActSEA	Nation-wide stakeholder workshops facilitated ranking of environmental and social priorities, and reinforced the need to adequately address these priorities. Stakeholder consensus around the identified priorities manifested by the formulation of the nation-wide Forest Policy Action Matrix (in which government agencies and other actors commit themselves to a set of actions).	By bringing in local and arguably less powerful and influential stakeholders in the SEA-process (such as NGOs, CBOs, local community representatives) a more level playing field was created for the discussions and prioritization of actions.	Stakeholder workshops and open discussions brought up accountability issues as well as encouraged development of practices which may improve social accountability. With the formulation of the Forest Policy Action Matrix, the SEA provided stakeholders with a tool to hold government and other stakeholders to account.	Informed implementation of new Forest Act and offered stakeholders an opportunity to better understand the innovations in the new legislation, especially the opportunities for rural communities to take charge of new forest user rights, and invest in enhanced forest management. Raised awareness of the need for inter-sectoral/ministerial collaboration and implementation of the new Forest Act.
West Africa Mineral Sector Strategic Assessment	Contributed to improved dialogue over environmental and social issues, including quite elaborate techniques for involving local, national and regional stakeholders in the ranking of priorities. Stakeholders validated policy recommendations to promote regional harmonization and transborder management of key environmental and socioeconomic issues associated with mining in West Africa.	"Opened up" examination of the institutional mechanisms used to deal with regional planning and harmonization. Strengthened civil society organizations working in the mining sector by promoting discussion on a regional agenda for mining reform.	Led to a stakeholderproposal of a "multi-stakeholder framework" for continuation of the policy dialogue begun during WAMSSA consultations. It would include a series of multi-stakeholder bodies formed at the regional, national and local level to ensure transparent stakeholder participation and social accountability for mining development decisions.	Clarified the link between regional harmonization/coordination and, enhancing governance. Stakeholders became committed to the idea of a regional cluster-based approach to mining policy in the Mano River Union. West African governments accepted the WAMSSA proposal for a multi-stakeholder framework.
Sierra Leone Strategic Environmental and Social Assessment	Priorities were selected by stakeholders in provincial workshops. National priorities were drawn from the provincial priorities, and validated by stakeholders in a national workshop. Environmental and social priority setting informed	Initiated a multi-stakeholder dialogue on the environmental and social dimensions of mining sector reform. However, involvement of local mining communities and customary authorities in the dialogue was limited.	Contributed to refinement of the Justice for the Poor (J4P) initiative in Sierra Leone, which has fostered public debate on issues of accountability in mining communities.	Provided data and information to the World Bank's J4P initiative.

	preparation of a loan to support mining reform.			Dalogue incorporated multiple perspectives of mining and environmental sector authorities, donors, and civil society stakeholders at provincial and national levels.
Malawi Rapid SESA	Environmental and social priorities were identified and discussed by stakeholders during a stakeholder workshop. However, time restrictions constrained the ability to fully examine priorities as part of the rapid SESA.	The stakeholder workshop encouragedsome weaker stakeholders, notably from civil society, to claim larger stakes in the mining sector reform process and in specific mining operations.	Against a background of deep mistrust the efforts to collect and share information on key environmental and social concerns in the rapid SESA were small but highly relevant for strengthening social accountability.	Increased understanding of: (i) the need for improved coordination between ministries in order to manage mining sector risks and opportunities; (ii) the fact that civil society organizations cannot be ignored, but need to be brought into the development process; and, (iii) the need for benefit sharing from mining to local communities. Triggered a full-fledged SESA as part of the mining sector restructuring in Malawi.
Dhakametropolitan development planning	Identification of environmental priorities was based on a combined ranking of the SEA team's analytical assessment and selected stakeholders' ratings of environmental concerns. However, these were not used to guide subsequent consultations and have not been addressed in the District Area Plans. Vulnerability and health aspects were poorly considered.	The limited length of consultation initiatives provided little time for individual reflection and mutual understanding to develop. By not providing feedback to participants, the SEA process missed an opportunity to empower constituencies by providing them with a tool to demand accountability.	SEA recommendations regarding institutional reform and improved accountability do not appear to have been taken forward by the Capital Development Authority, or any other national actor.	Although the Capital Development Authority (RAJUK) did not consider the SEA recommendations relevant, the SEA helped the World Bank Country Office and RAJUK to recognise the need for capacity development within RAJUK through continued technical assistance. Highlighted that RAJUK had a long way to go before it could fulfil its land use planning responsibilities and may thus have helped to narrow the focus of the proposed World Bank intervention.

(*Continues*)

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Table 2. (Continued)

SEA Pilot	Attention to environmental priorities	Stakeholder involvement and strengthening of constituencies	Social accountability	Policy learning
Hubei road transport planning	Produced an overall holistic picture of the possible environmental impacts of planned transport projects. This outcome increased the awareness of senior managers at the Hubei Provincial Communication Department (HPCD) about macro-level environmental implications of the proposed development of road transport.	No substantial impact on constituencies, although the relatively open sharing of baseline data in the Hubei case was considered to be unusual, and led to technical and social learning on the part of participating institutional stakeholders.	No substantial impact on social accountability.	Helped to strengthen environmental management at the HPCD, includingnew criteria to examine environmental performance of its various departments. Data sharing with regard to baseline analyses contributed to learning. Contributed to a new circular, encouraging the enforcement of environmental requirements during expressway constructions.

Source: adapted from Tables 2.1 and 2.2 from World Bank *et al*., 2011.
SEA, strategic environmental assessments; NGOs, non-governmental organisations, CBOs, community-based organisations; WAMSSA, West Africa Minerals Sector Strategic Assessment; J4P, Justice for the Poor; SESA, strategic environmental and social assessment; HPCD, Hubei Provincial Communication Department.

in civil society, with a lever for holding government to account. Sometimes the influence on social accountability was more indirect. In, for example, Sierra Leone, the evaluation found that the SEA indirectly contributed to social accountability through influencing the Justice for the Poor Initiative, which works with community level accountability in the mining sector. The SEA showed that the coexistence of formal and indigenous political structures without a clear cut harmonisation in land use responsibilities can lead to distorted incentives. Access to mineral resources under a dual system of mining contracts granted by the state and land use rights granted by the Chiefs created an enforcement gap that impaired land reclamation in Sierra Leone. Without greater harmonisation of responsibilities, strengthening of the Chief system may not solve and could even worsen environmental degradation from mining activities (World Bank, 2008).

Policy learning around environmental issues related to the reform process

The space for deliberation on environmental concerns that the SEAs created contributed to the emergence of new perceptions of both problems, trade-offs and potential solutions among stakeholders in several cases. For example, the West African SEA of mining reform had a substantial impact on stakeholders' views on regional harmonisation of mining policy and its importance for addressing transborder environmental and social impacts of mining activities in the region. There are some examples where the SEAs catalysed subsequent assessments or other activities and an associated process of policy learning. Taken together, these activities may have a substantial influence on the long-term policy developments in the sectors. In, for example, Malawi, the SEA led the way for other SEAs related to the mining sector and the Shire basin, and in Kenya, the SEA of the forest reform influenced the subsequent task force designing policies to reverse the degradation of the Mau forests. It also influenced the World Bank to introduce requirements for strategic environmental and social assessments to be undertaken in the preparation of country strategies for the reduction of deforestation and forest degradation. Currently, around 35 countries are preparing such strategies (FCPF, 2011).

The quality of the strategic environmental assessment process

The degree of influence of the SEAs can partly be explained by the quality of the analytical work and processes for stakeholder engagement used by the team conducting the SEA. As mentioned previously, in several cases, the resources for the SEAs were too limited to allow for local or regional processes of stakeholder engagement, which limited the empowering effect of the SEAs on environmental constituencies. In other cases, the limited abilities of some of the SEA teams to undertake institutional and governance analyses or facilitate a constructive dialogue and consensus building among stakeholders constrained the influence of the SEAs. This indicates that the traditional skills in environmental science or engineering of many consultants undertaking SEA need to be complemented with expert skills in social sciences and dialogical practices in order to enhance the influence of SEA in sector reforms.

Contextual factors

The evaluation found that contextual factors were important for explaining the influence of the different SEAs. This corresponds to other studies showing that the potential benefits of SEA are far from always realised and that there are important context dependent constraints to using SEA in an effective way in practice (Boyle, 1998; Hilding-Rydevik and Bjarnadóttir, 2007; Turnpenny *et al*., 2008; OECD, 2012). The identified contextual factors are displayed in Figure 1 and discussed in the succeeding text.

The timing of the SEAs in relation to the reform process and the political development in the countries were identified as crucial contextual factors explaining the degree of influence of the SEAs. The SEAs that were most effective were benefiting from a window of opportunity (Kingdon, 1984) for discussing and integrating environmental concerns in the sector reforms. Such an opportunity could arise from changes in political and environmental conditions. For example, the SEA of Kenya's forests act formed part of a broader process of changing forest management practices where there was a new political openness to discuss environmental and social priorities. After a long period of deadlock, the election of the Kibaki government in 2003 made

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forest sector reform possible. The growing problems with water and energy provision services in Nairobi and other cities also induced a broader recognition of the need for measures to prevent further environmental degradation and created a momentum for forest sector reform (World Bank, 2007; World Bank *et al*., 2011). In some of the SEA cases, contextual factors changed after the completion of the SEA process in such a way that pursuing implementation of the SEA recommendations was not meaningful. In the case of the SEA of Sierra Leone Minerals Sector reform, the newly elected government decided to postpone reform processes initiated by the previous administration, effectively closing the process the SEA was intended to inform and influence.

Lack of ownership of the SEA within the ministry or agency behind the reform process was identified as another contextual factor seriously hindering the integration of environmental concerns. Because SEA is a new approach to many sector ministries and agencies, there is often a need to develop capacity within these organisations on the role of SEA and how SEAs can be undertaken. However, in some cases, the evaluation found that explaining the value of conducting SEA was not sufficient to incentivize agencies to undertake SEA in a strategic way. For example, the influence of the SEA of the Dhaka Metropolitan Development Plan was severely constrained because the Dhaka Capital Development Authority lacked interest in (and incentives for) engaging in the institutional analysis that formed part of the SEA and acting upon the recommendations from this analysis, which partly would undermine its authority. This lack of political will among power elites or reform proponents to open up the policy process to a transparent and broad dialogue on environmental risks and opportunities was identified as an important contextual factor, which limits the influence of SEA.

Several of the sector reforms that the pilot programme tried to influence—notably the mining and forestry sectors—include a large informal economy in which customary land tenure and other informal institutions play an important coordinating role. Although the importance of informal institutions was highlighted in the forestry and mining SEAs, the main focus in both the analytical and the participatory components of the SEAs remained on the formal institutions. The presence of important informal institutions is hence a contextual factor, which several of the SEAs could have paid more attention to.

A final contextual factor identified was the presence of organisations and actors, which can sustain the process of environmental mainstreaming that the SEA had contributed to. Without effective follow up and continued activities, the influence of a single SEA on learning, governance and sector reform is likely to be meagre. The loss of momentum for integrating environmental concerns in the reform process after the completion of the SEA which was observed in several cases may partly be explained by the incentives involved in the World Bank pilot programme. The financial support and technical advice provided by the World Bank led to SEAs of a technically high quality but in some cases also limited the ownership of the SEA process of the sector agencies involved.

In conclusion, the need to adapt SEA to the specific institutional context of the reform process was identified as a key prerequisite for successful outcomes. Although several positive contributions of the SEAs on environmental integration have been documented, the SEAs would probably have been more influential if they had paid more attention to the ownership and commitment of the SEAs among ministries and agencies leading the reform process; if more resources had been devoted to stakeholder participation and in particular the representation of vulnerable groups; paid more attention to the role of informal institutions; and had included stronger mechanism for ensuring the follow up of the recommendations of the SEAs. (World Bank *et al*., 2011)

IMPLICATIONS FOR PUBLIC ADMINISTRATIONS IN DEVELOPING COUNTRIES

Most public administrations in developing countries have limited experience and capacity for using SEA or other approaches for addressing environmental and social concerns in sector reforms. Increasing this capacity entails developing human resource expertise for conducting SEA, a sound legal and financial basis for SEA and a clear institutional structure with agreed allocation of roles and responsibilities within the public administration (Steinhauer and Nooteboom, 2012). Research on processes of institutional adoption calls for caution when introducing formal rules, which have their origin in the USA and Europe—such as assessment procedures—in developing countries with different informal rules (Rodrik, 2000; Acharya, 2004; Grindle, 2004). Nevertheless, many developing countries have

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started the introduction of SEA by importing ambitious legislation on SEA from other countries (Dalal-Clayton and Sadler, 2005; Ahmed and Fiadjoe, 2006; OECD, 2012). This creates a risk of setting formal rules that are difficult to implement in practice because of lack of capacity and incentives. Rather than beginning with legally mandating that SEAs are conducted for all plans and programmes with potentially significant environmental impacts, a more strategic and cost-effective[10] approach for capacity constrained developing countries may be to aim at conducting SEAs of a few selected sector reforms of strategic importance for both the economy and the environment (World Bank *et al*., 2011). Growing experience from introducing SEA in developing countries suggests that SEA institutions and practice should co-evolve gradually and that blueprint solutions should be avoided. The SEA institutional architecture should not be legally prescribed in the first instance but be decided on over time on the basis of practical experience with SEA (Steinhauer and Nooteboom, 2012).

The evaluation of the World Bank SEA pilot programme (World Bank *et al*., 2011) suggests that the sector ministry or agency leading the reform process should also be in charge of the SEA, rather than the Ministries of Environment, which traditionally have environmental assessments under their purview. Environmental ministries and agencies have an important advisory role to play by providing information and knowledge to the sector reform team and the SEA process. They can also be a knowledge hub on SEA and support capacity development in sector agencies.

When possible, the team undertaking the SEA should be members of the policy team preparing the sector reform. This facilitates the interaction between sector specialists, who are knowledgeable on enabling and blocking factors for sector growth, with specialists familiar with the environmental challenges facing the sector. Letting the reform proponent be in charge of the SEA also facilitates the uptake and follow up of the recommendations from the SEA. However, assigning the ownership of the SEA to the reform proponent is not free from potential tensions. If a sector is under strong pressure by vested interests, there may be strong opposition to engage in an SEA that opens up the policy process to broader groups of stakeholders and public scrutiny. A legal requirement forcing the sector agency to conduct an environmental assessment is not sufficient to green sector reforms in such situations (Nitz and Brown, 2001; Noble, 2009). In the worst case, the SEA can be performed as window dressing for settling criticism with no effects on environmental integration in the decision-making process. It is thus vital to assure that there is high level commitment and capacity for conducting SEA within the sector prior to its commencement. If this is not the case, valuable resources may be wasted. A crucial challenge is thus to create incentives for the agencies leading the reform process to use SEA as a strategic decision-support tool for greening growth (OECD, 2012).

Our analysis identifies several other factors than legal requirements that can incentivise sector agencies to integrate environmental concerns in sector reforms. A change in environmental conditions can create demands for improvements from civil society and the private sector pushing environmental concerns on to the sector reform agenda. Ministries of finance and planning or other powerful ministries can put pressure on sector agencies to increase their efforts in addressing environmental and social concerns, for example through including references to SEA in national planning documents or planning guidelines. Through supporting capacity development and specific SEAs development agencies can also provide incentives for sector agencies to use SEA. However, development agencies should maintain a supportive role rather than themselves take the lead in implementing specific SEAs (World Bank *et al*., 2011, OECD, 2012). Incentives for addressing green growth concerns through the use of SEA or other approaches can also be created at the international level, as shown by the use of strategic environmental and social assessments by the many developing countries currently developing strategies for reducing deforestation and degradation.

Although sector agencies should play a leading role in SEAs of sector reforms, the involvement of a range of other actors is also important. Not least because sector reforms generally impact on many other sectors in society, information sharing and coordination across sectors is necessary. Inter-ministerial advisory committees involving

[10]Because of its analytical and public participation components, SEAs of sector reforms require investment in time and money. In the World Bank's SEA pilot programme, a rapid SEA required around 3 months and US$30 000 to be completed. In the same programme, full-fledged policy SEAs took from 9 to 18 months and from US$120 000 to US$500 000 to be completed (Loayza *et al*., 2011).

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ministries of planning, finance, environment and different sector agencies as well as committees with representatives from national, provincial and local authorities can be useful for this purpose (OECD, 2012).

The evaluation of the World Bank's SEA Pilot Programme suggests that substantive efforts and resources are needed in order to ensure the representation of community groups and other weak and marginalised stakeholders in a way that promotes goals of strengthened constituencies and accountability around environmental concerns linked to sector reforms (World Bank *et al*., 2011). One solution can be to integrate the dialogue on environmental concerns into a broader dialogue on priorities of the sector reform process. This was, for example, the case in the SEA of the forestry reform process in Liberia where the participatory elements of the SEA were integrated with the consultations around policy reform of community land rights (World Bank, 2010b).[11]

Our analysis indicates that forums for multi-stakeholder dialogue, such as the one created in WAMSSA, have a potential to be an effective force for enhancing accountability and learning around environmental and social concerns. But to be sustainable beyond the completion of an SEA such mechanisms need to be institutionalised and linked to already existing mechanisms within the public administration. This institutionalisation is important to overcome the 'event culture' that tends to prevail in relation to calls for increased public participation and civic engagement (Ackerman, 2005).

Our final observation concerns how public administrations can choose to frame or label assessment processes. A sector reform process normally involves several different types of economic, financial, social and environmental assessments. Depending on the context and the needs of the authorities leading the reform, an environmental assessment can be conducted separately or integrated with the other assessments. In the World Bank pilot programme, several of the lead authorities found it pertinent to do integrated social and environmental assessments. In other cases, public administrations have chosen to conduct similar assessments under a climate change label. Our analysis indicates that the name, framing and scope of the assessment should be tailored to the particular context and needs of the sector agency and stakeholders involved in the reform process. What matters is creating a process that draws attention to environmental priorities when the sector reform agenda are set, fosters policy learning through repeated and sustained stakeholder interaction and facilitates access to information and empowerment of environmental constituencies.

CONCLUSIONS

Climate change and ecosystem degradation place the need for greening economic growth on the international policy agenda. In principle, there are many policy instruments available that could make growth greener. However, market imperfections, information asymmetries, incomplete property rights and power relationships all combine in creating structures where powerful interests are vested in processes that are polluting and that degrade or destroy sensitive ecosystem resources. As a consequence, policy instruments that would green growth are seldom implemented.

To make growth greener, we argue in this article, it is crucial to address the poor level of information on environmental assets as well as the weak institutions and incentives hindering the greening of sector reforms in developing countries. Our analysis indicates that SEA involving substantive analytical work and extensive stakeholder engagement can make an important contribution in this regard. This includes improving the knowledge on environmental risks and opportunities linked to the reform process, raising attention to environmental priorities, opening the reform process to a broader set of stakeholders, which can hold decision makers accountable and promote policy learning. By doing this, SEA can fill an important gap, not least in developing countries beleaguered by low transparency and dysfunctional participatory and co-ordinating institutions.

However, the benefits from using SEA in developing country sector reforms are seldom realised. Experience and capacity to conduct SEA is generally very limited, and many of the SEAs conducted are 'pilots' supported by development cooperation agencies. Although these specific SEAs can influence sector reform processes, this

[11]This SEA was not part of the World Bank pilot programme, but the methodology used was influenced by the SEA of the Kenyan forest sector reform.

influence is generally punctuated rather than long term and transformative. A crucial challenge to enhance the use of SEA is to create incentives for the lead agencies to use SEA repeatedly as a strategic decision-support tool for greening growth. Without a strong ownership by the sector agencies, there is a risk that the legal requirements for SEA—which are now being introduced by environmental agencies in many developing countries—will be viewed mainly as bureaucratic hurdles to be circumvented at the lowest effort possible. Although developing legal requirements is necessary for institutionalising SEA, the legal framework should arguably develop gradually on the basis of experience. The great diversity in formal and informal institutions across countries calls for avoiding blue print approaches to the application of SEA.

Finally, SEA should not be seen as a silver bullet for integrating environmental concerns in sector reforms but rather as one tool in the bigger toolbox that sector agencies and other stakeholders can use in order to make growth greener and more inclusive.

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Paper V

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Challenges to institutionalizing strategic environmental assessment: The case of Vietnam

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ABSTRACT

Building on new institutional theory, this paper develops an analytical framework for analyzing constraints to the institutionalization of strategic environmental assessment (SEA) at four different institutional levels. The framework is tested in an empirical analysis of the environmental assessment system in Vietnam, which is a frontrunner among developing countries regarding the introduction and use of SEA. Building on interviews with Vietnamese and international experts, as well as an extensive literature review, we identify institutional constraints which challenge the effective use of SEA in Vietnam. We conclude that commonly identified constraints, such as inadequate training, technical guidelines, baseline data and financial resources, are strongly linked to constraints at higher institutional levels, such as incentives to not share information between ministries and severe restrictions on access to information and public participation. Without a thorough understanding of these institutional constraints, there is a risk that attempts to improve the use of SEA are misdirected. Thus, a careful institutional analysis should guide efforts to introduce and improve the use of SEA in Vietnam and other developing countries. The analytical framework for analyzing constraints to institutionalization of SEA presented in this paper represents a systematic effort in this direction.

Introduction

Assisted by development aid, a growing number of developing countries have recently introduced legislation on strategic environmental assessments (SEAs). The aim is to improve the integration of environmental concerns in strategic decision-making by subjecting plans and programs to additional environmental analysis and stakeholder involvement.

Originating in North America and Western Europe, legislation on SEA is a formal institution containing primarily procedural rules about when and how environmental assessments should be conducted during the development of plans, programs and sometimes policies. However, in many developing countries, formal and informal institutions differ greatly from those in North America and Western Europe, affecting the interpretation and application of the new procedural rules in practice.

The purpose of this paper is twofold: to develop and test an analytical framework for analyzing constraints on the institutionalization of SEA in developing countries. The paper adds to the growing body of research suggesting that contextual factors play a fundamental role in how environmental assessment systems work in practice (Ahmed and Sánchez-Triana, 2008; Annandale, 2001; Bina, 2008; Boyle, 1998; Hilding-Rydevik and Bjarnadottir, 2007; Kolhoff et al., 2009; Runhaar and Driessen, 2007; Slunge et al., 2011). The earlier technically-oriented approaches to environmental assessments, built on a belief that improved information would lead to better decisions by rational decision-makers, has been increasingly challenged. Instead, more recent analyses stress the role of institutions and governance conditions, the non-linearity of public decision-making, and the potential role that participation, deliberation and learning can have on environmental assessment systems (Ahmed and Sánchez-Triana, 2008; Bina, 2008; Kørnøv and Thissen, 2000; Nilsson and Nykvist, 2009). In the words of Bina (2008, p. 718), "Two decades of practice have shown that good information alone – though essential – will not necessarily lead to better planning or better choices.… It is the context within which planning and assessment occur, and especially all the qualities that are commonly recognised under the framework concept of 'good governance' that makes the difference".

This literature forms part of a broader recognition within social science and development policy on the fundamental role of institutions and governance for economic and social development (see e.g. Acemoglu et al., 2004; Rodrik et al., 2004; World Bank, 2003), as well as environmental and natural resources management (e.g. Ostrom, 1990; Vatn, 2005).

Against this background, it is noteworthy that the use of institutional analysis is still fairly limited in development practice relating to SEA

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(OECD, 2012), as well as in many academic evaluations of environmental assessment systems (e.g., Briffett et al., 2003 and Clausen et al., 2011). There are a growing number of studies focusing on the role of institutional factors for the performance of environmental assessment systems (see, for example, Bina, 2008; Boyle, 1998; Slunge and Loayza, 2012; Turnpenny et al., 2008; World Bank et al., 2011). However, the analytical frameworks and methodologies used in these studies vary widely. For example, Boyle (1998) identifies certain cultural characteristics which shape the performance of environmental assessment systems in Thailand, Indonesia and Malaysia. Bina (2008) uses four dimensions – social, cultural, political and values – to analyze contextual factors limiting the effectiveness of the Chinese environmental assessment system. Turnpenny et al. (2008) study institutional capacities and constraints for integrated policy assessment at the micro, meso and macro levels in four different European countries.

While these and other studies have yielded important knowledge about the role of institutional factors for the performance of SEA systems, the different analytical frameworks used in the studies make comparisons across cases and countries difficult. We propose that the general framework for studying institutions at four different levels developed by Nobel laureate Oliver Williamson (2000) can be useful also for studying SEA institutionalization. We believe that the structure of this analytical framework can be particularly useful when studying SEA institutionalization in countries where both formal and informal institutions differ considerably from the institutions in the U.S. and Western Europe where environmental assessment procedures were first invented.

We test the analytical framework through an empirical analysis of the use of strategic environmental assessment in Vietnam. Vietnam is an interesting case because it is a frontrunner among developing countries in relation to SEA. Development agencies from Germany, Sweden, Denmark, Switzerland and Holland as well as international development banks have played an instrumental role in introducing SEA in Vietnam. They have financed a large number of "pilot SEAs" and numerous training programs for staff in governmental agencies, and have provided technical expertise for the development of a legal framework and technical guidance for SEA in Vietnam (Clausen et al., 2011; Dusik and Xie, 2009). As development aid to Vietnam decreases as the country reaches middle income status, it is uncertain how sustainable or institutionalized the SEA system is without external resources. Vietnam is also interesting as a case study because its formal and informal institutions are very different from the institutions in the countries where SEA was first invented. Importantly, public participation and free and open access to information – which are crucial aspects of environmental assessment systems – are severely restricted in Vietnam (The World Bank Group, 2013).

Besides developing and testing an analytical framework for studying constraints to institutionalization of SEA, the paper also offers lessons learned and associated policy implications for governments that are introducing SEA as well as development agencies supporting such efforts.

The paper proceeds as follows. In the next section, we develop the analytical framework as well as the methodology used for the empirical analysis. In section three, we present the results from the empirical analysis. In the concluding section, we discuss the implications from the empirical analysis from testing the analytical framework.

Analytical framework and methodology

Analytical framework

The study of institutions has a long tradition, but a new institutionalism emerged in the late 1980s as a reaction to the then-dominant actor-centered analyses in the social sciences (March and Olsen, 1989; Nilsson, 2005; North, 1990). For the purpose of this paper, we follow North's (1990) definition of institutions as "…the humanly designed constraints that structure human interaction…made up of formal constraints (e.g., rules, laws, constitutions), informal constraints (e.g., norms of behavior, conventions, self-imposed codes of conduct), and their enforcement characteristics". Institutionalization can be described as a process of internalizing a new set of formal norms into an existing system of formal and informal norms so that the new norms become rules that are actually used in practice, what Ostrom (2005, p. 20) defines as "rules in use".

The slowly changing nature of norms, as well as their importance in the enforcement of formal rules, is one important factor explaining the difficulties involved in changing institutions. While formal institutions, such as water or forest legislation, may change rapidly, informal institutions, such as norms guiding water or forest use, generally change more slowly (North, 1990; Williamson, 2000). When studying processes of institutionalization, it is thus crucial not only to analyze legal frameworks and other formal building blocks, but also to consider norms and other informal institutions.

Steinhauer and Nooteboom (2012) have made one of the few attempts to define what characterizes an SEA system that is institutionalized. According to these authors, an SEA system is institutionalized when there is sufficient expertise in a country to apply SEA; a sound legal and financial basis for SEA is in place; and there is a clear institutional structure with agreed roles and responsibilities (see Fig. 1, box 1). While this definition points to crucial parts of an SEA system, it is not complete. Most importantly, it does not include the performance or effectiveness of the SEA system. This is crucial because it is often during implementation, when there is interplay between formal and informal norms, that the greatest challenges to institutionalization are found (North, 1990). It is also during the implementation phase that policy reforms typically encounter difficulties, not least in developing countries (Batley, 2004; Thomas and Grindle, 1990). In our view, an SEA system that is institutionalized should also be effective in the sense that it leads to improved integration of environmental concerns in strategic decision-making, ultimately contributing to improved environmental outcomes (Fig. 1, boxes 3 and 4). The key mechanisms through which SEA is commonly understood to lead to integration of environmental concerns in decision-making are through (i) improving the information on which decisions are made; (ii) increasing stakeholder participation and access to information in decision-making; and (iii) providing a forum for deliberation, coordination and learning (Fig. 1, box 2) (Ahmed and Sánchez-Triana, 2008; OECD, 2006; Therivél, 2010).

However, there may be several formal and informal constraints limiting the effectiveness of an SEA system. Several authors have argued that these contextual constraints tend to make the link between SEA and environmental outcomes indirect rather than direct, stressing the effect SEA can have on for example the framing of problems and the strengthening of stakeholder groups (Ahmed and Sánchez-Triana, 2008; Nilsson, 2005). Terms such as incremental effectiveness (Bina, 2008), transformative effectiveness (Cashmore et al., 2004) and normative effectiveness (Chanchitpricha and Bond, 2013) have been used when studying these types of indirect effects.

In our analysis of formal and informal institutional constraints, we build on the framework for studying institutions at four different levels developed by Nobel laureate Oliver Williamson (2000). The first level is *Social Embeddedness*, which comprises informal institutions such as norms, religion and culture. The second level is the *Institutional Environment* or the formal rules of the game, including constitutions and the executive, legislative, judicial and bureaucratic functions of government. The third level is the *Institutions of Governance*, where much of the day-to-day policy making takes place. Institutions at this level include the different parts of government bureaucracy, as well as laws and regulations. The fourth level is *Resource Allocation and Employment*, where incentives created by institutions at the other levels affect the choices of the different actors in society. This fourth level of analysis corresponds to the "action arena" in the Institutions and Development

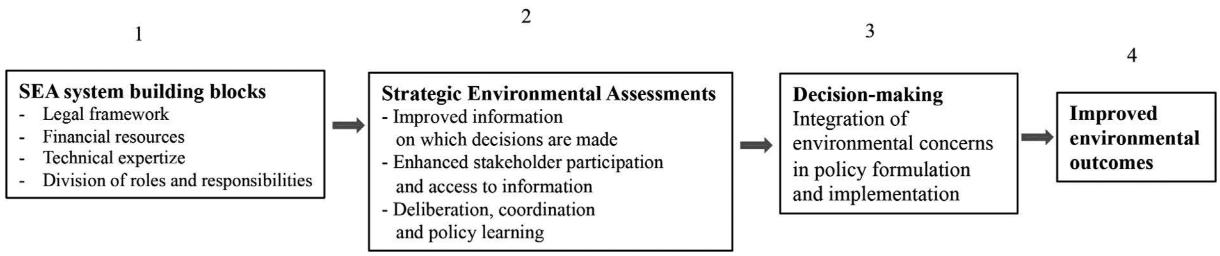

Fig. 1. Conceptual model of an institutionalized SEA system.

framework developed by Ostrom (2005).[1] We choose to use the term action arena for this level of analysis because the term does a good job of capturing the practice dimensions of the SEA system in which we are interested.

Feedback mechanisms between the different institutional levels constitute an important element of Williamson's framework. The institutions at higher levels constrain choices at lower levels, but changes at lower levels can also generate institutional change at the higher levels through different feedback mechanisms.

Fig. 2 displays how the SEA system is embedded in formal and informal institutions at the four levels identified by Williamson (2000).

Table 1 outlines the analytical framework used to structure the analysis of the empirical data.

Inspired by Ostrom's (2005: 27) distinction between frameworks, theories and models as “a nested set of theoretical concepts — which range from the most general to the most detailed” the guiding questions in our framework are deliberately of an open character. As Ostrom writes (2005: 28), “frameworks organize diagnostic and prescriptive inquiry. They provide the most general set of variables that should be used to analyze all types of settings relevant for the framework”. Our purpose is primarily to identify institutional constraints, not to identify causal effects for which we would also need a more developed theory and model.

Nilsson and Nykvist (2009) and Turnpenny et al. (2008) have undertaken the institutional analyses of impact assessment systems that come closest to a Williamson-type layered institutional framework. While Nilsson and Nykvist (2009) analyzed the role of impact assessments in the Swedish committee system, Turnpenny et al. (2008) studied institutional capacities and constraints for integrated policy assessment at the micro, meso and macro levels in four European countries. On the micro level the analyses concerned the individuals involved in doing assessments in the bureaucracy and the availability of resources (time, money, staff) and human resources (skills, educational background etc.) for doing the assessments. On the meso level organizational issues such as management structures, organizational culture, coordination procedures and incentive systems were analyzed. Finally, on the macro level the analysis focused on wider issues such as the administrative and legal context as well as the role of stakeholders in the decision making process.

There are many similarities between these frameworks for layered institutional analysis. Indeed, our empirical study was initially inspired by the micro–meso–macro framework. However, during the analysis we found that the explicit emphasis in Williamson's framework on the institutions of governance, the institutional environment and social embeddedness provided a better way for structuring and interpreting the data about Vietnam. We believe that this has to do with the relatively stronger emphasis in Williamson's framework on institutional constraints that are more distant from the action arena in comparison to the studies conducted by Nilsson and Nykvist (2009) and Turnpenny et al. (2008) using the micro–meso–macro framework which put a relatively stronger focus on the micro (individual) and meso (organizational) levels.

Methodology

The analytical framework was tested in an empirical analysis of constraints to the institutionalization of SEA in Vietnam. The empirical analysis is based on a substantive literature review – including the extensive gray literature on SEA in Vietnam – as well as 15 semi-structured interviews conducted during the spring of 2011 in Vietnam.[2] To probe the findings in our study, two additional interviews were conducted with Vietnamese civil servants working with SEA in sector ministries in March 2013. Interviews were selected to represent a variety of experiences related to the Vietnamese SEA system. The interviewees (see Table 2) included Vietnamese civil servants involved in commissioning and reviewing SEAs for socio-economic development plans and sector strategies in Vietnam, SEA regulators at the Ministry of Environment and Natural Resources at the national and provincial level, Vietnamese SEA practitioners and experts at consultancy companies and research institutes, and international SEA experts with experience from programs that support SEA capacity development in Vietnam. International SEA experts with long experience from Vietnam assisted us in identifying potential interviewees within these different categories. A few additional interviewees were identified during the interview process in Vietnam. It could have been valuable to conduct additional interviews with for example officials at the provincial level or additional sector ministries, but due to resource constraints this was not feasible. While additional interviews could have yielded important nuances about the Vietnamese SEA system, we believe that they would not have significantly influenced the general findings about the constraints to SEA institutionalization presented in this study. We draw this conclusion based on the large consistency among the interviewees about constraints to SEA institutionalization in Vietnam.

The interviews were guided by a semi-structured questionnaire focusing on understanding how the SEA system works as well as the key obstacles to institutionalization at different institutional levels. Originally the empirical study was guided by the framework for institutional analysis of impact assessment systems described in Turnpenny et al. (2008), but, as explained above, the Williamson framework was used for structuring and analyzing the gathered data. The findings from the empirical study presented in Section 3 are based on a synthesis of the findings from the literature review and the interviews conducted.

Constraints to institutionalizing SEA in Vietnam

The action arena

Formal rules about the use of SEA were introduced in Vietnam through the revision of the Law on Environment Protection in 2005. The law mandates that SEA be conducted for many different kinds of strategies and plans at the national, provincial and sector levels. For example, SEAs are mandated when developing national and provincial 5-

[1] The Institutions and Development framework (IAD) is an analogous layered framework for institutional analysis. The levels of analysis in the IAD framework are the constitutional arena, the collective choice arena and the action arena.

[2] See Trang, 2011 for a description of the questionnaires used.

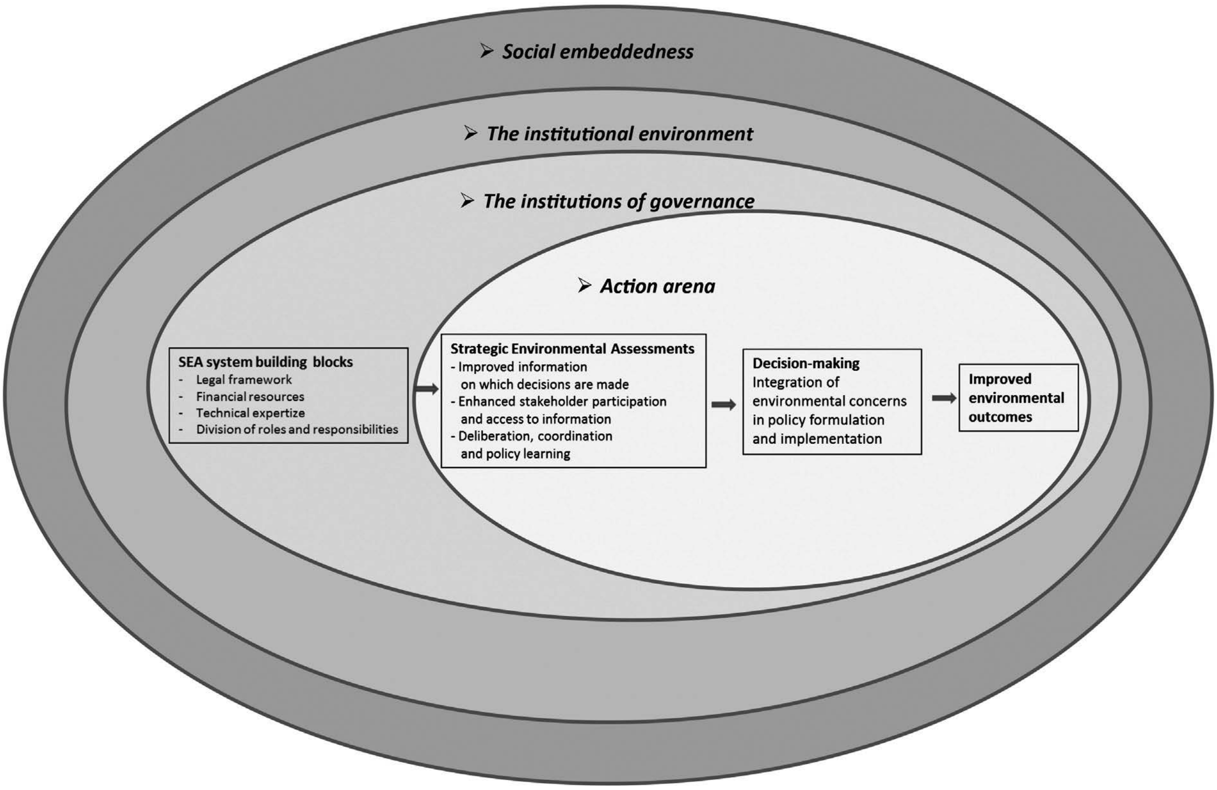

Fig. 2. A layered framework for institutional analysis of SEA systems.
Source: Author

year plans for socio-economic development. The law and the more detailed guidance that have been issued subsequently also specify who is responsible for conducting SEA – typically the same agency responsible for the strategy or plan – what the SEA report should contain, and who should review the SEA (Dusik and Xie, 2009).

Approximately 200 to 300 SEAs were conducted in Vietnam in the period 2002–2012. Many of these were undertaken with strong financial and technical support from development agencies. An increasing number of SEAs have been undertaken as a consequence of the legal requirement introduced in 2005. Before 2009, around 50 SEAs had been undertaken by different ministries and provincial authorities, mainly in relation to regional and provincial socio-economic development plans. However, in more recent years, the numbers of SEAs conducted have increased drastically.

However, several studies indicate that, while many of the donor initiated “pilot SEAs” are of good technical quality, most other SEAs are of low quality (Bass et al., 2009; Chu, 2008; Dalal-Clayton, 2009; Dusik and Xie, 2009; Le, 2008; Le and Le, 2008; Le, 2012; Luu and Dunn, 2008). The common problems identified by these studies include limited access to data as well as weak analysis of baseline data and the impacts of different development alternatives.

These problems were confirmed by the interviews conducted in this study. Many interviewees identified limited access to and poor quality of data as a key constraint to SEA effectiveness. While some interviewees referred to technical problems, such as lack of systematic documentation of environmental data at government agencies, others pointed to problems with corruption, as noted by one international SEA expert: “government departments do not want to share information because they can sell the information or use the information for their own benefit”.

Interviewees consistently emphasized that, despite the considerable effort devoted by international donors to SEA training, understanding and capacity on how to conduct and review SEAs remain low. Many SEA practitioners have a strong background in environmental assessment at the project level, and often get stuck in a too-detailed level of analysis that is not appropriate for strategic planning. As one of the international SEA experts commented: “local experts want to focus on detail, hard data, and miss the big picture. They should start asking more strategic questions.” A related problem, stressed by many interviewees, is that many senior bureaucrats responsible for planning lack an understanding of what SEA is and how it can contribute to improve planning. One national SEA expert said that “leaders either do not understand the

Table 1
Institutional levels and guiding questions.

Institutional level	Assessment
Social embeddedness	Which norms, religious and cultural characteristics influence how the SEA system works?
The institutional environment	How do constitutional rules and government structure influence how the SEA system works?
The institutions of governance	How do the legal framework and planning practices influence how the SEA system works?
Action arena	How is the SEA system working in practice? Does it contribute to improved analysis and information about environmental concerns related to strategic decision-making; improved participation and coordination; and ultimately to improved integration of environmental concerns in decision-making? Which incentives do government officials and other actors face in relation to SEA?

Table 2
Interviewees.

Interviewee category	Number of interviewees
Vietnamese civil servants in sector ministries involved in commissioning and reviewing SEAs for socio-economic development plans and sector strategies	5
SEA regulators at Ministry of Environment and Natural Resources at the national and provincial level	3
Vietnamese SEA experts at consultancy companies and research institutes	4
International SEA Experts with long experience from working in Vietnam	5

benefit of SEA or have too high expectation of SEA…that it will provide specific solutions of where to have a rice padding field". A civil servant commissioning SEAs in one of the sector ministries expressed that "many provincial and ministerial leaders do not see the need for SEA or see it as just another obstacle to the planning process". This is related to another common observation, that SEAs are often not being conducted simultaneously with strategic planning, as is required by law, but rather very late in the process, after key decisions have been made.

Another obstacle to effective use of SEA identified by several interviewees is the limited use of stakeholder and public participation. Although stakeholder consultation is mandated by SEA law, interviewees stressed that it is often poorly conducted and superficial. Stakeholder consultations in the form of seminars or written comments are often "organized too late, after the SEA has already been almost completed". Hence, comments are usually not fully taken into account. The stakeholder consultations mainly involve discussions among interested state agencies and state-sanctioned organizations. One Vietnamese SEA expert observed that 'district and civil society almost do not participate because they are not invited. The SEA and planning team do not like to invite them because they often talk a lot and request for their rights and benefits'. Also the limited capacity of the SEA experts for leading stakeholder consultations was highlighted as a problem. One international SEA expert even claimed that "local SEA experts have no facilitation or negotiation skills and cannot get people with different background to agree on anything".

Finally, the budget assigned for conducting SEA was by many interviewees observed to often be very low, thus reducing the incentive to produce good quality SEAs. The lack of sanctions against ministries and authorities who do not undertake SEAs as required or undertake SEAs of poor quality was highlighted as an important problem by interviewed SEA regulators at the Ministry of Environment and Natural Resources.

Social embeddedness

In a study of EIA systems in Thailand, Malaysia and Indonesia, Boyle (1998) identified the reliance on paternalistic authority, hierarchy, and status as principles of social organization; the dependence on patron–client relationships for ensuring loyalty and advancement; and the desire to avoid conflict and maintain face in personal relations as cultural characteristics that severely constrained the effectiveness of the systems of environmental assessments in these countries. Also Victor and Agamuthu (2014), in a recent overview of policy trends of SEA in Asia, claim that cultural dimensions may explain limitations in public participation found in Vietnam and other Asian countries.[3]

Confucianism asserts perhaps one of the most important cultural influences on norms and behavior in Vietnam. Shin (2012) argues that, although Confucianism's sociocultural roots in Vietnam were never as deep as those in China and Korea, Confucian norms do persist and have regained momentum since the reunification. Such norms include deference to authority and respect for hierarchy, as well as a system of "familism", including a strong drive to protect "the family" against outside aggression (Bell, 2008; Jamieson, 1995; Shin, 2012).

A common observation among the interviewees is the lack of collaboration and open sharing of information between Vietnamese ministries and provinces. Indeed, several interviewees identify this as a key constraint to effective use of SEA in Vietnam. However, interviewees had different explanations about this constraint. One international SEA expert with long experience from working in Vietnam characterized Vietnamese ministries as "extended families", where the overriding intention is to "promote the integrity, strength, and prosperity of the ministry or unit at all costs". He stressed that this results in "intensely private organizations that do not easily give up information, or allow 'outsiders' to gain access to decision-making power". In contrast, Vietnamese SEA experts pointed mainly to a lack of incentives for government officials to engage in coordination and information sharing. SEA practitioners find it difficult to obtain baseline information when ministries or provinces maintain their information as a "private asset". Several interviewees noted that one needs to have 'personal contacts' or 'pay' to get access to information.

The strong "silo culture" within ministries also makes cross-sectoral collaboration difficult. The limited collaboration between ministries such as the Ministry of Environment and Natural Resources and the Ministry of Planning and Investment has also resulted in parallel, and somewhat contradictory, technical guidelines on how to undertake SEA.

Another observation, stemming from international SEA experts interviewed, is that Vietnamese bureaucrats are intensely aware of the need to defer to authority, however irrational or inefficient the outcome. Junior officers spend a considerable amount of time ensuring that they do not inadvertently antagonize superiors by stepping too far away from the confines of the "party line". This bureaucratic culture encourages conservatism and excessive attention to detail; neither characteristic readily supports the experimental and entrepreneurial aspects of SEA. This culture of not wanting to "rock the boat" also results in low personal motivation for junior and mid-ranking bureaucrats to be proactive in suggesting an increased or better use of SEA.

While it is too simplistic to ascribe individual behavior in a particular situation to Confucian or other cultural norms, it is plausible that these norms do play a role in explaining the constraints to effective use of SEA in Vietnam.

The institutional environment

Constitutional rules and government structure influence how the SEA system works in practice in several ways. The central role played by the Communist Party of Vietnam is essential for understanding how strategic decision-making and planning are undertaken. The Communist Party shapes the ideology and development direction of the country through its power, which is embedded in key political institutions such as the National Assembly, the State Presidency and the Government (Dang and Beresford, 1998; Nguyen and Teicher, 2010). The Party's Central Committee, made up of 160 members who are high-ranking government leaders, is the main forum for strategic decision-making in Vietnam. These members are selected through a comprehensive and semi-competitive election process once every five years (Malesky et al., 2011).

While the Constitution provides for legislative, executive and judicial branches of government, in practice the judiciary is kept in a subservient role to the other branches. The dominance of the Communist Party in the legislative and executive branches means that judicial independence is

[3] Using Hofstede's cultural dimensions of power distance index, where distance to power is defined as the extent to which the less powerful members of institutions and organizations within a country expect and accept that power is distributed unequally.

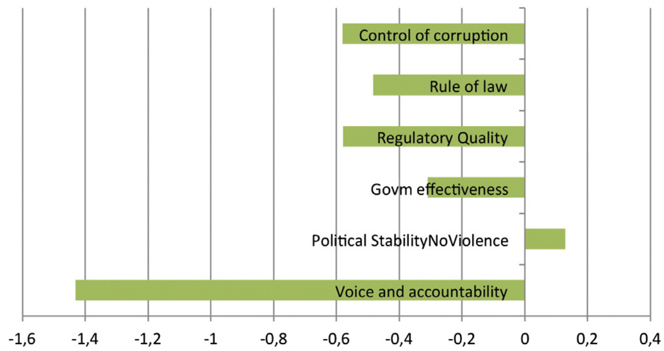

Fig. 3. Worldwide Governance Indicators 2012 — Vietnam. Each governance indicator ranges from −2.5 (weak) to +2.5 (strong) governance performance. The six aggregate indicators are based on a large number of underlying data sources reporting the perceptions of governance of a large number of survey respondents and expert assessments. Details on the underlying data sources for Vietnam, the aggregation method, and the interpretation of the indicators, can be found at www.govindicators.org.
Source: The World Bank Group (2013). Worldwide Governance Indicators 2013

not necessarily respected, judicial reviews of laws are not undertaken and, consequently, the rule of law is weak (The World Bank Group, 2013).

This formal institutional structure significantly affects the prospects for applying SEA in the Vietnamese decision-making context and partly explains some of the obstacles identified to SEA effectiveness. First, the strong top-down characteristics of the Vietnamese political system make the priorities of the Communist Party, and particularly its Central Committee, tremendously important for decision-making at all levels in society. The Communist Party's deep involvement in the Government forces public officials to comply with the Party's principles, as communicated in official statements and speeches, as their first priority, and with formal rules and instructions as only a secondary priority. National as well as international SEA experts interviewed noted that the importance of these informal channels of decision-making in Vietnam limits the effectiveness of formal and procedural tools, such as SEA, that are intended to support the decision-making process.

Accordingly, the political priorities signaled by the Communist Party become very important for government bureaucrats. Beginning with the Doi Moi policy in 1986, the Communist Party has put a very strong focus on economic liberalization, growth and social development, while environmental concerns have been a much less prominent policy priority. Against this background, the lack of leadership and commitment to SEA, as observed by many interviewees, can be an important constraint to SEA effectiveness. There is a risk that formal SEA requirements will become just a bureaucratic hurdle imposed by the Ministry of Environment if public officials perceive that environmental concerns are not important political priorities.

The institutions of governance

The institutions of governance in Vietnam display several characteristics which can help us understand some of the constraints to SEA effectiveness identified in the previous section. According to the Worldwide Governance Indicators, Vietnam scores particularly badly on the indicator voice and accountability (Fig. 3).[4] This indicator concerns the extent to which citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and free media. The state's control over media and the very strong limitations on the freedom of association and expression make public participation, which is a key component of SEA, a challenge in Vietnam.

Also of interest is the low score on the indicator on Government effectiveness,[5] which concerns the quality of the government's policies and services and the degree of its independence from political pressures. Rather than a Weberian state bureaucracy, independently implementing what politicians have decided, Vietnamese ministries are intrinsically linked with the Communist Party (Nguyen and Teicher, 2010). A significant majority of managerial staff are members of the Communist Party and, in order to be influential in the Party, it is important to increase or maintain decision-making power within a ministry. Some of the national and international SEA experts interviewed underlined that there can be strong incentives for ministries to draft legislative proposals without consulting other ministries, because such consultation may be perceived as decreasing the decision-making power of the agency initiating the request for consultation. In addition, provincial leaders are typically members of the Party, and often directly influence high-level decisions without much coordination with neighboring provinces or concerned ministries.

Ministries or provinces developing a plan or program often find it unnecessary and time consuming to open up "their" planning process to the scrutiny of outsiders. For the same reason, public consultation with civil society organizations such as the women's union, farmer's union or scientists' association can often be perfunctory. The weak incentives for government ministries or provinces to share information or engage in inter-departmental or regional coordination and stakeholder consultations clearly make it difficult for SEA to function as intended.

The parallel involvement in planning of the Communist Party of Vietnam and the formal ministerial bureaucracy has resulted in highly informal and opaque strategic planning practices. Lack of coordination has led to the existence of a plethora of low quality and contradictory laws and policies. For example, while a Socio-Economic Development Plan aims at promoting tourism and protecting world cultural heritage sites, the industrial sector strategy can simultaneously contain plans for extensive industrial infrastructure development in the same location. One of the international SEA experts interviewed pointed to a specific case in the Halong Bay area where this has happened.

Vietnam's low score on the World Governance Indicator *Control of Corruption*[6] is also of interest. While thorough documentation of corrupt practices is scant, there is anecdotal evidence that information, positions and even decisions can have a price within the Vietnamese bureaucracy. The use of public office for private gain can be one important explanation of the difficulties observed in accessing information when conducting SEA. Information is seen as an asset by government officials in public agencies and is accessible only through personal connections or bribes. In a society where corruption is widespread, it is likely that there will be resistance to the adoption of procedures such as SEA that aim to open up decision-making processes to additional analysis and consultation.

Discussion and conclusion

Substantial efforts have been made to introduce and institutionalize a systematic use of strategic environmental assessments in Vietnam. In no other developing country have development agencies invested so much in support of training, technical advice and different "pilot SEA studies". A legal framework mandating the use of SEA has been in place since 2005, different ministries have issued substantive technical

[4] −1.4 on a scale from −2.5 to +2.5.

[5] The score is −0.3 on a scale from −2.5 to +2.5. The indicator "Government effectiveness" reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

[6] Vietnam's score on the indicator "Control of corruption" is −0.6 on a scale from −2.5 to +2.5. The indicator reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

Table 3
Summary of constraints to the institutionalization of strategic environmental assessment in Vietnam.

Institutional level	Identified constraint	Implication for the use of SEA
Social embeddedness	Deference to authority/strongly hierarchical bureaucracy	Excessive attention to detail in order to not commit errors when undertaking required tasks. Not conducive for strategic thinking and experimentation with new methods and tools required for good SEA.
	Silo culture/“familism” within ministries	Hinders sharing of information and collaboration across ministries and sectors.
	Personal networks are extremely important for career advancement and “to get things done” in the bureaucracy.	Formal SEA procedures can easily be undermined if key decision-makers don't clearly signal their importance.
Institutional environment	The Vietnamese Communist Party plays an instrumental role in strategic planning, often in parallel with the formal bureaucracy.	Civil servants consider signals from leaders in the Communist Party more important than formal rules for SEA.
	The judiciary branch of government is weak in relation to the executive and legislative branches, resulting in weak rule of law.	Can undermine the implementation of the recommendations from SEA since breaching environmental laws may not be penalized.
Institutions of governance	Strong limitations on access to information, freedom of association and expression	Public participation is weak. The only participation is by concerned parts of the bureaucracy at national and provincial levels and organizations allowed to exist by the state.
	A state bureaucracy that is not politically independent, but intrinsically linked to the Communist Party.	Consultation often avoided in order not to lose decision-making power to other ministries or lose influence within the Communist Party. Civil servants consider signals from leaders in the communist party more important than formal rules.
	Informal and uncoordinated planning practices	SEA often carried out very late in the planning process, after key decisions have been taken.
	Widespread corruption within the state bureaucracy	Resistance to the adoption of SEA if it implies opening up decision-making processes to additional analysis and consultation. In an open process, it would be more difficult to use public power for private gain.
Action arena	Limited awareness among senior bureaucrats as to why SEA is important	Low priority, including human and financial resources, given to SEA.
	Inadequate knowledge about how to apply SEA among practitioners	Analyses are often too detailed and project oriented. Information provided is not useful for strategic planning and for making choices between strategic options.
	Inadequate financial resources for conducting SEA.	SEAs done in a rapid way without much consultation with stakeholders.
	Low sharing of information between ministries	Difficult to obtain necessary data for analysis. Decreased usefulness of SEA report.
	Stakeholder consultations often avoided or of poor quality.	Important viewpoints are not represented in the SEA. Less scope for learning and coordination as part of SEA.

guidance on how SEA should be carried out, and a large number of SEAs have been undertaken in relation to socio-economic development plans at the provincial and sector levels. Important formal building blocks of an SEA system are thus in place in Vietnam. Different reports and evaluations also indicate that specific pilot SEAs – notably those financed by development agencies – have contributed to improved integration of environment in important decisions (e.g., Dusik and Xie, 2009; Le, 2012).

However, our analysis indicates that there is a large gap between how the SEA system is supposed to work, as stipulated in SEA legislation and guidelines, and actual practice. This gap between theory and practice emanates from several important constraints to the effective use of SEA at different institutional levels. Table 3 summarizes the identified institutional constraints and their implications for the use of SEA.

Most of the constraints to effective use of SEA identified within the action arena may at a first glance seem easy to address. Additional training programs can fill knowledge and awareness gaps; formal legal procedures or guidelines can be revised and improved; additional budgetary resources for conducting SEA may be made available by development agencies or by developing a clear “cost norm” for SEA, and so forth. These kinds of activities have been the focus of much development assistance related to SEA.

However, our layered institutional analysis indicates that the constraints within the action arena are strongly linked to formal and informal constraints at other institutional levels, and this makes them considerably harder to address. Improving SEA guidelines on stakeholder consultation can lead to only marginal improvements when the key constraint is the government's restrictions on access to information and freedom of association and expression. Similarly, guidelines and trainings on how to compile environmental baseline information as part of an SEA will have limited effect when strong informal rules prevent free and open sharing of information between ministries and agencies. Further, raising the awareness of senior civil servants about the benefits of SEA can be difficult if there are no strong signals from the Communist Party about the need to consider environmental priorities in planning. Also, the informal rules emanating from Vietnamese cultural and religious traditions, as well as the one-party system, play an important role for how SEA works in practice. It is through an analysis of constraints within the institutional environment and governance levels that important differences between the Vietnamese one-party system and the Western democracies, where SEA has its roots, become visible.

Without a thorough understanding of these institutional constraints, it is easy to have unrealistically high expectations about what formal SEA procedures can deliver, and there is a risk of investing scarce resources in a suboptimal way. Instead of adapting SEA procedures to the institutional context in a “good enough” approach, there is a risk of introducing a too-ambitious approach based on international best practices developed in other contexts (Grindle, 2004, 2007).

An important implication for international development agencies and other advocates for environmental assessment systems is that a careful institutional analysis should be undertaken prior to attempts to introduce SEA in developing countries. The analytical framework for analyzing constraints to institutionalization of SEA presented in this paper represents a systematic effort in this direction.

SEA procedures can be adapted to a specific institutional context based on prior institutional analysis. For this to be doable, the institutional analysis must not result in an overwhelmingly long list of institutional constraints for integrating environment into decision-making. Rather, the analysis should identify the most important or “binding” constraints to the use of SEA and integration of environmental concerns into decision-making (Grindle, 2004; Rodrik, 2006).

Our analysis indicates that the lack of open access and sharing of information, as well as the weak coordination across sectors and levels of government, constitute the most important constraints to the performance of the SEA system in Vietnam. Consequently, issuing yet another technical SEA guideline – which reportedly is popular among Vietnamese authorities – is not likely to address the key shortcomings of the Vietnamese SEA system. Reforms for improved sharing of information, consultation and coordination would arguably have a larger impact on environmental integration in decision-making. However, changing institutions of governance is not easy and these types of (democratic) reforms would probably be heavily resisted by the political elite in Vietnam.

A more modest and realistic way to improve the integration of environmental concerns in Vietnamese decision-making could involve small steps toward improved sharing of information, coordination and consultation. An SEA system may contribute in this direction if it for example provides unrestricted access to completed SEA reports, increases the space for stakeholder dialog and creates arenas for information exchange and coordination between ministries and agencies. This could be a way to slowly empower broader groups in the Vietnamese society and, in the long run, possibly contribute to broader institutional reform.

Our study adds to the growing empirical literature about constraints to the effectiveness of environmental assessment systems. Notably, several of the findings in our study resonate with findings in studies from other Asian countries. Wirutskulshai et al. (2011) underline the importance of the planning context and governance structure – in particular limited provisions for public participation – for constraining the effectiveness of SEA in Thailand. Strong deference to authority was one among several cultural characteristics that Boyle (1998) identified as constraints to EIA effectiveness in Thailand, Malaysia and Indonesia. A bureaucratic culture working against collaboration across government departments and a general lack of transparency were major constraints to the effectiveness of the Chinese system of plan EIA identified by Bina (2008).

Through applying our conceptual framework to the empirical analysis the study also deepens the understanding of how layered institutional analysis can be used to study constraints to SEA institutionalization. The study demonstrates how constraints at one institutional level can be linked to constraints at other institutional levels. This resonates with for example Turnpenny et al (2008, p. 771) who in their study of constraints to impact assessment systems in four European countries concluded that "micro-level constraints such as availability of time and resources often have their roots in meso and macro-level institutions". Understanding these constraints at different institutional levels is an important step toward improving the use of SEA in Vietnam and other developing countries.

Finally, our study has provided some issues for further research. Institutional theory has been criticized for being better at explaining stability than change (Hill, 2005). This may be particularly troubling for studies concerning countries like China and Vietnam which despite lacking essential "good governance institutions" have experienced an extremely rapid economic development during the last decades (Grindle, 2007). In retrospect we can see that leading institutional analysts like Gunnar Myrdal grossly underestimated the potential for economic development in Asia (Myrdal, 1968). Could it be that we, through focusing on institutional constraints, also underestimate the potential for these countries to rapidly improve environmental assessment systems and environmental conditions? A more detailed analysis of the constraints to SEA institutionalization identified in this study could shed further light on the strength of these constraints and how they are linked. A more detailed analysis of particular SEA cases in Vietnam could also provide insights about the factors supporting the implementation of the many SEAs in Vietnam (Zhang et al., 2013). Regarding the analytical framework used in this study, the criteria for what aspects to assess within the different institutional levels as well as the methodology for identifying binding institutional constraints could be developed further.

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This thesis combines analyses of risk perceptions and behavioural responses to environmental health risks at the individual level with analyses of environmental risk management procedures and decision-making at the policy level.

In papers 1–3, we analyse the role of risk perceptions and exposure for protective behaviour against ticks, Lyme borreliosis and tick-borne encephalitis (TBE). We estimate people's willingness to pay for risk reduction and the effect of a potential TBE vaccine subsidy on the rate of vaccination. The empirical analysis is based on a survey with 1 500 randomly selected respondents in Sweden.

In papers 4–5, we analyse the role of institutions for the effectiveness of strategic environmental assessments in low- and middle-income countries. The empirical analysis is based on interviews with a wide range of stakeholders involved in strategic environmental assessments of policy reforms.

By combining environmental economic valuation and environmental assessment, this thesis bridges two scientific fields and practices that would benefit from more interaction.

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