Transactions of the Royal Society of Tropical Medicine and Hygiene (2005) **99**, 268—278

www.elsevierhealth.com/journals/trst

Echinococcosis in Tunisia: a cost analysis

Meghan M. Majorowski[a,*], Hélène Carabin[a,1], Mohamed Kilani[b], Afif Bensalah[c]

[a] *Wellcome Trust Centre for the Epidemiology of Infectious Diseases, University of Oxford, Oxford, UK*
[b] *École Nationale de Médecine Vétérinaire de Sidi Thabet, Université Tunis II, 2020 Sidi Thabet, Tunisia*
[c] *Laboratoire d'Épidémiologie et d'Écologie Parasitaire (LLEP) (Unité d'Épidémiologie), Institut Pasteur de Tunis, 13 rue place Pasteur, B.P. 74, 1002 Tunis Belvedère, Tunisia*

Received 30 July 2003; received in revised form 22 June 2004; accepted 22 June 2004
Available online 15 January 2005

KEYWORDS
Echinococcus granulosus;
Zoonosis;
Domestic animals;
Humans;
Cost analysis;
Tunisia

Summary *Echinococcus granulosus* infection is a preventable zoonosis of human and veterinary public health importance in Tunisia. We aimed to comprehensively quantify human and animal echinococcosis losses in Tunisia. Itemized cost menus were developed for the health of both domestic animals and humans, and for productivity monetary losses. The incidence and prevalence of the disease in all species were obtained from national and personal reports. The domestic animal and human costs of echinococcosis in Tunisia were estimated using age-stratified rates and losses, productivity losses (including those not formally employed) and Monte Carlo sampling to represent the uncertainty inherent in some epidemiological and economic values. Echinococcosis in Tunisia causes significant direct and indirect losses in both humans and animals of approximately US$10—19 million annually. These estimates are based on numerous methodological improvements over previous studies and are of considerable consequence relative to Tunisia's US$21.2 billion gross domestic product. A cost—benefit analysis of control programmes using the methodological advances presented here and regional comparison to other endemic diseases is warranted. These may provide information to assist policy decision-makers in prioritizing the allocation of scarce resources.

1. Introduction

Echinococcus granulosus infection is a preventable zoonosis of human and veterinary public health importance that remains problematic in several countries. The parasite cycles in a predator/prey relationship between carnivore 'definitive' hosts which harbour the tapeworm stage and herbivore

* Corresponding author. Present address: 1300 W Altgeld #111, Chicago, IL 60614, USA. Tel.: +1 312 551 3664; fax: +1 312 884 6258.
E-mail address: meghan_majorowski@mckinsey.com (M.M. Majorowski).
[1] Present address: Department of Biostatistics and Epidemiology, College of Public Health, Oklahoma University Health Sciences Center, 801 NE 13th Street, Oklahoma City, OK 73104, USA.

0035-9203/$ — see front matter © 2004 Royal Society of Tropical Medicine and Hygiene. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.trstmh.2004.06.011

'intermediate' hosts which harbour the larval hydatid cyst stage. Humans become infected with hydatid cysts if they inadvertently ingest tapeworm eggs passed in faeces of infected carnivores that contaminate the environment. The disease in both humans and domestic animals (e.g. sheep, goats, cattle, camelidae) has been successfully eliminated through control programmes implemented in a few islands (Cyprus, New Zealand, Tasmania and Iceland) (Economides et al., 1998; Roberts and Gemmell, 1994). However, in a continental developing country like Tunisia, several elements limit the feasibility of implementing a control program: scarce economic and personnel resources, extensive sheep farming practices, free movement of herds and humans, religious customs involving home slaughter of livestock and borders with other countries where the disease is endemic. These elements also contribute to a high disease burden (Gemmell, 2000) reflected by Tunisia having the highest reported rate of surgery for human echinococcosis in the region (annual average 15/100 000) (Ministère de La Santé Publique, 1993). Yet, these rates only reflect one aspect of the total burden of a zoonotic disease like echinococcosis.

To provide local and international decision-makers with an estimate of the magnitude of echinococcosis, one needs to estimate both the human and animal disease burden at the same time using additive methodologies. While concepts such as quality of life years or disability-adjusted life years (DALY) (McGuire et al., 1988) are often used to describe human disease burden, it is not possible to incorporate animal losses into these values. One useful method available to quantify losses due to human and animal echinococcosis is to allocate a monetary value per average case specific to each species (including humans) and multiply these values by the annual species-specific number of incident cases. In fact, as early as 1978, the WHO recommended that socio-economic evaluation should be an essential part of all programmes for the control of parasitic zoonoses (WHO, 1978). One other group of researchers has recently attempted to quantify human and animal echinococcosis losses in Uruguay, Jordan and Wales (UK) (Dowling, 2000; Torgerson and Dowling, 2001; Torgerson et al., 2000, 2001). This type of analysis is challenging because very few reliable data are available on the rates of infection and the costs of treatment (or productivity losses) needed for at least the four key species that incur monetary losses (humans, sheep, goats and cattle). The aim of this study is to estimate the overall monetary losses of animal and human echinococcosis to Tunisia using a Monte Carlo sampling method to represent the uncertainty inherent to these epidemiological and economic values.

2. Materials and methods

The overall cost of zoonoses in general should be calculated by the following expression:

$$\sum_{s=1}^{S}\sum_{a=1}^{A}\left[N_{a,s}\beta_{a,s}\left(\sum_{x=1}^{X}\pi_{x,a,s}C_{x,a,s}\right)\right]$$

For echinococcosis, this would correspond to the additive societal costs for all affected species (S) across all age groups (A). For the age-species-specific population of size ($N_{a,s}$), with the age-species-specific annual rate of echinococcosis infection ($\beta_{a,s}$), there is an age-species proportion ($\pi_{x,a,s}$) of infected individuals with symptoms x. Ideally, one would include the whole spectrum of symptoms attributable to echinococcosis in human (see Discussion). Due to limited available data on the impact and the rate of the infection in humans, the symptoms were restricted to surgery and long-term disability among surgical cases. For animals, the symptoms included ranged from condemned offal at the abattoir to productivity losses (see Table 1). The total cost is calculated by multiplying the unit cost due to each symptom x ($C_{x,a,s}$) by the age-species-specific proportion of symptom x. A societal approach is adopted throughout to represent the monetary impacts of the infection and disease on the society as a whole, including both health care provider (HCP) and non-HCP costs (Drummond et al., 1997). The sum of the societal costs in all species is defined as the overall cost.

2.1. Data source

Data on the costs of echinococcosis were gathered through literature review and local Tunisian reports. Epidemiological data on *E. granulosus* infection and disease were obtained from scientific journals, books, governmental reports and the Internet. Two government reports published by the Tunisian Ministry of Public Health on echinococcosis surgical incidence were extensively reviewed (Ministère de La Santé Publique, 1993, 1995). FAOSTAT data were used for livestock prices, primary production and products, and animal and human demographic data (FAOSTAT, 2000). Local data were used to estimate abattoir condemnations.