

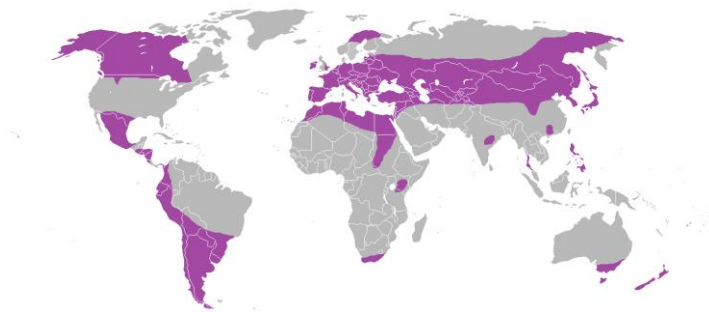


# Overview of the Socioeconomic Impact of Echinococcosis in Endemic Countries

*Christine M. Budke*



**How do we assess/convey the impact of echinococcosis on a country/region/world?**



Source: [http://www.isradiology.org/tropical\\_diseases/tmcr/chapter3/geographic.htm](http://www.isradiology.org/tropical_diseases/tmcr/chapter3/geographic.htm)

## Burden of disease assessment

**Disease burden** is the impact of a health problem on an area measured by financial cost, mortality, morbidity, or other indicators.



## How do you measure “impact” of disease on a population?

- **Disease Frequency**
  - Prevalence
  - Incidence
  - Mortality
- **Monetary losses**
  - Human health/animal production
  - Direct costs/indirect costs
- **Health adjusted life years**



## Disability Adjusted Life Year (DALY)

- Developed in the 1990s
- A time-based measurement unit (metric) for estimating the health burden caused by different diseases
- Meant to be interchangeable and equivalent across locations and cultures

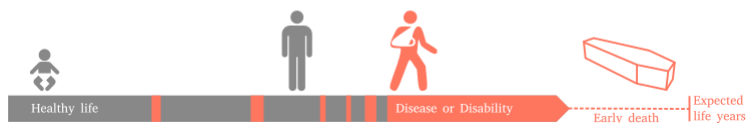
## Disability Adjusted Life Year (DALY)

### DALY

Disability Adjusted Life Year is a measure of overall disease burden, expressed as the cumulative number of years lost due to ill-health, disability or early death

$$= \text{YLD} + \text{YLL}$$

Years Lived with Disability      Years of Life Lost



$$\text{DALY} = \text{Years Lived with Disability (YLD)} + \text{Years of Life Lost (YLL)}$$

## **Disability Adjusted Life Year (DALY)**

- Requires information on the frequency of the condition in the population
  - Requires information on clinical manifestations associated with the condition
    - Converted to disability weights (0-1 scale)
  - Requires information on duration of clinical manifestations
  - Requires information on mortality attributed to the condition
- 

## **Disability Adjusted Life Year (DALY)**

Measures health that is “lost” rather than something “gained”

Programs thus should aim at REDUCING DALYs



## Initial DALY estimates for echinococcosis

*Am. J. Trop. Med. Hyg.*, 71(1), 2004, pp. 56-64  
Copyright © 2004 by The American Society of Tropical Medicine and Hygiene

### USE OF DISABILITY ADJUSTED LIFE YEARS IN THE ESTIMATION OF THE DISEASE BURDEN OF ECHINOCOCCOSIS FOR A HIGH ENDEMIC REGION OF THE TIBETAN PLATEAU

CHRISTINE M. BUDKE, QIU JIAMIN, JAKOB ZINSSTAG, WANG QIAN, AND PAUL R. TORGERSON

*Institute for Parasitology, University of Zurich, Zurich, Switzerland; Sichuan Institute of Parasitic Diseases, Chengdu, Sichuan, People's Republic of China; Department of Public Health and Epidemiology, Swiss Tropical Institute, Basel, Switzerland*

**Abstract.** Shiqu County, located on the Tibetan plateau of western China, has an extremely high prevalence of both human alveolar echinococcosis (AE), and cystic echinococcosis (CE). The short form 12 version 2 quality of life survey, which was used to evaluate the extent to which morbidity associated with echinococcosis should be accounted, verified that there was a significant reduction in the mean health scores in all categories for individuals diagnosed with abdominal echinococcosis compared with an age and sex cross-matched population. Results of a larger ultrasound survey, which screened 3135 subjects, demonstrated that the prevalence rates of AE and CE were both approximately 6% with a combined prevalence rate of 11.4%. Prevalence rates adjusted for the age and sex structure of Shiqu County were 4.6% for AE and 4.9% for CE with an estimated overall adjusted prevalence rate of 9.5%. The burden of disease associated with echinococcosis was calculated using disability adjusted life years (DALYs) based on these estimated prevalence rates. Monte-Carlo techniques were used to model the uncertainty in the prevalence estimates and the disability weights. Using these methods, we estimated that the total numbers of DALYs lost due echinococcosis was 50,933 (95% confidence interval [CI] = 41,995–61,026). The DALYs lost consisted of approximately 32,978 (95% CI = 25,019–42,422) due to AE and 17,955 (95% CI = 14,268–22,128) due to CE and suggests an average of approximately 0.81 DALY lost per person. This study has clearly shown that the impact of DALYs lost due to echinococcosis, in terms of medical treatment costs, lost income, and physical and social suffering, is likely to be substantial in this highly endemic region of China.

## Initial DALY estimates for echinococcosis

RESEARCH

### Global Socioeconomic Impact of Cystic Echinococcosis

Christine M. Budke,\* Peter Deplazes,\* and Paul R. Torgerson\*

Cystic echinococcosis (CE) is an emerging zoonotic parasitic disease throughout the world. Human incidence and livestock prevalence data of CE were gathered from published literature and the Office International des Epizooties databases. Disability-adjusted life years (DALYs) and monetary losses, resulting from human and livestock CE, were calculated from recorded human and livestock cases. Alternative values, assuming substantial underreporting, are also reported. When no underreporting is assumed, the estimated human burden of disease is 285,407 (95% confidence interval [CI] 218,515–366,133) DALYs or an annual loss of US \$193,529,740 (95% CI \$171,567,331–\$217,773,513). When underreporting is accounted for, this amount rises to 1,009,662 (95% CI 862,119–1,175,654) DALYs or US \$763,980,979 (95% CI \$676,040,731–\$857,982,275). An annual livestock production loss of at least US \$141,605,195 (95% CI \$101,011,553–\$183,422,465) and possibly up to US \$2,190,132,464 (95% CI \$1,572,373,055–\$2,951,409,989) is also estimated. This initial valuation demonstrates the necessity for increased monitoring and global control of CE.

Emerging Infectious Diseases • www.cdc.gov/eid • Vol. 12, No. 2, February 2006



TEXAS A&M  
UNIVERSITY

# Global Burden of Disease Study

THE LANCET

Volume 381 Number 10101 Pages 1012-1080 December 15, 2012 January 4, 2013 www.thelancet.com

The Global Burden of Disease Study 2010



GBD Study 2010  
GBD Study 2013  
GBD Study 2015  
GBD Study 2016  
GBD Study 2017

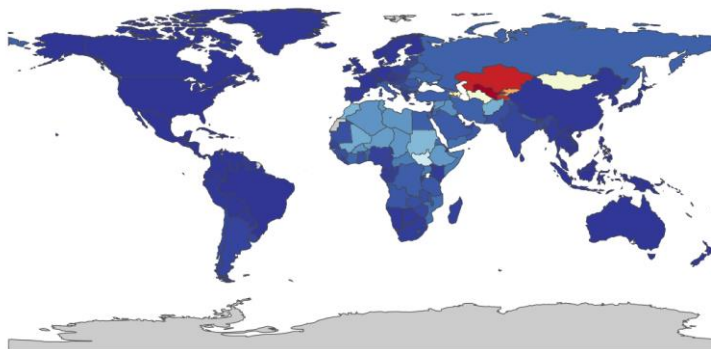
Collected and analyzed by a consortium of more than 3,600 researchers in more than 145 countries, the data capture premature death and disability from more than 350 diseases and injuries in 195 countries, by age and sex, from 1990 to the present, allowing comparisons over time, across age groups, and among populations.



TEXAS A&M  
UNIVERSITY

## Cystic Echinococcosis

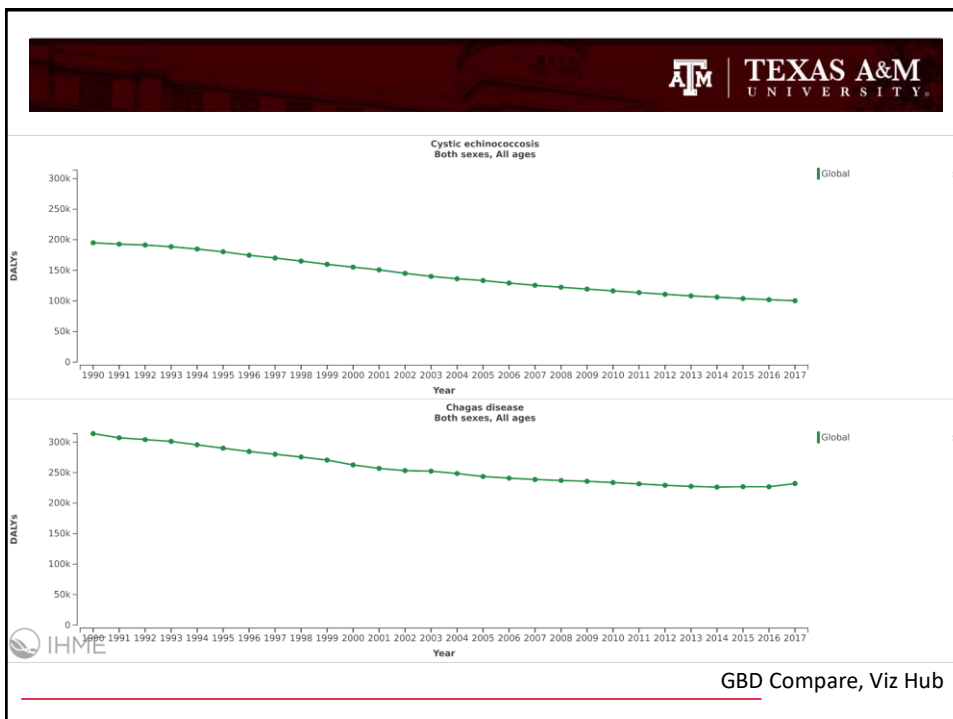
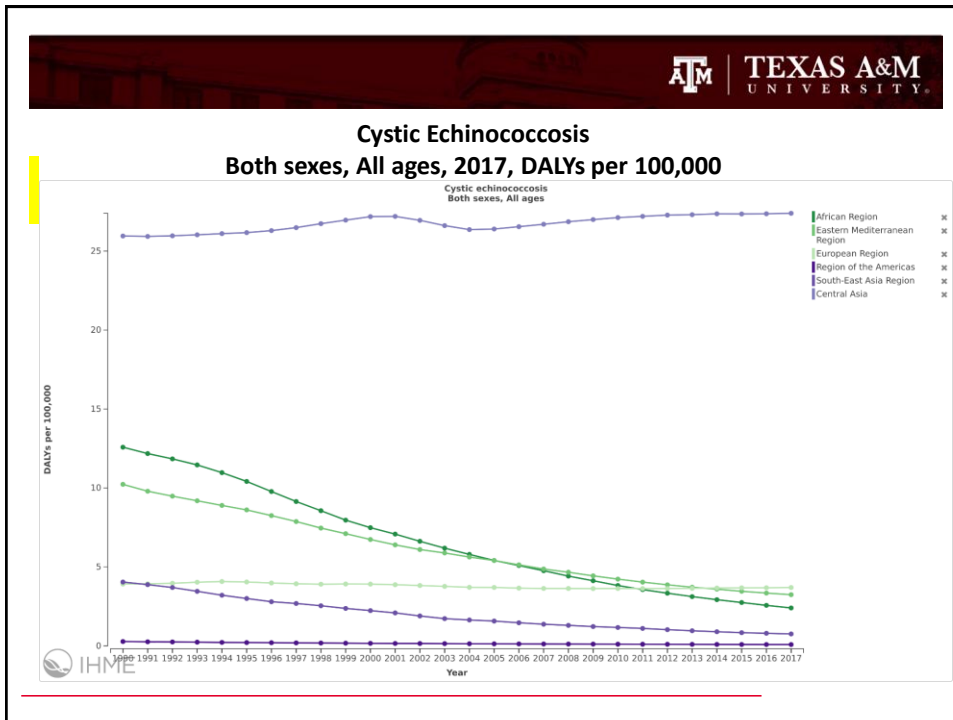
Both sexes, All ages, 2017, DALYs per 100,000



DALYs: 100,284 (72,812-138,668)

New Cases: 139,600 (90,170-213,899)

GBD Compare, Viz Hub







## WHO-Foodborne Disease Burden Epidemiology Reference Group (FERG)

1. Conduct epidemiological reviews for mortality, morbidity, and disability for each of the major foodborne diseases
2. Provide models for the estimation of foodborne disease burden where data are lacking
3. Develop cause attribution models to estimate the proportion of diseases that are foodborne
4. Produce burden of disease estimates for selected pathogens

## WHO-Foodborne Disease Burden Epidemiology Reference Group (FERG)

*Am. J. Trop. Med. Hyg.*, 88(6), 2013, pp. 1011–1027  
doi:10.4269/ajtmh.12-0692  
Copyright © 2013 by The American Society of Tropical Medicine and Hygiene

### A Systematic Review of the Literature on Cystic Echinococcosis Frequency Worldwide and Its Associated Clinical Manifestations

Christine M. Budke,\* Hélène Carabin, Patrick C. Ndimubanzi, Hai Nguyen, Elizabeth Rainwater, Mary Dickey,  
Rachana Bhattacharai, Oleksandr Zeziulin, and Men-Bao Qian

*Department of Veterinary Integrative Biosciences, College of Veterinary Medicine, Texas A&M University, College Station, Texas;*  
*Department of Biostatistics and Epidemiology, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma;*  
*Department of Health Promotion Sciences, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma;*  
*National Institute of Parasitic Diseases, Chinese Center for Disease Control and Prevention, Shanghai, People's Republic of China*

**Abstract.** A systematic literature review of cystic echinococcosis (CE) frequency and symptoms was conducted. Studies without denominators, original data, or using one serological test were excluded. Random-effect log-binomial models were run for CE frequency and proportion of reported symptoms where appropriate. A total of 45 and 25 articles on CE frequency and symptoms met all inclusion criteria. Prevalence of CE ranged from 1% to 7% in community-based studies and incidence rates ranged from 0 to 32 cases per 100,000 in hospital-based studies. The CE prevalence was higher in females (Prevalence Proportion Ratio: 1.35 [95% Bayesian Credible Interval: 1.16–1.53]) and increased with age. The most common manifestations of hepatic and pulmonary CE were abdominal pain (57.3% [95% confidence interval (CI): 37.3–76.1%]) and cough (51.3% [95% CI: 35.7–66.7%]), respectively. The results are limited by the small number of unbiased studies. Nonetheless, the age/gender prevalence differences could be used to inform future models of CE burden.

# WHO-Foodborne Disease Burden Epidemiology Reference Group (FERG)

OPEN ACCESS Freely available online

PLOS MEDICINE

## The Global Burden of Alveolar Echinococcosis

Paul R. Torgerson<sup>1,2\*</sup>, Krista Keller<sup>1</sup>, Melissa Magnotta<sup>1</sup>, Natalie Ragland<sup>1</sup>

<sup>1</sup> Ross University School of Veterinary Medicine, St. Kitts, West Indies, <sup>2</sup> Section of Epidemiology, Veterinary Faculty, University of Zurich, Zurich, Switzerland

### Abstract

**Background:** Human alveolar echinococcosis (AE) is known to be common in certain rural communities in China whilst it is generally rare and sporadic elsewhere. The objective of this study was to provide a first estimate of the global incidence of this disease by country. The second objective was to estimate the global disease burden using age and gender stratified incidences and estimated life expectancy with the disease from previous results of survival analysis. Disability weights were suggested from previous burden studies on echinococcosis.

**Methodology/Principal Findings:** We undertook a detailed review of published literature and data from other sources. We were unable to make a standardised systematic review as the quality of the data was highly variable from different countries and hence if we had used uniform inclusion criteria many endemic areas lacking data would not have been included. Therefore we used evidence based stochastic techniques to model uncertainty and other modelling and estimating techniques, particularly in regions where data quality was poor. We were able to make an estimate of the annual global incidence of disease and annual disease burden using standard techniques for calculation of DALYs. Our studies suggest that there are approximately 18,235 (CI: 11,900–28,200) new cases of AE per annum globally with 16,629 (91%) occurring in China and 1,606 outside China. Most of these cases are in regions where the disease is endemic and therefore will be fatal cases. Based on using disability weights for hepatic carcinoma and estimated age and gender specific incidence we were able to calculate that AE results in a median of 666,434 DALYs per annum (CI: 331,000–1.3 million).

**Conclusions/Significance:** The global burden of AE is comparable to several diseases in the neglected tropical disease cluster and is likely to be one of the most important diseases in certain communities in rural China on the Tibetan plateau.

**Citation:** Torgerson PR, Keller K, Magnotta M, Ragland N (2010) The Global Burden of Alveolar Echinococcosis. *PLOS Negl Trop Dis* 4(6): e722. doi:10.1371/journal.pntd.0007222

**Editor:** Simon Brooker, London School of Hygiene & Tropical Medicine, United Kingdom

**Received:** January 8, 2010; **Accepted:** April 29, 2010; **Published:** June 22, 2010

**Copyright:** © 2010 Torgerson et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

**Funding:** This work was supported by a grant from the World Health Organization. This was part of a commissioned work as part of a global burden of food-borne diseases study. The sponsor only had a limited role in the study design. The sponsor also provided access to databases for researching the material. The data analysis, decision to publish, and preparation of the manuscript were undertaken solely by the authors, although the sponsor indicated that they would like to see this information contained in the manuscript published in the scientific literature.

**Competing Interests:** The authors have declared that no competing interest exists.

\* E-mail: p.torgerson@vetclin.ch.uk

First global estimate of the number of DALYs lost annually due to AE

\*Largest burden estimated to be in China

# WHO-Foodborne Disease Burden Epidemiology Reference Group (FERG)

PLOS MEDICINE

## RESEARCH ARTICLE

### World Health Organization Estimates of the Global and Regional Disease Burden of 11 Foodborne Parasitic Diseases, 2010: A Data Synthesis

Paul R. Torgerson<sup>1\*</sup>, Brecht Devleesschauer<sup>2,3,4</sup>, Nicolas Praet<sup>4</sup>, Niko Speybroeck<sup>5</sup>, Anne Lee Willingham<sup>6</sup>, Fumiko Kasuga<sup>7</sup>, Mohammed B. Rokri<sup>8</sup>, Xiao-Nong Zhou<sup>9</sup>, Eric M. Fèvre<sup>10</sup>, Banchoo Srifa<sup>11</sup>, Neyla Gargouri<sup>12</sup>, Thomas Fürst<sup>13</sup>, Christine M. Budke<sup>14</sup>, Hélène Carabin<sup>15</sup>, Martyn D. Kirk<sup>16</sup>, Frederick J. Angulo<sup>17</sup>, Arie Havelaar<sup>18,19,20</sup>, Nilanthi de Silva<sup>21\*</sup>

<sup>1</sup> University of Zurich, Zurich, Switzerland, <sup>2</sup> Ghent University, Ghent, Belgium, <sup>3</sup> Université catholique de Louvain, Brussels, Belgium, <sup>4</sup> Institute of Tropical Medicine, Antwerp, Belgium, <sup>5</sup> Ross University School of Veterinary Medicine, St. Kitts, West Indies, <sup>6</sup> National Institute of Health Sciences, Tokyo, Japan, <sup>7</sup> Tehran University of Medical Sciences, Tehran, Iran, <sup>8</sup> Chinese Center for Disease Control and Prevention, Shanghai, People's Republic of China, <sup>9</sup> University of Liverpool, Liverpool, United Kingdom, <sup>10</sup> International Livestock Research Institute, Nairobi, Kenya, <sup>11</sup> Khon Kaen University, Khon Kaen, Thailand, <sup>12</sup> Hlma Pharmaceuticals, Amman, Jordan, <sup>13</sup> Imperial College, London, United Kingdom, <sup>14</sup> Texas A&M University, College Station, Texas, United States of America, <sup>15</sup> University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma, United States of America, <sup>16</sup> The Australian National University, Canberra, Australia, <sup>17</sup> Centers for Disease Control and Prevention, Atlanta, Georgia, United States of America, <sup>18</sup> National Institute for Public Health and the Environment, Bilthoven, The Netherlands, <sup>19</sup> Utrecht University, Utrecht, The Netherlands, <sup>20</sup> University of Florida, Gainesville, Gainesville, Florida, United States of America, <sup>21</sup> University of Kelantan, Kelantan, Malaysia

\* paul.torgerson@access.uh.ch (PRT); n.de Silva@gmail.com (NDS)



### OPEN ACCESS

**Citation:** Torgerson PR, Devleesschauer B, Praet N, Speybroeck N, Willingham AL, Kasuga F, et al. (2015) World Health Organization Estimates of the Global and Regional Disease Burden of 11 Foodborne Parasitic Diseases, 2010: A Data Synthesis. *PLOS Med* 12(12): e1001820. doi:10.1371/journal.pmed.1001820

**Academic Editor:** Limor Ziv-Sadlan, Mahidol Oxford Tropical Medicine Research Unit, THAILAND

Both CE and AE were included in year 2010 FERG estimates for disease burden using DALYs

## WHO-Foodborne Disease Burden Epidemiology Reference Group (FERG)

**Illnesses:** 188,079 (156,848-1,770,405)

**Deaths:** 2,225 (749-19,677)

**\*DALYs:** 183,573 (88,082-1,590,846)

**Foodborne DALYs:** 39,950 (16,996-322,953)

CE

**Illnesses:** 18,451 (11,384-29,619)

**Deaths:** 17,118 (10,184-27,346)

**DALYs:** 687,823 (409,190-1,106,320)

**Foodborne DALYs:** 312,461 (9,083-640,716)

AE

\* About 67,000 higher than GBD estimates for the same year

\*For year 2010

## Country-level Studies Using DALYs

**CE:**

China

Greece

Italy

Kyrgyzstan

Nepal

Peru

**AE:**

China

Kyrgyzstan

Nepal

## Challenges When Comparing DALY-based Study Findings

- Differences in disease frequency estimation
    - Surgical cases
    - Medical cases
    - Community ultrasound-based prevalence
    - Etc.
  - Differences in organ system involvement
    - Liver
    - Lung
    - Etc.
  - Differences in disability weights
  - Decision to use age-weighting and/or discounting
- 

## Monetary losses associated with echinococcosis

### Human losses:

Quantifiable medical costs include, but are not limited to, diagnostic testing, surgical treatment, post-surgical care, and medical therapy

Indirect costs commonly associated with echinococcosis include, wage/productivity losses, due to the inability to work, as well as travel costs to and from treatment

Difficult to quantify!

---

## The impact of livestock-associated losses

### Livestock-associated losses due to

- \*organ condemnation
- decreased carcass weight
- decreased fecundity
- decreased milk production
- decreased hide value



Losses due to offal condemnation will vary based on the legislative requirements of the country (e.g., compulsory condemnation and destruction of infected organs) as well as what percentage of animals is slaughtered under veterinary supervision

In addition to production losses, export restrictions can have a devastating effect on the local and regional economy

## Country-level Studies Using Monetary Burden

### Human and Livestock

Argentina  
China  
Iran  
Jordan  
Kyrgyzstan  
Peru  
Spain  
Tunisia  
U.K.

### Human or Livestock

Australia (livestock only)  
Austria (human only)  
Italy (human only)  
Kenya (livestock only)  
Iraq (livestock only)

## Challenges When Comparing Monetary Burden Study Findings

- Are indirect costs included?
  - Pertains to both human and livestock disease
- Which cases are included?
  - Surgical cases
  - Medical cases
  - Community ultrasound-detected cases
- How are cost data collected/recorded?
- Societal versus patient perspective?

## zDALYs

One Health 5 (2018) 40–45



Contents lists available at ScienceDirect

One Health

journal homepage: [www.elsevier.com/locate/onehit](http://www.elsevier.com/locate/onehit)



zDALY: An adjusted indicator to estimate the burden of zoonotic diseases

Paul R. Torgerson<sup>a,\*</sup>, Simon Rüegg<sup>a</sup>, Brecht Devleeschauwer<sup>b,c</sup>, Bernadette Abela-Ridder<sup>d</sup>,  
Arie H. Havelaar<sup>e,f</sup>, Alexandra P.M. Shaw<sup>g,h</sup>, Jonathan Rushton<sup>i</sup>, Niko Speybroeck<sup>b</sup>

<sup>a</sup> Section of Epidemiology, Vetsuisse Faculty, University of Zurich, Winterthurerstrasse 270, CH-8057 Zurich, Switzerland

<sup>b</sup> Institute of Health and Society (IHSS), Université catholique de Louvain, Clos Chapelle aux champs, 30, 1200 Bruxelles, Belgium

<sup>c</sup> Department of Public Health and Surveillance, Scientific Institute of Public Health (WIV-ISP), Brussels, Belgium

<sup>d</sup> Department of Food Safety and Zoonoses (FOS), World Health Organization, Avenue Appia 20, CH-1211 Geneva 27, Switzerland

<sup>e</sup> Institute for Sustainable Food Systems, Emerging Pathogens Institute and Animal Sciences Department, University of Florida, Gainesville, FL, USA

<sup>f</sup> Institute for Risk Assessment Sciences, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands

<sup>g</sup> Division of Infection and Pathway Medicine, Edinburgh Medical School: Biomedical Sciences, College of Medicine and Veterinary Medicine, The University of Edinburgh, Chancellor's Building, 49 Little France Crescent, Edinburgh EH16 4SB, UK

<sup>h</sup> A.P. Consultants, 22 Welbourn Blueprint Centre, Duke Close, Andover SP10 5AP, UK

<sup>i</sup> Institute of Infection and Global Health, University of Liverpool, UK



## zDALYs versus DALYs

**Goal: to incorporate animal-associated losses into the DALY estimate**

$$\text{DALY} = \text{YLL} + \text{YLD}$$

$$\text{zDALY} = \text{YLL} + \text{YLD} + \text{ALE}$$

**ALE = monetary value of animal health losses/GNI per person**

YLL=Years of Life Lost

YLD=Years Lived with Disability

GNI= Gross National Per Capita Income

Data used to estimate the zDALY for cystic echinococcosis (CE).

	Year	Animal losses <sup>a</sup>	US\$ 2015 equivalent	GNI per capita 2015
Iran	2010	\$132 million	\$143 million	\$6550
Jordan	2001	\$3.58 million	\$4.82 million	\$4680
Kyrgyzstan	2013	\$5.5 million	\$5.6 million	\$1170
Peru	2007	\$3.85 million	\$4.40 million	\$6130
Spain	2005	€15.5million	\$25.8 million	\$28,530
Tunisia	2000	\$8.38 million	\$11.45 million	\$3980

Animal loss equivalents (ALEs): CE.

	Human population	ALEs	ALEs/100,000 person years
Iran	79.1 million	21,832	27.6
Jordan	7.59 million	1030	13.5
Kyrgyzstan	5.94 million	4786	80.6
Peru	31.8 million	718	2.3
Spain	46.1 million	904	2.0
Tunisia	11.3 million	2877	25.5

Torgerson et al., 2018

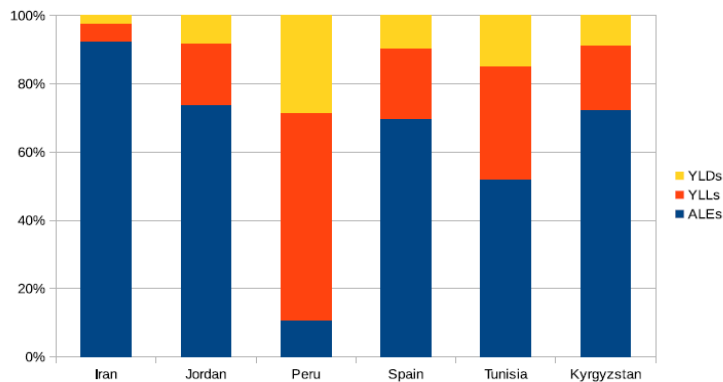
Burden of disease for CE in terms of DALYs and zDALYs.

Source: data from WHO Foodborne Disease Burden Epidemiology Reference Group (FERG) [42].

	YLDs	YLLs	DALYs	DALYs/ 100,000 person years	ALEs/ 100,000 person years	zDALY/ 100,000 person years
Iran	537	1198	1735	2.19	27.6	29.8
Jordan	113	250	363	4.78	13.5	18.3
Kyrgyzstan	573	1258	1831	30.8	80.6	111
Peru	1943	4185	6128	19.3	2.3	21.6
Spain	126	271	397	0.86	2.0	2.86
Tunisia	758	1689	2447	21.7	25.5	47.2

Torgerson et al., 2018

### Variations in the Proportion of the zDALY due to ALEs by Country



Torgerson et al., 2018



## The Future

- Expanded initiatives to incorporate animal-associated losses into zoonotic disease burden estimates
- Inclusion of AE in GBD estimates
- Better disease frequency estimations through expanded patient database networks



Thank You

