One Health Approach To Tackling Toxoplasmosis

Dr Clare Hamilton, Dr Sarah Thomson, Dr David Smith, Professor Lee Innes

20 November 2025
Moredun Research Institute
9.00am-3.30pm

REPORT

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1. Overview

Toxoplasma gondii is widely regarded as a classic One Health parasite because its impact spans human health, animal health, and the environment. The most recent data from Public Health Scotland shows 47 laboratory-confirmed human cases of toxoplasmosis in 2023, continuing a steady rise over the past decade. Cats (domestic and wild) are the only known definitive hosts of the parasite, capable of shedding millions of oocysts in their faeces that can persist in soil and water for long periods of time, leading to widespread environmental contamination and exposing livestock, wildlife, and humans to infection. The parasite causes significant veterinary disease, including abortion in sheep and goats, whilst also posing a major public health concern through foodborne transmission, environmental exposure, and congenital infection. Fatal infections have also been reported in some marine mammals. As transmission pathways cross ecosystem boundaries, effective control of *T. gondii* requires a co-ordinated approach integrating public health, veterinary medicine, agriculture, and environmental management.

The aim of the symposium was to bring together experts and stakeholders from a wide range of disciplines to discuss a One Health approach to tackling toxoplasmosis (Table 1). We wanted to provide a platform to discuss and assess the current epidemiological landscape of toxoplasmosis and to share ideas and innovations for detection and control, whilst also identifying critical knowledge gaps. These discussions will help shape future research priorities and inform effective policy and intervention strategies to reduce the burden of *T. gondii* across sectors.

Thirty-two invited participants took part in the symposium which was held at the Moredun Research Institute on 20th November 2025. The morning sessions consisted of talks from experts in the field, focusing on public health perspectives, clinical data, veterinary impacts, vaccination, environmental and foodborne transmission, and developments in state-of-the-art research tools to aid future drug and vaccine development. Two of the speakers were able to provide European perspectives, detailing outcomes from a multi-country, collaborative project addressing source attribution of *T. gondii*, and summarising current parasite genotyping tools available to aid epidemiological studies and source tracking during outbreaks (www.onehealthejp.eu/projects/foodborne-zoonoses/jrp-toxosources). One of the invited participants was from Brazil, so could also share experiences from South America during the discussions. The afternoon session comprised three breakout discussion groups focusing on identifying knowledge gaps and future steps.

We conducted a participant survey at the start and end of the day to gather opinions on priority areas for research, barriers to control, engagement with other sectors, and next steps.

This report summarises the main outcomes from the day and highlights areas for future prioritisation to tackle toxoplasmosis.

Table 1:
List of stakeholders represented at the symposium

Stakeholder Category	Organisations Represented
Public Health	Scottish Toxoplasma Reference Laboratory; Toxoplasma Reference Unit, Public Health Wales; Public Health Scotland; Scottish National Blood Transfusion Service
Animal Health, Farming	National Sheep Association; Sheep Veterinary Society; Animal and Plant Health Agency; Scotland's Rural College (SRUC)
Veterinary pharmaceutical industry	Merck Sharp & Dohme (MSD)
Food and Water Safety	Food Standards Scotland; Scottish Water; Drinking Water Quality Regulator for Scotland
Policy	Scottish Government Animal Health and Welfare Department; Scottish Government Rural and Environment Science and Analytical Services (RESAS)
Academic	Moredun Research Institute; SRUC; University of Strathclyde; Heriot Watt University; Friedrich-Loeffler-Institut, Germany; Statens Serum Institut, Denmark; University of Londrina, Brazil

2. Motivation for symposium

Toxoplasma gondii is thought to infect approximately one third of the global population, although there is significant variation between countries and risk groups. In Scotland, 13.2% of 1400 blood donors had antibodies to *T. gondii*, and *T. gondii* DNA was detected in 17.9% of brain tissue deposited at the Medical Research Council Sudden Death Brain Bank (Burrells et al., 2016). Most immune competent people remain asymptomatic and will be completely unaware of being infected; however, there have been reports of severe disease in healthy individuals, particularly in central and South America, caused by more virulent strains of the parasite (Brito et al., 2023; Carme et al., 2002). Despite this, the greatest burden of infection lies with immune compromised individuals, such as those with HIV-AIDS, and those on immune suppressant drugs (e.g. transplant recipients) or undergoing chemotherapy. In this cohort, latent infections can reactivate due to suppressed immunity and can result in severe disease including encephalitis, ocular disease, or disseminated (whole-body) infection. Another vulnerable group are pregnant women, where a first-time infection can result in miscarriage, stillbirth, or severe abnormalities in the foetus, depending on the stage of pregnancy when infection occurs. Congenital toxoplasmosis is estimated to affect 1 in 10,000 live births in the UK. Although the disease is notifiable in England and Wales, and *T. gondii* is a notifiable organism in Scotland, there is currently (2026) no mandatory screening programme for pregnant women in the UK (UK National Screening Committee, 2016).

Toxoplasma also presents a major problem to the livestock industry in the UK, and worldwide, as infection can result in abortion and neonatal mortality in sheep and goats, resulting in significant reproductive losses. This can have an economic impact for farmers, as well as impacting food security by reducing numbers of viable offspring. A study of Scottish sheep flocks reported the presence of *T. gondii* antibodies in all 125 flocks surveyed, with an individual overall mean seroprevalence of 56%, increasing from South to North (Katzer et al., 2011). There is an effective vaccine available for use in breeding ewes, but the vaccine contains live parasites (tachyzoites) which impacts its shelf-life and gives rise to safety concerns for the handler (Innes et al., 2019). Also, as it is used seasonally, there can be issues with its availability.

Cats are the only known definitive hosts of *T. gondii,* shedding oocysts (eggs) in their faeces causing widespread environmental contamination. These oocysts are particularly robust and can survive in soil and water for many months, posing a risk of infection to grazing livestock and wild game, but also to humans through contaminated soil, produce, and water. When livestock and game animals become infected, the parasite can form cysts in their tissues, and this poses an important route of infection to people when the meat is consumed raw or undercooked. Indeed, *T. gondii* is considered an important foodborne pathogen and ranks highly when assessing disease burden (WHO, 2015).

Despite our knowledge of *T. gondii,* key gaps remain. The true global burden of disease - particularly congenital infection - is underestimated due to inconsistent surveillance and diagnostic approaches, and we still lack clarity on the relative importance of different transmission routes, in part because environmental detection of oocysts is technically challenging and methods are not standardised. Key gaps also persist in the environmental fate and transport of oocysts, and the genetic diversity of circulating strains of the parasite. Effective vaccines for use in humans and cats are absent, and the current vaccine for sheep has limitations. Importantly, existing drug treatments for humans do not eliminate latent infection. Finally, the impacts of climate change, flooding, land use shifts, and changes in farming and cat populations on future transmission dynamics remain uncertain, highlighting the need for integrated, cross-sectoral research.

Given these knowledge gaps, and the overlapping significance of *Toxoplasma* to public health, veterinary health, and the environment, we proposed to host this symposium to bring together key stakeholders encompassing these disciplines to help identify future research priorities.

3. Programme & speaker summaries

9.00-9.30 **Registration and Tea/Coffee**

9.30-9.45 **Welcome and Introduction: Dr Clare Hamilton**

SESSION 1: MEDICAL / VETERINARY FOCUS

Chair: Professor Lee Innes, Moredun Research Institute

Lee is a Principal Scientist at the Moredun Research Institute where her career has focused on developing solutions to control diseases caused by protozoan parasites of livestock. She combines this with her role as Director of Communications where she has established collaborations with artists, film makers and podcasters to increase the reach and accessibility of Moredun's work. Lee was awarded an MBE in the New Years Honours in 2015 for services to scientific research and science communication, and also holds Honorary Professorships at Heriot Watt University, University of Edinburgh and University of Glasgow. Lee was elected as a Fellow of the Royal Society of Edinburgh in 2017 and an Associate of the Royal Agricultural Societies in 2019. More recently, Lee successfully negotiated with the NHS and SRUC to set up testing of Covid samples during the pandemic to support the NHS and this was the first veterinary facility to do so showing the power of a One Health approach.

9.45-10.10 ***Human toxoplasmosis overview, and impact in Scotland***

Dr Sally Mavin, Scottish Toxoplasma Reference Laboratory, Raigmore Hospital, Inverness

Dr Sally Mavin has been Director of the Scottish Toxoplasma Reference Laboratory (STRL), based at Raigmore Hospital in Inverness, since February 2020 and has worked on the laboratory diagnosis of toxoplasmosis as a clinical scientist for more than 20 years. The reference laboratory receives samples from patients from all over Scotland for confirmatory testing, offers scientific and clinical advice to healthcare staff from throughout Scotland and works closely with colleagues in Public Health Scotland to collate and improve epidemiological information on toxoplasmosis.

Sally is a member of the UKNEQAS toxoplasma scientific advisory Group and has recently been working closely with colleagues at the Moredun Research Institute to improve the *T. gondii* cell culture system within the reference laboratory and further develop testing methods.

10.10-10.25 ***Incidence, diagnosis and impact of toxoplasmosis in England and Wales***

Dr Stephen Hadfield, Toxoplasma Reference Unit, Public Health Wales, Swansea

Stephen Hadfield is a Consultant Clinical Scientist and Acting Head of the Toxoplasma Reference Unit for England and Wales. After gaining a Microbiology BSc (hons.) at Cardiff University and Virology MSc at Imperial College, London, he completed a PhD at the University of Southampton focused on quantitation of hepatitis C virus. He remained in Southampton to introduce molecular epidemiological methods for investigation of bacterial infections until joining Public Health Wales in 2002. He initially worked at the national Cryptosporidium Reference Unit, developing molecular methods for detection and epidemiology of *Cryptosporidium* spp. Since 2014, he has worked at the national Toxoplasma Reference Unit which provides diagnostic and clinical advice services to support patient care throughout England and Wales, and also the Republic of Ireland. His research interests include development of methods for serodiagnosis, molecular detection and epidemiology of *Toxoplasma gondii*.

10.25-10.50 *Veterinary impact of toxoplasmosis*

Dr Andrew Robinson, SRUC

Andrew Robinson qualified from Glasgow Vet School in 1999 (having done an intercalated degree with a BSc in genetics in 1997) and worked in mixed practice for over 20 years. Two years ago, he joined SRUC Vet Services working out of St Boswells as a Veterinary Investigation Officer and combines this part-time role with a part-time role working as a small animal vet in first opinion practice. Andrew has a particular interest in helping farmers maximise the efficiency and output of their sheep flocks. Outside of work he is trying to breed a thoroughbred fast enough to win a race.

10.50-11.05 *Vaccination as a control strategy for ovine abortion*

Sara Robson-Ingham, MSD

Sara Robson-Ingham is a Regional Veterinary Adviser (Ruminants) for MSD Animal Health, having previously spent several years working as farm vet in a predominantly beef and sheep practice in County Durham.

11.05-11.25 Tea/Coffee break

SESSION 2: ENVIRONMENT / TRANSMISSION / RESEARCH FOCUS

Chair: Professor Fiona Henriquez, University of Strathclyde

Fiona gained her PhD in molecular parasitology, with the characterisation of dense granule proteins in the obligate parasite *Toxoplasma gondii*. She has continued in this area with a focus on host-pathogen interactions and parasite modulation of the host environment and immune response. Fascinated by toxoplasmosis in the eye, she began to work on the opportunistic pathogen, *Acanthamoeba* and the infection *Acanthamoeba* keratitis (AK). Her research focuses on the development of new treatments and prevention measures for AK, and understanding the host-pathogen interactions, focusing on innate immune cells. Fiona's research contributes to the 'One Health' agenda and addresses several UN SDGs through interdisciplinary and cross-sector collaborators. She has gained experience and knowledge of the decision-making processes and communication channels in health economies, stakeholder mapping, drug development and environment disinfection.

11.25-11.50 *ONLINE: One Health approach to Toxoplasma gondii source attribution - TOXOSOURCES*

Professor Pikka Jokelainen, Statens Serum Institut, Denmark

Dr Pikka Jokelainen (DVM, MPG, PhD, Adj. prof.) is Head of Function for Infectious Disease Preparedness and One Health at Statens Serum Institut, Copenhagen, Denmark. Dr. Jokelainen has published over 130 scientific articles, mainly in the areas of One Health, zoonoses, infectious disease preparedness, and science-policy interfaces. They hold several leading roles in large European One Health and preparedness initiatives, including co-ordinating the EU-HIP consortium that supports countries to improve IT-systems towards interoperability, EU-WISH Joint Action on wastewater-based surveillance, as well as the OH4 Surveillance consortium that strengthens integrated One Health surveillance approaches for zoonotic pathogens. In 2020-2022, they coordinated One Health EJP TOXOSOURCES project.

11.50-12.15 *Genotyping of Toxoplasma gondii - Why, how and what typing results can be expected in the European context?*

Dr Gereon Schares, Friedrich-Loeffler-Institut, Germany

Dr Gereon R.M. Schares is Scientific Director at the Friedrich Loeffler Institute, Federal Research Institute for Animal Health, Institute of Epidemiology, and Head of the German National Reference Laboratories for Echinococcosis, Toxoplasmosis, Dourine, and Surra.

Over the past decades, his laboratory has developed various methods for the detection and genetic characterization of zoonotic and veterinary parasites, as well as for identifying risk factors for their transmission to animals. Methods for the reliable detection of *Toxoplasma gondii* oocysts in cat feces have been applied in large-scale, long-term epidemiological studies using cats as the definitive hosts of *T. gondii*. These studies revealed a seasonality in oocyst shedding. The development of diagnostic tools for researching the epidemiology of other parasites also included the establishment of diagnostic procedures for the identification and characterization of veterinary parasites, e.g. *Neospora caninum*, an abortifacient in cattle, or *Besnoitia besnoiti*, a disease in cattle mechanically transmitted by insect vectors.

The isolation of viable parasites and their molecular typing methods were used to elucidate the global population structure of *T. gondii* and *N. caninum*. His laboratory identified highly polymorphic regions in the genomes of closely related *T. gondii* strains across Europe, and used a large number of strains from various parts of Europe to validate existing typing methods and establish a new Multilocus Sequence Typing method.

12.15-12.30 *Food and waterborne toxoplasmosis in Scotland*

Dr Clare Hamilton, Moredun Research Institute

Clare Hamilton is a senior research scientist working at the Moredun Research Institute on protozoan diseases of livestock. Clare first joined Moredun in 2000 as a research assistant in the protozoology group, before leaving to pursue a PhD on *Toxocara canis* at Trinity College Dublin. She remained in Dublin for 7 years working on liver fluke and teaching veterinary parasitology at University College Dublin. She re-joined Moredun in 2013 where she led a collaborative research project with Ross University School of Veterinary Medicine in St. Kitts (West Indies) investigating the epidemiology and genetic diversity of *Toxoplasma gondii* in the Caribbean. Clare's current research interests are in ovine abortion, food and waterborne toxoplasmosis, and molecular epidemiology and transmission dynamics of protozoan parasites.

12.30-12.45 *In vitro tools for studying Toxoplasma gondii biology*

Dr David Smith, Moredun Research Institute

David Smith leads a cellular and molecular parasitology research group whose work covers a range of protozoan and helminth parasites. The main aim of David's group is to identify parasite molecules that underpin a successful infection and to use these as targets in the development of novel vaccines or therapeutics. A major component of the group's research over the past several years has been to develop physiologically relevant tissue culture models derived from primary stem cells (i.e. organoids) for different mucosal tissues of cattle and sheep, including stomach, small and large intestine, upper and lower airway, liver and mammary. These models are now being applied to better understand host-parasites interactions and the parasite molecules for driving specific host responses (with a particular focus on immunomodulators), as well as to test novel mucosal vaccine adjuvants.

12.45-13.45 Lunch

13.45-14.45 Breakout discussion groups

1. **What current tools do we have to tackle toxoplasmosis and are these effective?**
2. **What do we understand about the transmission routes of toxoplasmosis in the UK, and where are the knowledge gaps?**
3. **How aware are the public of toxoplasmosis and how can we improve this?**

14.45-15.15 Reporting back and whole group discussion

15.15-15.30 Final summary and future plans

4. Breakout discussion group summaries

Group 1

What current tools do we have to tackle toxoplasmosis and are these effective?

- **We need to know more about transmission routes to improve control strategies.**
- **Diagnostic tests**
  - Current tools on offer are generally good.
  - We need improved diagnostics to be able to differentiate infections caused by tissue cysts (bradyzoites; in meat from infected animals) vs oocysts (sporozoites; in food/water contaminated with cat faeces). This would help inform us about transmission routes.
  - We need a test to differentiate acute/reactivated infection (tachyzoites) from latent infection (bradyzoites) to aid treatment options.
  - Could we develop a blood-based biomarker test to diagnose infection and help transform clinical decision-making and enable targeted treatment?
- **Treatments**
  - Current drugs, for use in people, can only manage active infection and do not eliminate tissue cysts.
  - We need a drug for tissue cysts, and this is particularly important for immune compromised people who face risk of reactivation.
  - We need more/better models (*in vitro*?) to be able to screen drug compounds and assess efficacy against tissue cysts.
- **Vaccination**
  - Issues with current vaccine for sheep (short shelf-life, availability, expense); an "anti-abortion" vaccine, targeting multiple abortifacient pathogens may improve uptake amongst farmers.
  - Do we need a vaccine for cats? How would we convince pet owners of the benefits? Could it be incorporated into other kitten vaccinations?
  - Should we develop a human vaccine? Who would be the target group?
  - Should we vaccinate livestock to reduce tissue cysts? How would we get buy-in from farmers?
- **Public health messaging is an important tool, but it is crucial to frame messaging correctly.**

Group 2

What do we understand about the transmission routes of toxoplasmosis in the UK, and where are the knowledge gaps?

- **Source attribution is helpful in an outbreak situation, but outbreaks of toxoplasmosis are rare (none reported in the UK), so understanding the route of infection can be difficult in individual cases.**
- **Should patient follow-up be improved? Should there be routine patient questionnaires to better understand risk factors?**
- **We need methods that can reliably distinguish tissue cyst infections from oocyst infections.**
- **We need better tools for detecting oocysts in environmental samples.**
- **What is the true incidence of *Toxoplasma* in retail meat? Are organically (outdoor) reared animals more "risky"?**
- **We need more thorough investigations of abortions in sheep flocks to better understand outbreak dynamics and risk factors.**
- **We need more recent data on the seroprevalence (exposure) of *Toxoplasma* in the general population. Blood donor surveys are a useful way of doing this.**
- **We need more research on the impact of climate change (increased rainfall, milder winters) on transmission of *Toxoplasma*. Are there changing patterns in diagnosed cases?**
- **Do we need to investigate how oocysts move from cat faeces into soil and water, and onto fresh produce?**
- **There are issues with genotyping methods due to low concentrations of parasite DNA in diagnostic samples. We need better methods for DNA enrichment.**

Group 3

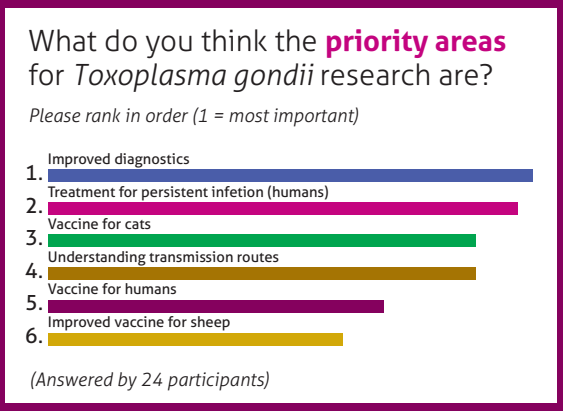
How aware are the public of toxoplasmosis and how can we improve this?

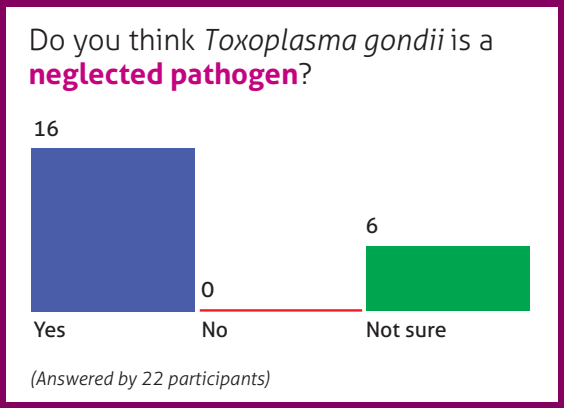
- There needs to be a balance between raising awareness and alarming people.
- Which groups of people should be prioritised for communication – pregnant women, immune compromised people, farmers?
- Should there be Continuing Professional Development (CPD) courses developed for medical / veterinary staff focusing on toxoplasmosis?
- There is a general awareness for pregnant women to avoid lambing and cleaning out cat litter trays but the specific link with *Toxoplasma* is probably not recognised.
- Awareness could be improved through the production and circulation of factsheets, animations, and websites.
- Using a "story telling" approach can help get messages across in an effective way to help increase the impact of communication.
- Do we need clearer guidance on cooking and freezing meat as a means of avoiding foodborne infection?
- Sushi is routinely frozen to reduce the risk of anisakiasis – could routine freezing of meat be introduced to reduce toxoplasmosis?
- There is a strong need for accurate diagnostic tests along with expert advice to help support pregnant women who may be at risk during their pregnancy.
- One Health education should be promoted in schools, highlighting simple preventative measures such as washing hands, food hygiene, and cooking / freezing of meat. These control measures could have multiple benefits against a range of zoonotic pathogens.

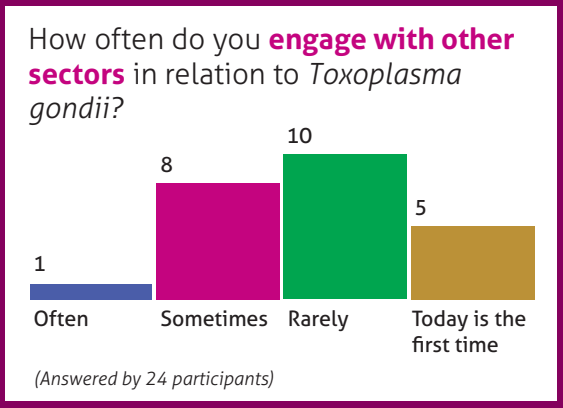
5. Participant surveys

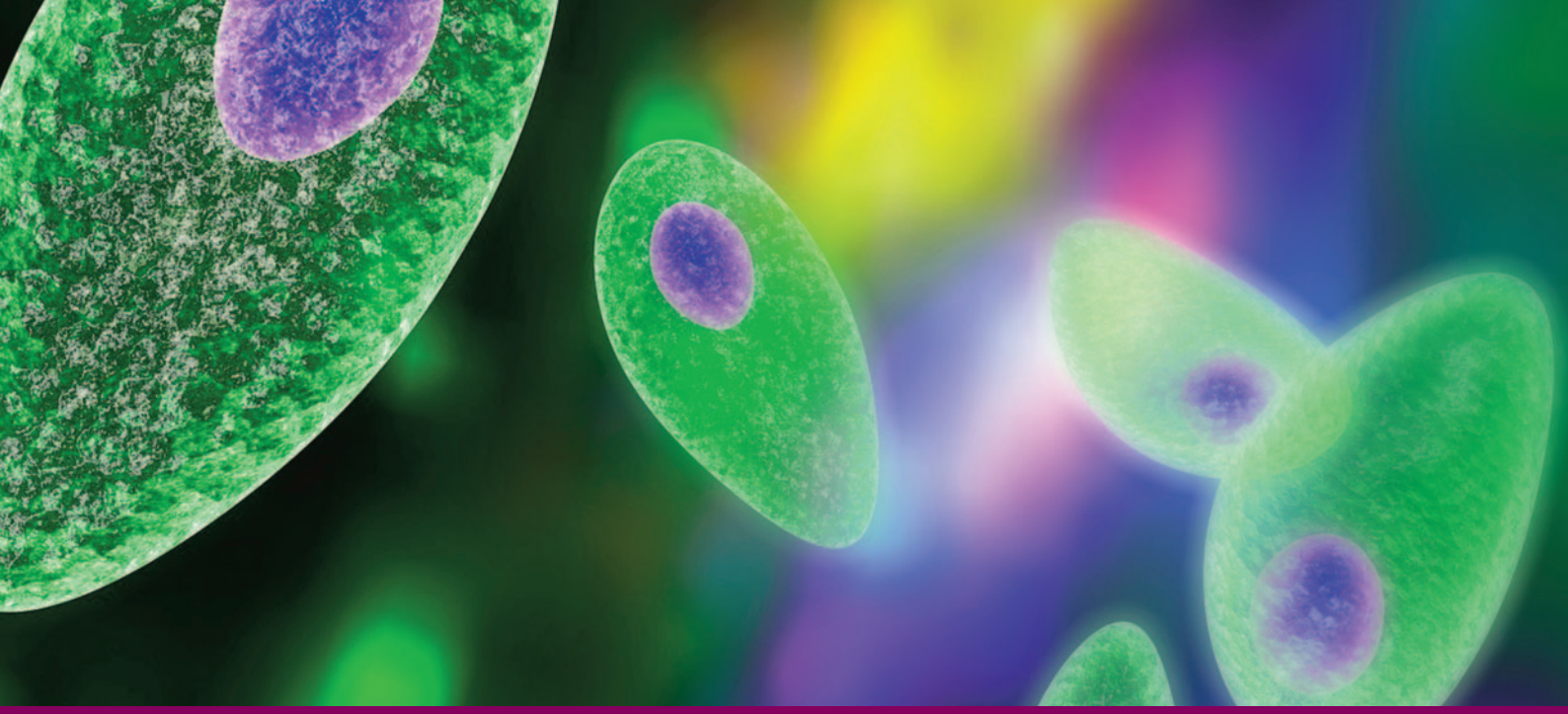
Pre-symposium survey

At the start of the day, and prior to any talks, we conducted a survey of the participants, using Mentimeter, to ascertain a baseline opinion on whether they considered *T. gondii* to be a neglected pathogen and what they believed to be priority areas for research. We also wanted to gauge how often cross-sectoral discussions took place. Results of the pre-symposium survey are shown below:









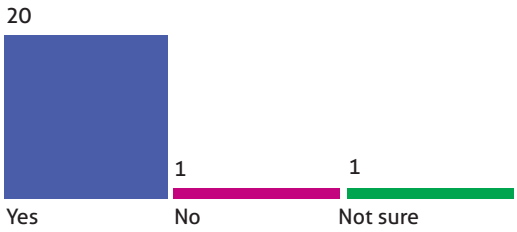
Post-symposium survey:

At the end of the symposium, we conducted a second survey which included two questions that had been posed in the pre-symposium survey to determine whether participants had changed their opinion following the talks and discussions held over the course of the day. We also wanted to identify what people believed to be the biggest barriers to controlling *T. gondii*, and to ask what people would like to happen next to take things forward. The results of the post-symposium survey are shown below:

What do you think is the biggest **barrier to controlling** *Toxoplasma gondii* ?

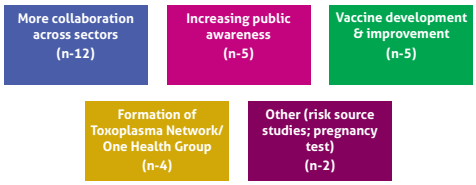
(Answered by 20 participants)

Do you think *Toxoplasma gondii* is a **neglected pathogen**?



(Answered by 22 participants)

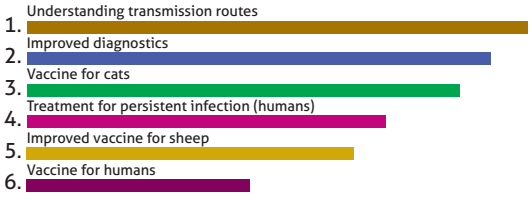
What would you like to see **happen next** as a result of this symposium?



(Answered by 20 participants)

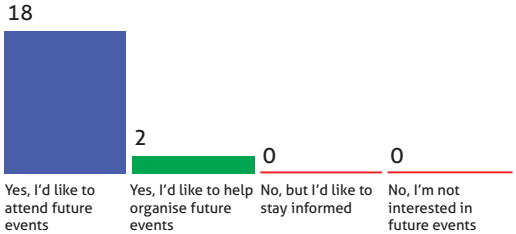
What do you think the **priority areas** for *Toxoplasma gondii* research are?

Please rank in order (1 = most important)



(Answered by 22 participants)

Would you like to be involved in **future events**?



(Answered by 20 participants)

6. Conclusions and main recommendations for future work

Overall, the symposium confirmed that *Toxoplasma gondii* remains a neglected pathogen and its true burden is still underestimated. The breakout discussion groups raised many questions highlighting persistent gaps in our understanding of toxoplasmosis that continue to limit our ability to address the disease effectively. Participants highlighted that meaningful progress against toxoplasmosis will require stronger cross-sectoral collaboration, bringing together human health, animal health, environmental science, and public health policy. Understanding transmission routes more clearly and improving diagnostic tools and education for risk groups emerged as central research priorities, especially given that limited awareness and major gaps in knowledge about *Toxoplasma* transmission routes continue to be the greatest barriers to effective control. The enthusiasm and engagement throughout the day demonstrated a clear appetite for ongoing One Health dialogue - paving the way for future meetings, and possibly the establishment of a Scottish *Toxoplasma* Network, to sustain momentum and drive co-ordinated action.

Main recommendations:

1. Studies are required to determine the true prevalence and burden of disease, in both humans and animals.
2. More evidence is required to understand the relative roles of oocyst-borne infections and tissue cyst-borne infections.
3. New and improved diagnostic tests, therapeutic treatments, and vaccines are required to fully tackle toxoplasmosis in both humans and animals.
4. Cross-sectoral collaboration is crucial to tackling *Toxoplasma* as its transmission cycles span human, veterinary and environmental health.
5. Education is key to improving awareness, especially amongst vulnerable groups who are most at risk of severe disease.

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For further information about this workshop
or if you would like to be included in future events please contact:

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