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Toxoplasmosis snapshots: Global status of *Toxoplasma gondii* seroprevalence and implications for pregnancy and congenital toxoplasmosis

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ABSTRACT

Toxoplasma gondii's importance for humans refers mainly to primary infection during pregnancy, resulting in abortion/stillbirth or congenital toxoplasmosis. The authors sought to evaluate the current global status of *T. gondii* seroprevalence and its correlations with risk factors, environmental and socioeconomic parameters. Literature published during the last decade on toxoplasmosis seroprevalence, in women who were pregnant or of childbearing age, was retrieved. A total of 99 studies were eligible; a further 36 studies offered seroprevalence data from regions/countries for which no data on pregnancy/childbearing age were available. Foci of high prevalence exist in Latin America, parts of Eastern/Central Europe, the Middle East, parts of south-east Asia and Africa. Regional seroprevalence variations relate to individual subpopulations' religious and socioeconomic practices. A trend towards lower seroprevalence is observed in many European countries and the United States of America (USA). There is no obvious climate-related gradient, excluding North and Latin America. Immigration has affected local prevalence in certain countries. We further sought to recognise specific risk factors related to seropositivity; however, such risk factors are not reported systematically. Population awareness may affect recognition of said risks. Global toxoplasmosis seroprevalence is continuingly evolving, subject to regional socioeconomic parameters and population habits. Awareness of these seroprevalence trends, particularly in the case of women of childbearing age, may allow proper public health policies to be enforced, targeting in particular seronegative women of childbearing age in high seroprevalence areas.

1. Introduction

Toxoplasma gondii is an obligate intracellular protozoan able to infect different species (Tenter et al., 2000). Sexual forms of the parasite are found in the intestinal epithelium of definitive hosts such as domestic cats: therein they transform into oocysts which are subsequently shed in the environment. Oocysts, remarkably stable environmentally, are transmitted to other hosts through inadvertent ingestion. Humans acquire *T. gondii* through ingestion of undercooked meat, contact with feline faeces and rarely through drinking contaminated water or through transplantation of a contaminated organ (Hill and Dubey, 2002).

Human toxoplasmosis is usually subclinical or resembles a minor viral illness (Montoya and Liesenfeld, 2004). It is nevertheless the most common food-borne parasitic infection requiring hospitalisation (Vaillant et al., 2005) and the third most common cause of hospitalisation due to food-borne infection overall (Mead et al., 1999). Furthermore the parasite's bradyzoites can persist inside human cells for protracted periods and latent infection may be reactivated, typically in the case of AIDS where *T. gondii* reactivation causes severe encephalitis (Porter and Sande, 1992).

Primary infection during pregnancy may cause spontaneous abortion or stillbirth. A newborn exposed to *T. gondii* in utero may develop congenital toxoplasmosis with major ocular and neurological consequences. The disease burden of congenital toxoplasmosis, as represented by disability-adjusted life years (DALY), is the highest among all food-borne pathogens (Havelaar et al., 2007).

Due to its long-term complications and the fact that *T. gondii* is omnipresent, epidemiological studies on its seroprevalence help shape health policies in individual countries. The purpose of this is to collectively evaluate available epidemiological data on the worldwide seroprevalence of *T. gondii*, particularly focusing on pregnant women or women of childbearing age (15–45 years).

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2. Materials and methods

A literature search was initially performed in PubMed (http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed) and Scopus (www.scopus.com) databases using as keywords the terms "seroprevalence OR seropositivity" AND "toxoplasma OR toxoplasmosis". We subsequently searched these databases and a general search engine (Google, http://www.google.com) using the terms "Toxoplasma OR Toxoplasmosis" and individual country names, for all countries (e.g. "toxoplasmosis AND Afghanistan", and so on). We additionally searched the SciELO (scientific electronic library online, www.scielo.br) database with the keyword toxoplasmosis, for hitherto unretrieved relevant Latin American literature. A further search was performed in the references of the initially retrieved articles. We also searched abstract books of last decade's international infectious disease congresses for additional studies, including the Infectious Diseases Society of America's annual meetings (http://www.idsociety.org/Content.aspx?id=1900), the International Congress of Infectious Diseases (http://www.isid.org), and the European Congress of Clinical Microbiology and Infectious Diseases (http://www.blackwellpublishing.com/eccmid18).

We selected articles published during the last decade, i.e. after January 1, 1999 and registered until December 30, 2008 (when a final search was re-performed), irrespective of the date of retrieval of the contained data. Available literature on the subject published prior to 1999 has been summarised in a relevant review, published in 2000 (Tenter et al., 2000). For countries for which no recent data were available, relevant data search was extended until 1990, in order to create a global view of *T. gondii* seroprevalence. Articles written in languages other than English, Greek, Spanish, French or Italian were translated by a native speaker of the individual language.

Included studies reported seroprevalence rates either in women of childbearing age or pregnant, or in the general population or a representative sample of it. Studies focusing on specific target groups (for example HIV-positive patients or slaughterhouse workers or children or psychiatric patients) were excluded. We also excluded studies focusing on a specific sub-group of pregnancy, women with bad obstetric history, since their results cannot be reliably translated to general prevalence rates. For a study to be included, the minimum number of patients was preset as 100, in order to minimise undue sampling biases into prevalence estimates.

2.1. Statistical analysis

Confidence intervals (CIs) for seroprevalence rates in each individual study were either derived from the relevant study, or estimated using the freely available online Sample Size Calculator (Creative Research Systems, http://www.surveysystem.com/sscalc.htm). When CIs were not available from an individual study, we calculated 95% CIs using the available sample size and percentages, and presumed that the population from which the sample size was derived was too large (or unknown) to exert any significance on 95% CIs.

3. Results

Fig. 1 depicts the current global *T. gondii* seroprevalence status, according to the data retrieved and subsequently analysed and discussed.

3.1. North and Latin America

Numerous studies derive from Latin America, in particular Brazil; data for USA are derived from the nationwide NHANES study (Jones et al., 2007), while limited information is available for Canada (Table 1). The majority of studies emerging from Latin American countries show significantly high seropositivity rates; the only exception is a large-sample study from Brasilia (Cabral et al., 2008): one can presume that Brazil's capital may exhibit a different socioeconomic structure compared to the rest of the country since it is a city recently built in order to serve as a federal centre. Seroprevalence studies in general population samples in Amerindians have shown even higher prevalence rates and potential correlations with sanitary practices and eating/drinking habits (the use of well water or the consumption of rodents or monkeys) (Boia

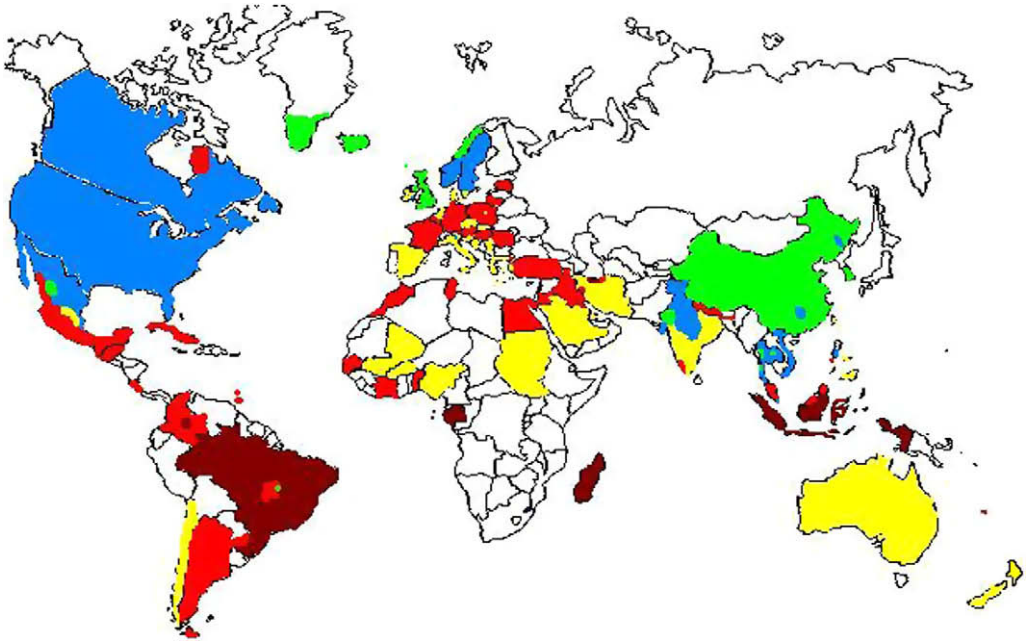

Fig. 1. Global status of *Toxoplasma gondii* seroprevalence. Dark red equals prevalence above 60%, light red equals 40–60%, yellow 20–40%, blue 10–20% and green equals prevalence <10%. White equals absence of data. Data as described in tables and text (Section 3).