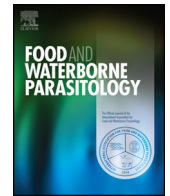




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Assessing the risk of human trichinellosis from pigs kept under controlled and non-controlled housing in Europe

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ABSTRACT

To support risk-based approach to prevent human trichinellosis, we estimated the human incidence for pigs originating from controlled and non-controlled housing, using a quantitative microbial risk assessment model for *Trichinella* (QMRA-T). Moreover, the effect of test sensitivity on human trichinellosis incidence from pigs from non-controlled housing was quantified. The estimated annual risk from pigs from non-controlled housing was 59,443 human trichinellosis cases without testing at meat inspection and 832 (95%CI 346–1410) cases with *Trichinella* testing, thus preventing 98.6% of trichinellosis cases per year by testing at meat inspection. Using the QMRA-T, a slight decrease in test sensitivity had a significant effect on the number of human trichinellosis cases from this housing type. The estimated annual risk for pigs from controlled housing was <0.002 (range 0.000–0.007) human cases with- and <0.010 (0.001–0.023) cases without *Trichinella* testing at meat inspection, which does not differ significantly ($p = 0.2075$). In practice, this means no cases per year irrespective of *Trichinella* testing. Thus controlled housing effectively prevents infection and *Trichinella* testing does not contribute to food safety for this housing type. Not testing for *Trichinella* requires evidence based full compliance with regulations for controlled housing.

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1. Introduction

Human trichinellosis is caused by ingestion of *Trichinella* muscle larvae in raw or improperly cooked meat or meat products. Within the nematode genus *Trichinella*, twelve taxa are recognized, which can infect a wide range of carnivores and omnivores, including humans and pigs (Pozio et al., 2009; Pozio and Murrell, 2006; Pozio and Zarlenga, 2013).

In Europe, the control of *Trichinella* is laid down in EU regulation 2015/1375 (European-Commission, 2015) for pigs, horses and other *Trichinella* susceptible animals used for human consumption. Biosecure or controlled housing conditions are directed at prevention of exposure to *Trichinella* and have to comply with regulations addressing feed safety, rodent control, building requirements, recorded management practices and on site audit programs (European-Commission, 2015; FAO-WHO, 2014a). Private standards such as the Danish Product standard in Denmark, QS Qualität und Sicherheit GmbH in Germany and Integrale Ketenbeheersing (IKB) in the Netherlands have been put in place to perform regular on-site audits and to document compliance with national law, and customer- and trade partner requirements (Alban and Petersen, 2016).

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Worldwide, >50% of slaughter pigs are produced under bio-secure (controlled) housing conditions (Pozio, 2014). Approximately 120 million (75%) of fattening pigs in Europe are kept under controlled housing conditions (Pozio, 2014) and none of these animals tested *Trichinella*-positive during the past two decades (Alban et al., 2008; Alban et al., 2011; Pozio, 2014). Consequently, the benefits of the *Trichinella* control program by testing pig carcasses at slaughter do not support the costs for these pigs. Therefore, *Trichinella* control moved to a risk-based approach and an exemption is made in EU legislation for pigs that are kept under controlled housing conditions, which means that these pigs no longer need to undergo individual carcass control (European-Commission, 2015).

To support this risk-based approach, we developed a quantitative microbial risk assessment model for *Trichinella* (QMRA-T) that includes the whole chain of events from primary production up to human trichinellosis incidence, based on prevalence data of pigs from non-controlled housing and wild boars, in combination with incidence data for human trichinellosis (Franssen et al., 2017). Defining parameters to estimate residual *Trichinella* infection risk for pigs from controlled housing in the QMRA-T is not straightforward, since no *Trichinella* positive animals have been demonstrated at meat inspection.

Trichinella testing at meat inspection is performed using a standardized reference method (European-Commission, 2015; ISO, 2015; Rossi and Pozio, 2008), for which test characteristics have been evaluated extensively (Riehn et al., 2013; Vallée et al., 2007). Recently, alternative tests have been introduced onto the market that may not have the same sensitivity as the reference method. So far, the effect of test sensitivity on the resulting number of human trichinellosis cases has not been quantified.

In the present study, we quantitatively evaluated the infection risk from pigs reared under controlled and non-controlled housing conditions with- and without *Trichinella* testing at meat inspection, using the QMRA-T model. Moreover, the effect of test sensitivity on expected human trichinellosis incidence from pigs from non-controlled housing was assessed.

2. Materials and methods

We used the QMRA-T model parametrized with data for pigs from non-controlled housing and wild boar from Poland, to model risk expressed as expected number of human trichinellosis cases per year (which may be a fractional number) (Franssen et al., 2017). Furthermore, the model performance was favorably assessed by comparing with epidemiological estimates of human cases. Briefly, the model used parameters to determine larval distribution between and within animals from a negative binomial distribution, followed by calculation of the number of *Trichinella* larvae per 100 g of diaphragm and probability of sampling larvae with 1 g (or 5 g for wild boar) diaphragm sample size from a binomial distribution at meat inspection. Next, the probability of recovering larvae from a pool of 100 g diaphragm samples following a beta-binomial distribution was determined. Missed positive carcasses at meat inspection and the number of *Trichinella* larvae in such positive carcasses are registered in the model. Distribution of *Trichinella* larvae over portions of pork was determined using a multinomial distribution. Finally, *Trichinella* inactivation after cooking was modelled based on consumer preference literature data, which were compared to and combined with temperature inactivation data from the literature. A previously described *Trichinella* dose-response for human infection (Teunis et al., 2012) was included in the QMRA-T, resulting in the number of human trichinellosis cases. One model run performed 1000 simulations with each simulation representing 1 year, to obtain robust estimates. Hence, model results are presented as mean with 95% confidence intervals (CI) and variability over model runs represents variability between years.

Table 1

Test parameters for QMRA modelling of human trichinellosis cases for non-controlled and controlled housing with- and without *Trichinella* testing at meat inspection.

Variable parameter	Pig, non-controlled	Pig, controlled	Unit
Observed prevalence	5.26×10^{-6}	$<4.17 \times 10^{-10}$	–
<i>m</i>	6.87×10^{-3}	5.30×10^{-7}	–
<i>k</i>	5.83×10^{-7}	4.51×10^{-11}	–
Abundance	0.3–211	0.1–0.8	LPG
<i>Trichinella</i> relative test sensitivity ^a	0.6–1 and 0	1 and 0	–
Number of swine	80	120	Million/year
Swine/pool	100		Pigs
Diaphragm weight tested	1		Gram
Iterations # escaped swine	1000		–
Iterations # larvae in diaphragm	1000		–
Portions/person ^b	94	147	100 g
Population EU ^c	504		Million
Number of loops per model run	1000		–

m: mean number of *Trichinella* muscle larvae (ML) in 50 g of diaphragm.

k: the clustering of *Trichinella* ML among individual swine.

^a Test sensitivity relative to the sensitivity of *Trichinella* testing using the artificial digestion test. A relative test sensitivity of 1 means testing according to the EU Reference method, 0 means no testing at all.

^b Average consumption of portions of shoulder, loin and belly per person per year calculated for EU, proportional to housing condition of origin.

^c Population size EU 2015; average EU population 2007–2016: 503.5 ± 3.2 M (Table 4).

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