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Assessment of the relative role of meat of domestic pigs, sheep, cattle, wild boars and moose for the exposure of humans to Toxoplasma gondii

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Introduction

Toxoplasma gondii is a zoonotic parasite prevalent worldwide. Meat from infected animals may contain tissue cysts with viable parasites and is therefore a potential source of infection for other hosts, including humans. Differences in consumption of meat and variation in the infection prevalence in animals between countries may be drivers of the geographical variation in seroprevalence observed in humans across the Nordic-Baltic region[1]. While consumption data are available, data on prevalence of *T. gondii* in different animal species used for human consumption are scattered, and no quantitative risk assessment studies have evaluated the risk of exposure of *T. gondii* through consumption of meat in the region. Therefore, the first objective of this study was to estimate the seroprevalence of *T. gondii* in domestic pigs, sheep, cattle, wild boars and moose in the Nordic-Baltic region. The next objective of the study is to develop a comparative exposure assessment (CEA) framework, and this is a work in progress. The CEA model will allow for the quantification and comparison of exposure to *T. gondii* parasites from various fresh and processed meat products consumed by different age-groups. This model will be applied to four countries.

Material and Methods

1. Systematic review (SR) and meta-analysis: To estimate the seroprevalence of *T. gondii* in domestic pigs, sheep, cattle, wild boars and moose in the Nordic-Baltic region, we conducted a systematic review and meta-analysis[1]. The apparent seroprevalence estimates retrieved from the individual studies were pooled using restricted maximum likelihood method with a random effects model to obtain a pooled seroprevalence estimate for each species.

2. CEA model framework: The framework for the CEA model was developed to estimate the annual risk of consuming one or more viable tissue cysts in different age-groups (≤4yrs, 5–14yrs, 15–24yrs, 25–44yrs, 45–64yrs, ≥65yrs) in Denmark, Finland, Norway and Sweden. The following steps were considered in the development of the CEA model framework:

a) Estimation of the true prevalence in the selected five animal species by country based on apparent seroprevalence collected in the SR and sensitivity and the specificity of the applied serological tests to detect infected animals. Where data on the sensitivity and the specificity of the serological tests were lacking, this information was extracted from the literature. If not available for specific animal species, surrogate data from other species were used. These sensitivity and specificity estimates were used as informative priors in a Bayesian hierarchical model to estimate the true prevalence for each species by country.

b) For each selected meat product originating from domestic pigs, sheep, cattle, wild boar or moose consumed in the region, we will use the food consumption survey data available for each country to estimate the average size of a portion of the meat product as well as the number of infected portions of each meat product consumed. We will do this by age-group and by country.

c) Conversion of true prevalence to number of tissue cysts per infected portion will be estimated from published data on both the number of bradyzoites in a portion from a true positive animal and the number of bradyzoites contained in a tissue cyst as described by Crotta et al[2].

d) Calculation of the probability that a portion contains one or more viable tissue cysts after salting, freezing or cooking will be based on reduction factors as described by Condoleo et al[3] adapted from Opsteegh et al[4]. The reduction factors will be applied at tissue cyst level; as the tissue cysts contain viable bradyzoites. We assumed that when the treatment is applied, all bradyzoites in a given tissue cyst will be assumed to either die or survive each treatment.

e) Estimation of the number of portions of each meat type containing viable tissue cysts consumed annually will be based on the number of portions consumed annually by each age-group by country and the probability that the portion contains viable tissue cysts.

f) Finally, relative comparison of exposure to viable tissue cysts by consumption of the different meat products, for source attribution of *T. gondii* infection will be performed for the four countries.

Results and Discussion

1. Systematic review and meta-analysis: The systematic literature review[1] included eight countries. Thirty-two studies qualified for the meta-analysis; 13 on domestic pigs, 6 on sheep, 3 on cattle, 6 on wild boars, and 4 on moose: Estimated pooled apparent seroprevalence of *T. gondii* was lowest in domestic pigs (6%, $CI_{95\%}$: 3–10%) and highest in wild boars (33%, $CI_{95\%}$: 26–41%)[1].
2. Preliminary framework for the CEA model: The preliminary true prevalence estimates to be used as one of the input parameters in the exposure assessment model are shown in Table 1. The present estimates from the Bayesian model is a work in progress and may therefore be further adjusted.

For the steps outlined in the flow diagram for the CEA model (Fig. 1), input values will be fitted using appropriate probability distributions during the model implementation stage.

Conclusion

The results of the systematic review and meta-analysis showed that a substantial proportion of animals raised or hunted for human consumption in the Nordic-Baltic region have been exposed to *T. gondii*. Therefore, meat of all the five animal host species are potential sources of infection in humans. The next step in this study is to implement the CEA model to quantify the importance of different meat products in *T. gondii* transmission through consumed meat in each of the four countries.

References

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Table 1: Preliminary true prevalence estimates for domestic pigs, sheep, cattle, wild boars and moose from Denmark, Finland, Norway and Sweden

	TP (95% CrI) in pigs	TP (95% CrI) in sheep	TP (95% CrI) in cattle	TP (95% CrI) in wild boars	TP (95% CrI) in moose
Denmark	5 (3–8)	N/A	N/A	49 (33–67)	N/A
Finland	0.3 (0.002–1)	23 (17–31)	11 (6–19)	35 (23–51)	1 (0.05–5)
Norway	2 (0.1–4)	22 (16–29)	N/A	N/A	5 (0.3–1)
Sweden	7 (5–9)	N/A	N/A	65 (50–87)	16 (9–25)

TP = true prevalence; CrI = 95% credible interval; N/A = No data available for the species in the country

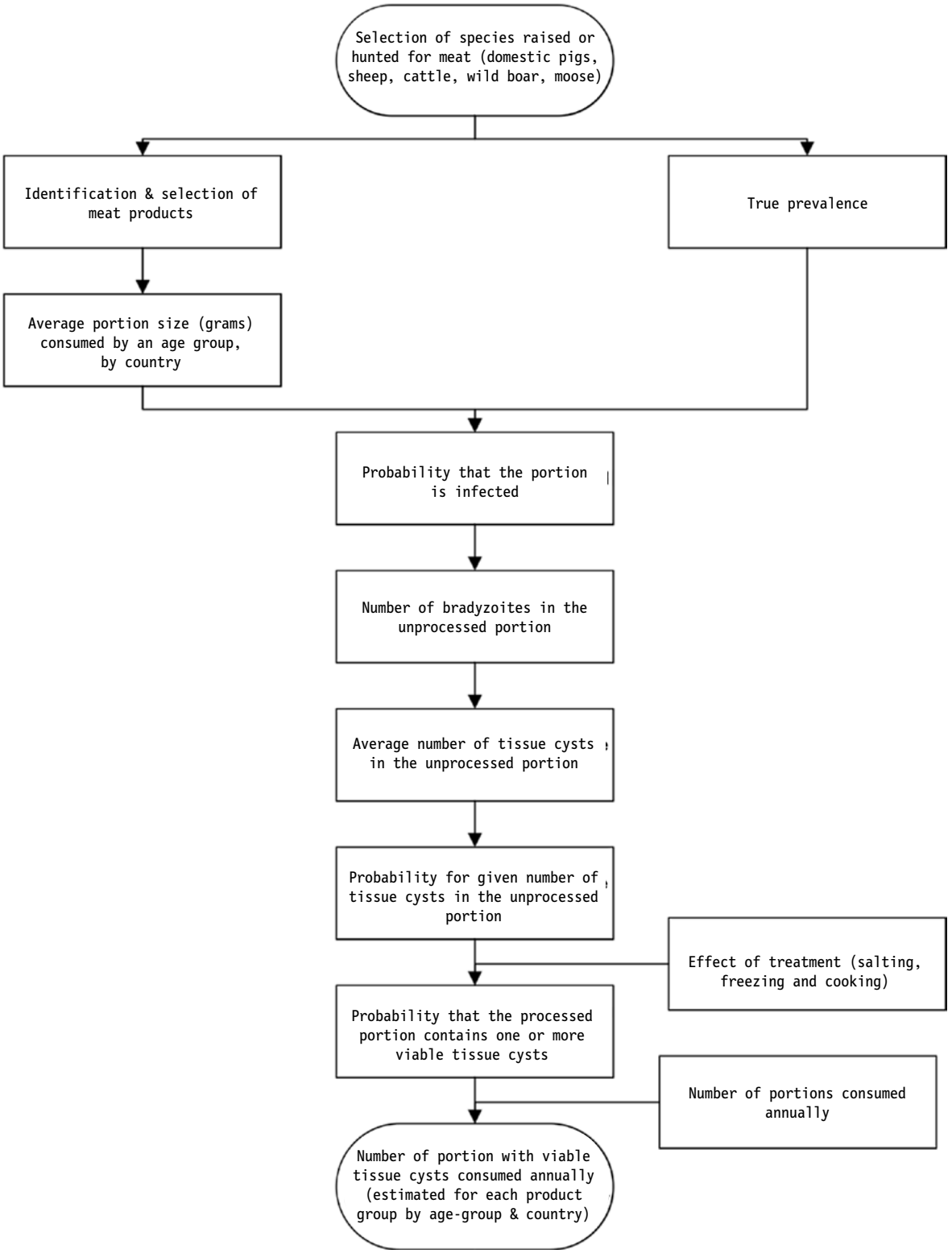

Figure 1: Flow chart of the comparative exposure assessment model to estimate the number of portions containing viable tissue cysts consumed per year by age-group and country