

# ***Taenia solium* Transmission Dynamics and the Burden of Neurocysticercosis**



ECWG meeting  
Institute of Tropical Medicine of Antwerp  
Nicolas Praet



April 16<sup>th</sup> 2012

# Presentation Plan

---

- Introduction
- The burden of NCC
- Why is it important to study the transmission dynamics of *Taenia solium*?

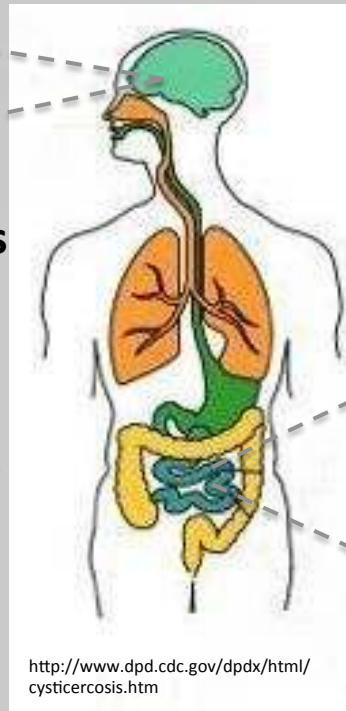
# Introduction

---

- Life cycle
- Distribution and risk factors
- The diagnosis of cysticercosis in pigs and humans



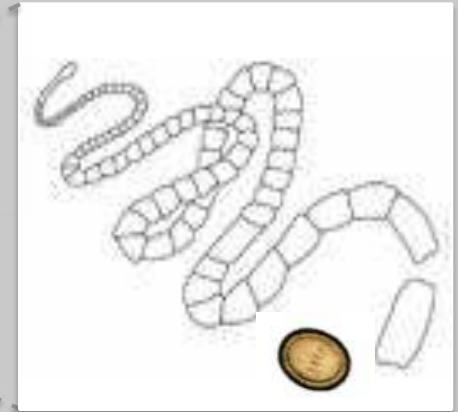
**Human cysticercosis**



*eggs accidentally consumed by humans*

*cysts in raw or undercooked infected meat consumed by humans*

**Taeniosis**

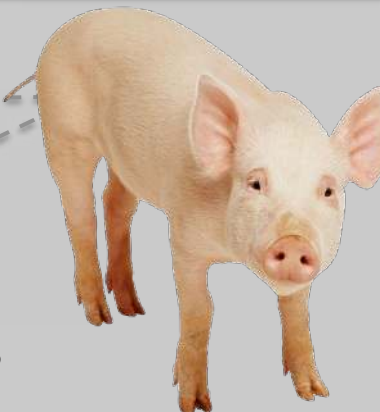


<http://www.dpd.cdc.gov/dpdx/html/cysticercosis.htm>

**Life Cycle**



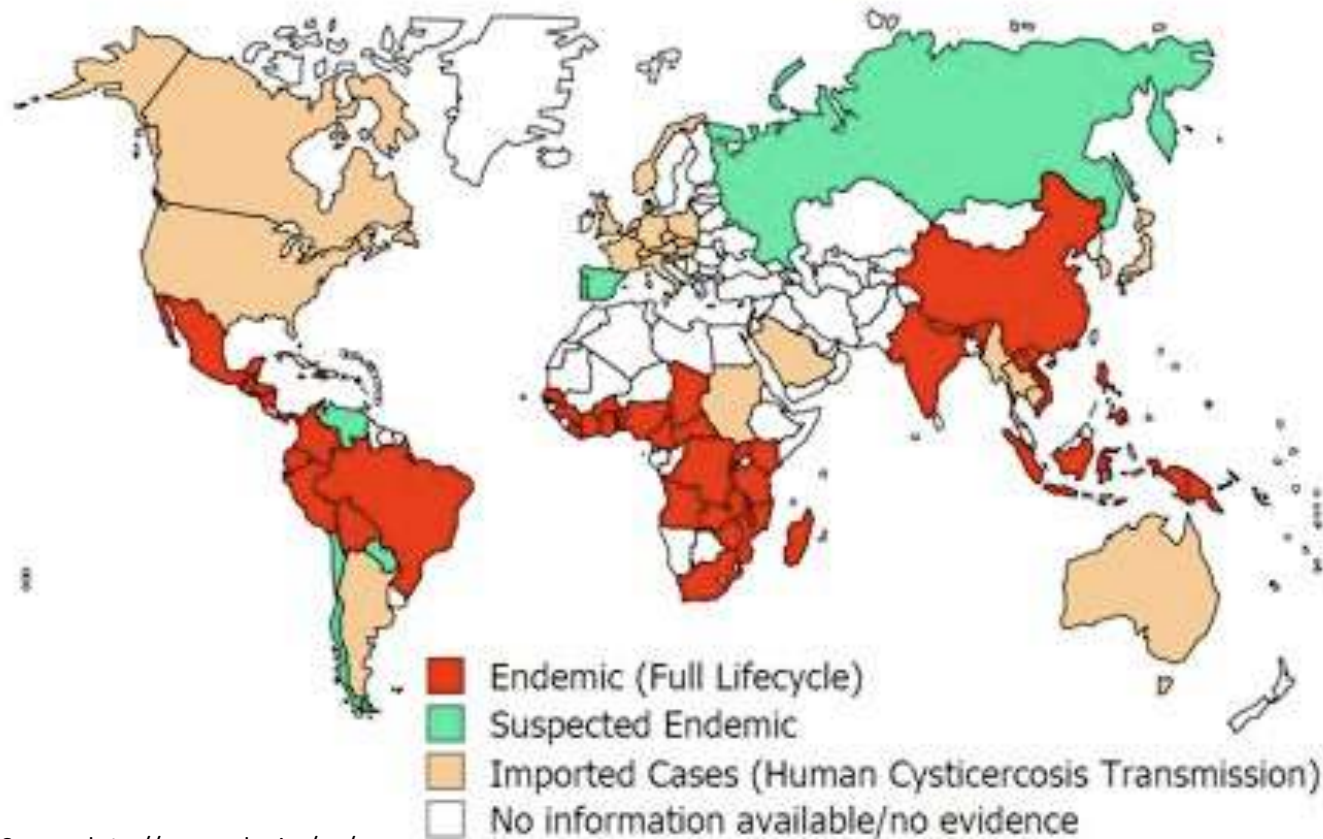
**Porcine cysticercosis**



*eggs in human faeces consumed by pigs*

# Where is *Taenia solium*?

Global distribution of *Taenia solium* cysticercosis/taeniosis



Source: <http://www.who.int/en/>

# Where is *Taenia solium*?

## Human to pig transmission: free-roaming pigs





# Where is *Taenia solium*?

**Human to pig transmission: no sanitations, open-air defecation**



# Where is *Taenia solium*?



**Human to pig transmission:**  
**latrines inappropriately built**



# Where is *Taenia solium*?

**Pig to human transmission: raw undercooked or pork, culinary habits**



# Where is *Taenia solium*?

**Human to human transmission: direct contact or food or water contaminated with eggs**



# How to diagnose cysticercosis?

 Looking for the parasite in pigs 



**TONGUE INSPECTION**



**CARCASS INSPECTION**



Looking for the parasite in humans



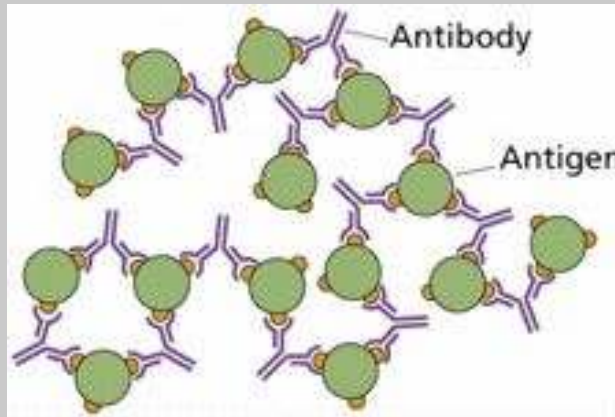
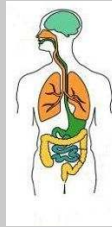
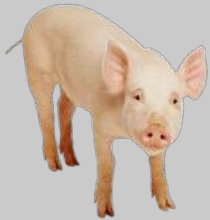
**IMAGING**



**SUB-CUTANEOUS NODULES**



# Looking for antibodies raised against *T. solium* or circulating antigens of the parasite in porcine and human serum



## ANTIBODY DETECTION

ELISA (Enzyme-linked immunosorbent assay)  
EITB (Enzyme-linked immunoelectrotransfer blot assay)



EXPOSURE

## ANTIGEN DETECTION

SANDWICH ELISA



INFECTION

# The disease burden of NCC

# The burden of a disease

## Why is it important to estimate the burden of a disease?

1. Setting priorities for public health research, policy and services
2. Comparing the cost-effectiveness of disease control programmes
3. Comparing the importance of a disease between countries/regions of the world

# How to estimate the burden of a disease?

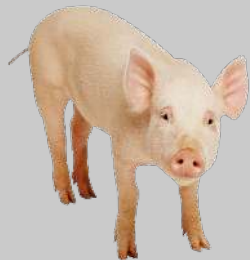
## Monetary burden



- Direct costs: medical doctor, diagnostic tests and treatments



- Indirect costs: incapacity to go to work or to get a job



- Animal production: carcass condemnation at slaughterhouse and meat price decrease



# Health Burden: Disability Adjusted Life Year (DALY)

DALYs = number of years of full health lost due to the disease



➤ = Years of Life Lost due to premature death  
= YLLs



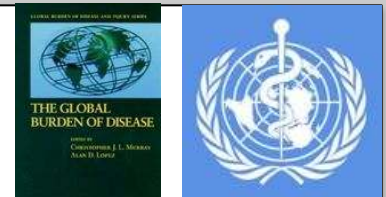
➤ = Years of Life lived with Disability  
= YLDs

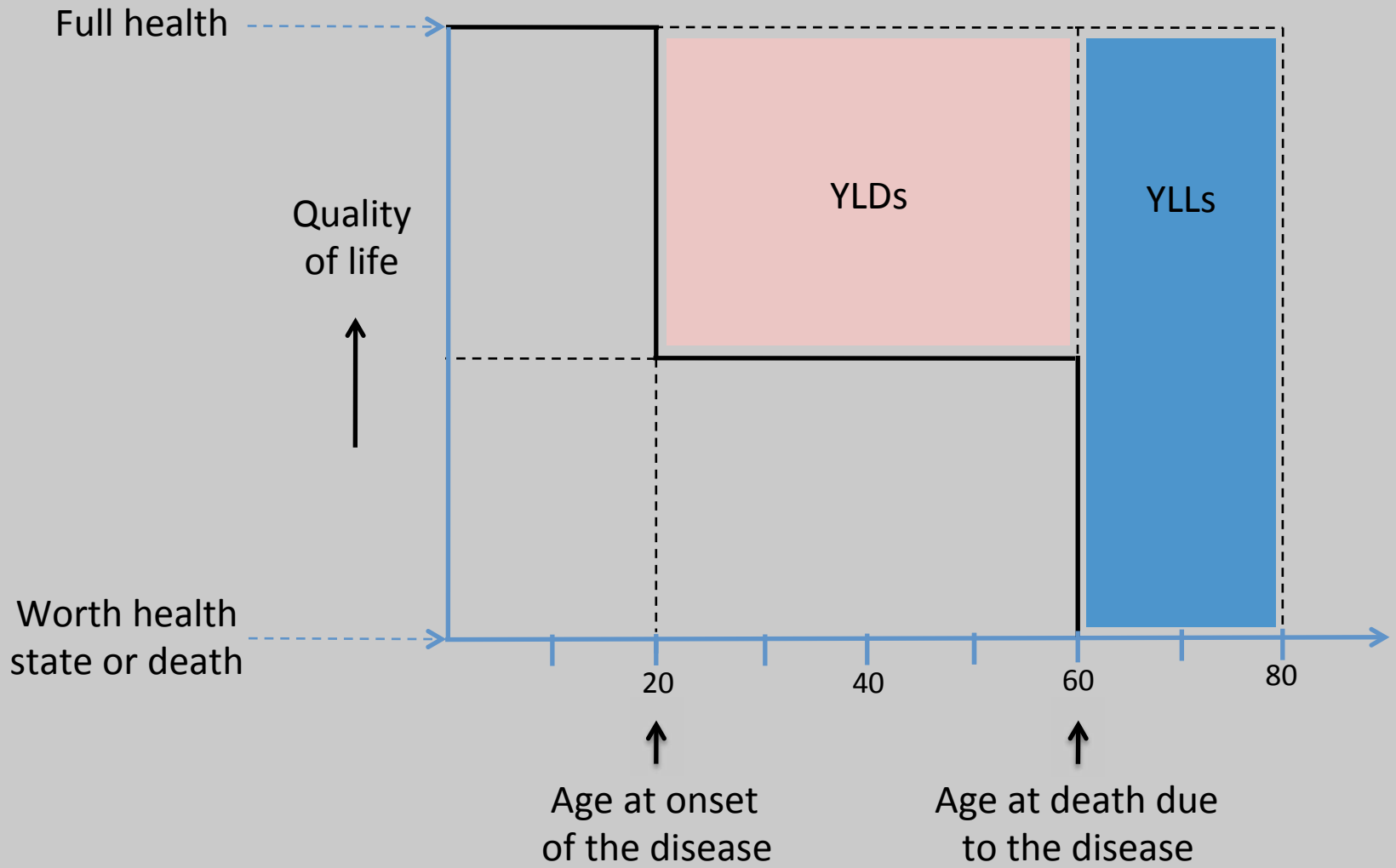


$$\text{DALYs} = \text{YLLs} + \text{YLDs}$$



Approach used by the World Health Organization to estimate the Global Burden of Diseases





➔ **DALYs = YLLs + YLDs**

# 3 comprehensive studies available

Tropical Medicine and International Health

doi:10.1111/j.1365-3156.2006.01627.x

VOLUME 11 NO 6 PP 906–916 JUNE 2006

## Estimation of the cost of *Taenia solium* cysticercosis in Eastern Cape Province, South Africa

H. Carabin<sup>1</sup>, R. C. Krecek<sup>2,3</sup>, L. D. Cowan<sup>1</sup>, L. Michael<sup>3</sup>, H. Foyaca-Sibat<sup>4</sup>, T. Nash<sup>5</sup> and A. L. Willingham<sup>6,7</sup>

- 1 *Department of Biostatistics and Epidemiology, College of Public Health, Oklahoma University Health Sciences Center, Oklahoma City, OK, USA*
- 2 *Ross University School of Veterinary Medicine, Basseterre, St. Kitts, West Indies*
- 3 *University of Johannesburg, Department of Zoology, Auckland Park, South Africa*
- 4 *Walter Sisulu University Faculty of Health Sciences, Mthatha, Eastern Cape, South Africa*
- 5 *Gastrointestinal Parasites Section Laboratory of Parasitic Diseases, National Institute of Allergic and Infectious Diseases, Bethesda, MD, USA*
- 6 *International Cysticercosis Coordination Center, Royal Veterinary & Agricultural University, Frederiksberg, Denmark*
- 7 *People, Livestock and the Environment Thematic Programme, International Livestock Research Institute, Nairobi, Kenya*

# 3 comprehensive studies available

OPEN  ACCESS Freely available online



## The Disease Burden of *Taenia solium* Cysticercosis in Cameroon

**Nicolas Praet<sup>1\*</sup>, Niko Speybroeck<sup>1,2</sup>, Rafael Manzanedo<sup>1</sup>, Dirk Berkvens<sup>1</sup>, Denis Nsame Nforninwe<sup>3</sup>, André Zoli<sup>4</sup>, Fabrice Quet<sup>5</sup>, Pierre-Marie Preux<sup>5</sup>, H el ene Carabin<sup>6</sup>, Stanny Geerts<sup>1</sup>**

**1** Institute of Tropical Medicine, Antwerp, Belgium, **2** Institute of Health and Society, Universit e Catholique de Louvain, Brussels, Belgium, **3** Batibo District Hospital, Batibo, Cameroon, **4** University of Dschang, Dschang, Cameroon, **5** Institute of Neuroepidemiology and Tropical Neurology, Limoges, France, **6** College of Public Health, The University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma, United States of America



# 3 comprehensive studies available

OPEN ACCESS Freely available online



## Estimating the Non-Monetary Burden of Neurocysticercosis in Mexico

**Rachana Bhattarai<sup>1</sup>, Christine M. Budke<sup>1\*</sup>, H el ene Carabin<sup>2</sup>, Jefferson V. Proa o<sup>3</sup>, Jose Flores-Rivera<sup>4</sup>, Teresa Corona<sup>4</sup>, Renata Ivanek<sup>1</sup>, Karen F. Snowden<sup>5</sup>, Ana Flisser<sup>6</sup>**

**1** Department of Veterinary Integrative Biosciences, College of Veterinary Medicine, Texas A&M University, College Station, Texas, United States of America, **2** Department of Biostatistics and Epidemiology, University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma, United States of America, **3** Hospital de Especialidades, Centro M dico Nacional Siglo XXI, Instituto Mexicano del Seguro Social, M xico Distrito Federal, Mexico, **4** Clinical Laboratory of Neurodegenerative Diseases, National Institute of Neurology and Neurosurgery, M xico Distrito Federal, Mexico, **5** Department of Veterinary Pathobiology, College of Veterinary Medicine, Texas A&M University, College Station, Texas, United States of America, **6** Facultad de Medicina, Universidad Nacional Aut noma de M xico (UNAM), M xico Distrito Federal, Mexico

# Burden estimation components

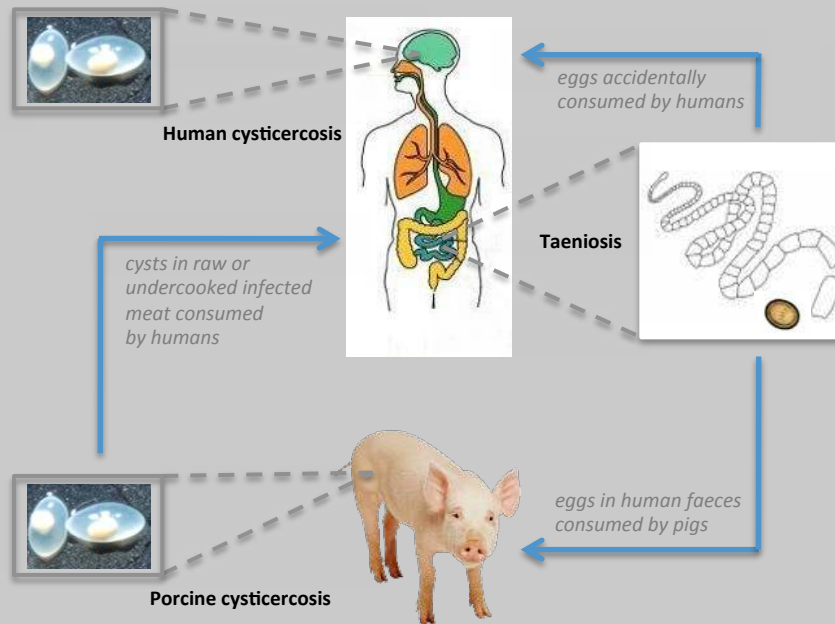
Monetary burden assessment

Health burden assessment

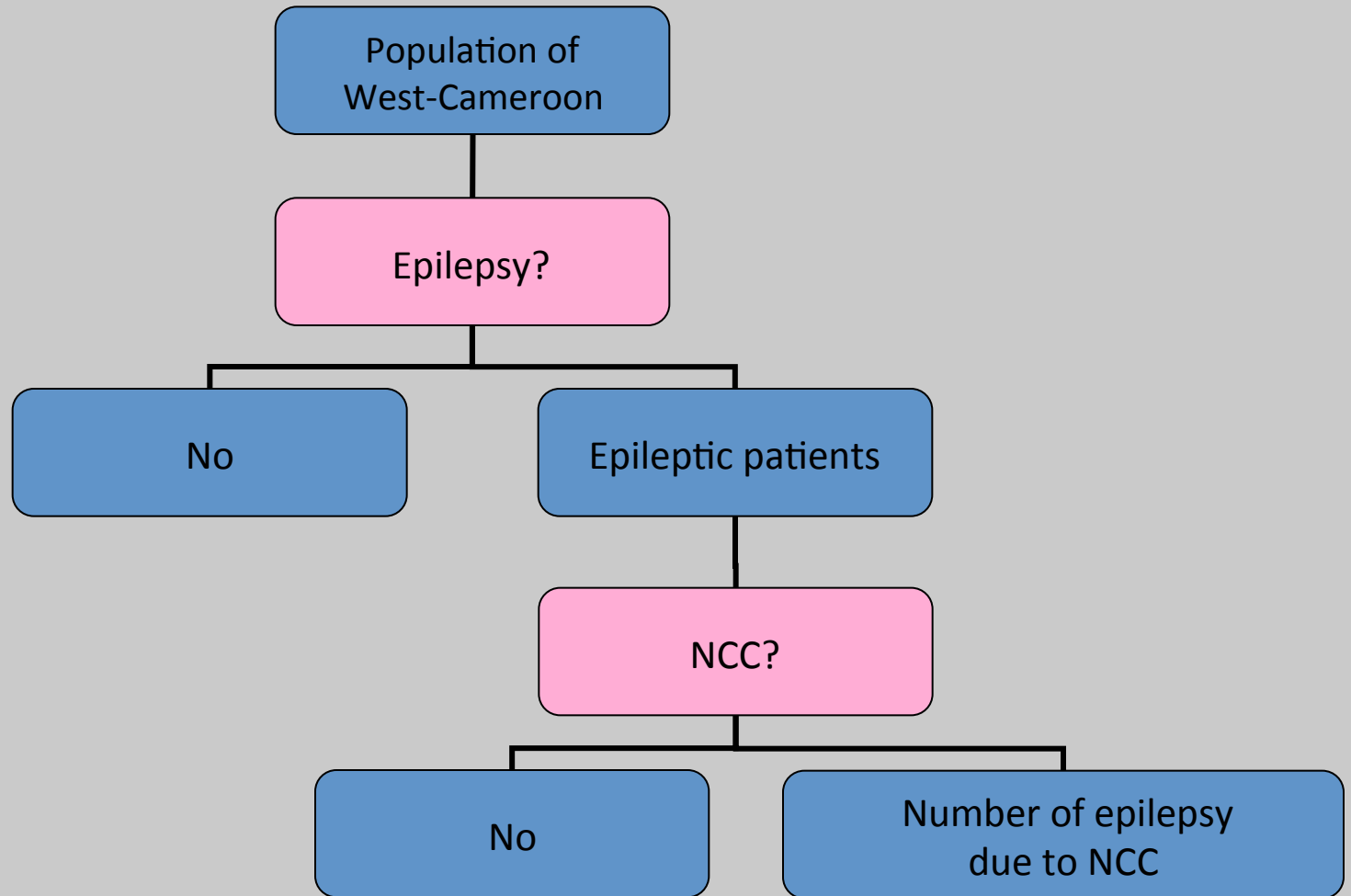
Direct & indirect costs linked to human health

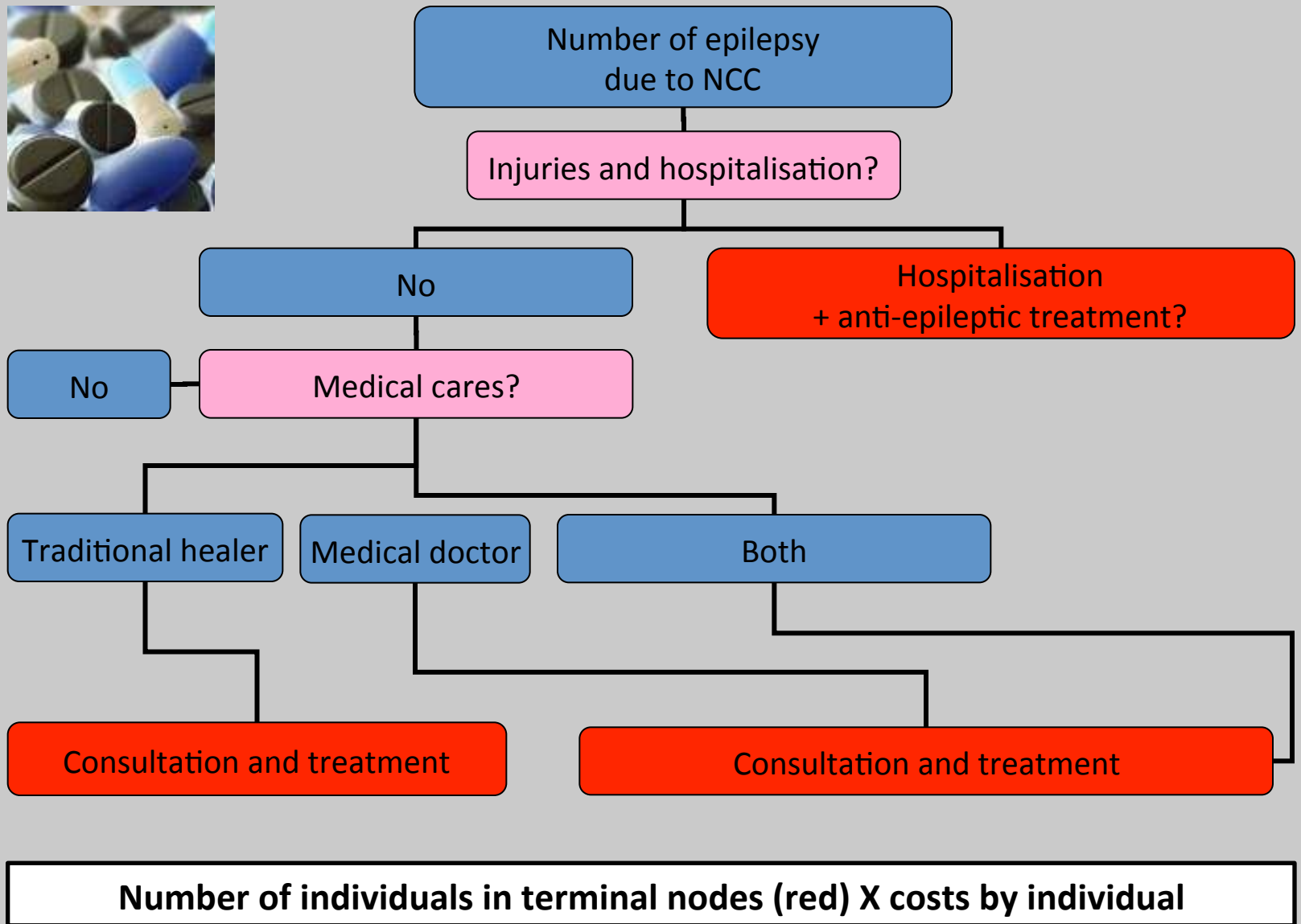
DALYs lost (YLLs + YLDs)

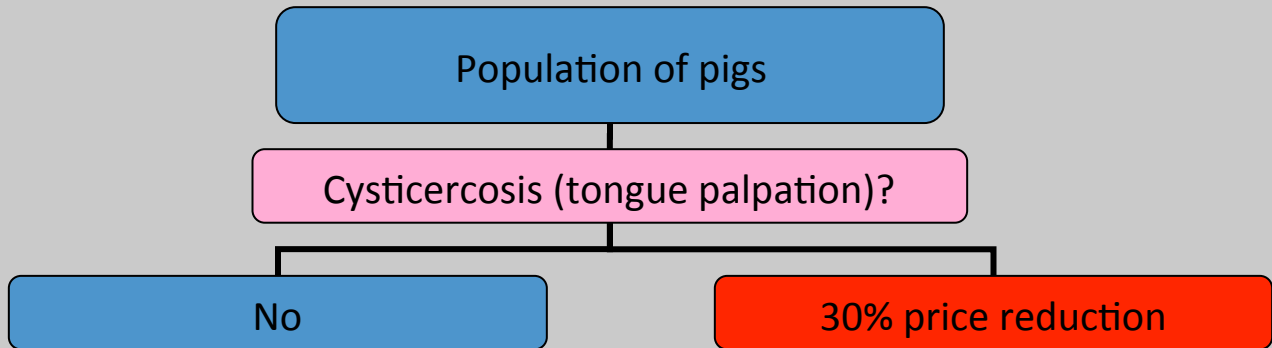
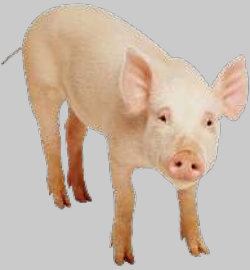
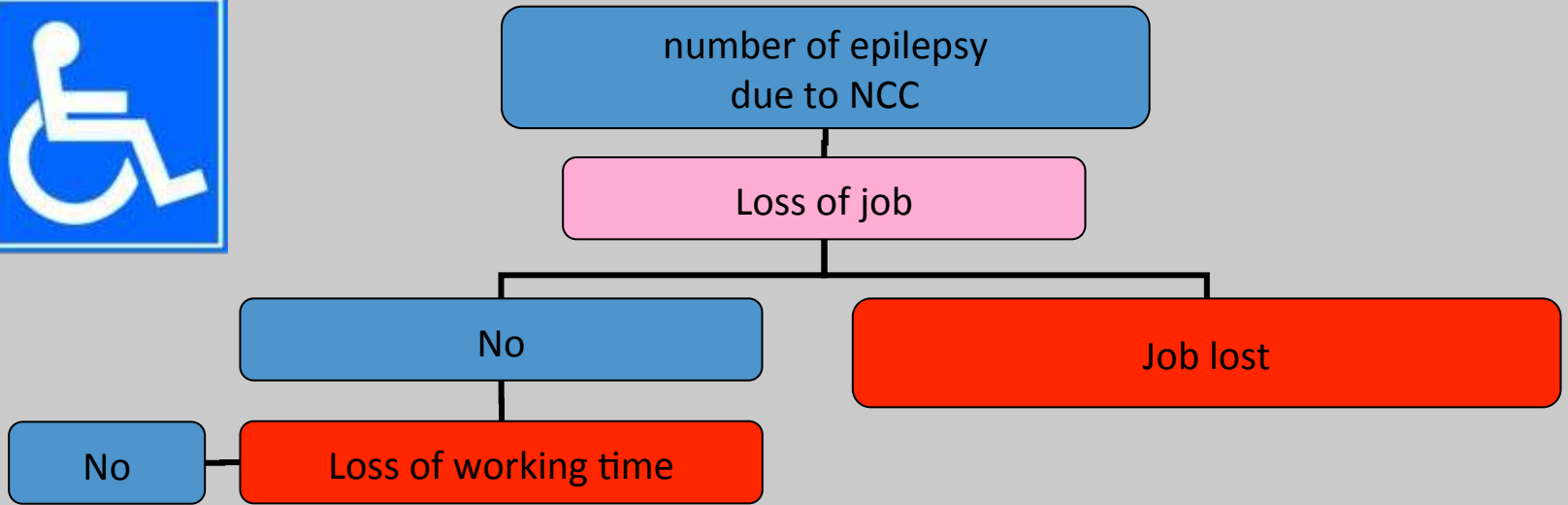
Costs linked to pig meat production (infected meat price decrease)



# Decision tree







**Number of individuals in terminal nodes (red) X costs by individual**

# Retrospective study

Collection of existing data to estimate

1. how many individuals are suffering from NCC
2. How many pigs are infected with *T. solium*



Searching for the necessary information:

1. National and international health statistics
2. Scientific publications
3. Expert opinion



Consider the uncertainty around this information by using probability distributions for almost each of above-mentioned parameters



# Monetary burden comparison

More cases in Cameroon but lower monetary burden: mainly due to difference in indirect costs (lower salary)

## 8. Comparison of the monetary burden of *T. solium* cysticercosis in West Cameroon and Eastern Cape Province South Africa.

	West Cameroon (This study)	ECP, South Africa [3]
• Population	5,065,382	7,088,000
• No. (%) of NCC-associated cases of epilepsy	50,326* (1.0)	34,662 (0.5)
• Overall monetary burden ( $\times 10^6$ Euro)	10.3	15.0–27.5 <sup>o</sup>
○ % due to human cysticercosis	95.3	73.1–85.4
○ % due to porcine cysticercosis	4.7	14.6–26.9
• Monetary burden per capita (Euro)	2.0	2.1–3.9

\* based on a prevalence of epilepsy of 3.6%.

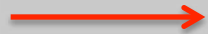
<sup>o</sup> different calculation methods were used (based on 2004 exchange rate of 1US\$ = 0.805 Euro).

doi:10.1371/journal.pntd.0000406.t008

# DALY studies comparison

Cameroon	Mexico
9 DALYs lost per 1,000 person-years*	0.25 DALYs lost per 1,000 person-years*

\*years of life in perfect health yearly lost per 1000 inhabitants of the area



Higher health burden in Cameroon mainly due to higher mortality rate

# Conclusions

---

1. Burden of human and porcine CC may be non negligible and deserves a more global assessment
2. Identification and description of disease data gaps (epidemiological and clinical)

# Conclusions

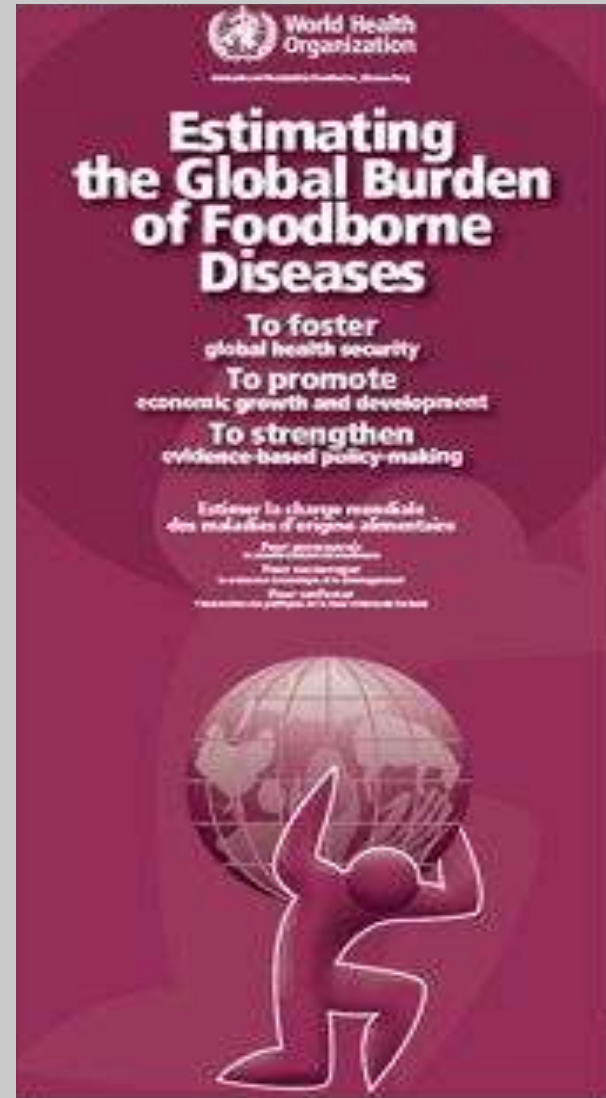
## 3. Comparison Monetary and Health burden approaches

	<b>Monetary Burden</b>	<b>Health (DALY) Burden</b>
Indicator	monetary costs related to morbidity	years lost due to morbidity AND mortality
Zoonotic infections	cost of animal production losses may be included	cost of animal production losses can NOT be included
Social impact	not taken into account	not taken into account
Economic impact	taken into account	not taken into account
Comparison between world regions	depends on time- and region-specific economical factors (difficulties in comparing poor and rich countries)	possible throughout the whole world
Interpretation for decision-makers	accessible	needs a certain background
Identification of decision-tree end component	sometimes difficult to identify for each cost	only mortality rate and incidence of each symptom to be identified
Disability weighting	not necessary	disability weights rather subjective and not context specific

# Perspectives: towards the assessment of the Global Burden of NCC

GBD of NCC considered by WHO in the framework of the Foodborne Disease Burden Epidemiology Group (FERG) initiative:

- Systematic review conducted
- % of NCC-associated epilepsy available: 29%
- DALY calculations on going (estimates expected in 2013)



# Why is it important to study the transmission dynamics of *T. solium*?

- Accurate burden estimates/filling data gaps on:
  - Age-related prevalence/incidence/mortality estimates (pigs and human)
  - Disease duration
- Cost-effective intervention programmes



# Why is it important to study the transmission dynamics of *T. solium*?



ELSEVIER

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)



INTERNATIONAL  
Journal for  
PARASITOLOGY

International Journal for Parasitology xxx (2007) xxx–xxx

[www.elsevier.com/locate/ijpara](http://www.elsevier.com/locate/ijpara)

## Simulating transmission and control of *Taenia solium* infections using a Reed-Frost stochastic model

Niels C. Kyvsgaard<sup>a,c,\*</sup>, Maria Vang Johansen<sup>b,c</sup>, H el ene Carabin<sup>d</sup>

<sup>a</sup> Department of Veterinary Pathobiology, Faculty of Life Sciences, University of Copenhagen, Stigb ojlen 4, DK-1870 Frederiksberg C, Denmark

<sup>b</sup> DBL-Institute for Health Research and Development, Charlottenlund, Denmark

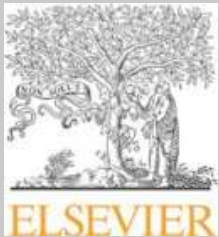
<sup>c</sup> WHO/FAO Collaborating Centre for Emerging and Other Parasitic Zoonoses, Danish Centre for Experimental Parasitology, Department of Veterinary Pathobiology, Faculty of Life Sciences, University of Copenhagen, Frederiksberg C, Denmark

<sup>d</sup> Department of Biostatistics and Epidemiology, College of Public Health, University of Oklahoma Health Sciences Center, OK, USA

Received 18 September 2006; received in revised form 24 November 2006; accepted 28 November 2006

# Study of the effect of age on the proportion of infected and exposed individuals

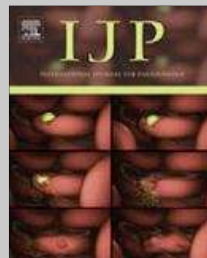
International Journal for Parasitology 40 (2010) 85–90



Contents lists available at [ScienceDirect](#)

## International Journal for Parasitology

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



## Age-related infection and transmission patterns of human cysticercosis

N. Praet <sup>a,e,\*</sup>, N. Speybroeck <sup>a,b</sup>, R. Rodriguez-Hidalgo <sup>c</sup>, W. Benitez-Ortiz <sup>c</sup>, D. Berkvens <sup>a,d</sup>, J. Brandt <sup>a</sup>,  
C. Saegerman <sup>e</sup>, P. Dorny <sup>a</sup>

<sup>a</sup> Institute of Tropical Medicine, Animal Health Department, Antwerp, Belgium

<sup>b</sup> Institute of Health and Society, Université Catholique de Louvain, Brussels, Belgium

<sup>c</sup> Centro Internacional de Zoonosis, Quito, Ecuador

<sup>d</sup> Department of Animal Production, Faculty of Bioscience Engineering, Ghent University, Ghent, Belgium

<sup>e</sup> Department of Infectious and Parasitic Diseases, Epidemiology and Risk Analysis Applied to Veterinary Sciences, Faculty of Veterinary Medicine, University of Liege, Liege, Belgium

# Modelling as a tool

- Available data and expert opinion on the transmission dynamics and control of *T. solium* need to be objectively synthesized in order to be objectively interpreted
- Large scale and multifactorial studies are expensive and difficult to implement



Modelling allows to use available information to estimate the prevalence/incidence and effect of control strategies on an objective manner and in different settings

Modelling may include several techniques such as:

- Bayesian approach
- Rule-based modelling
- Expert elicitation
- Stochastic approach (uncertainty)

# Conclusions

---

1. Burden of human and porcine CC may be non negligible and deserves a more global assessment
2. Identification and description of disease data gaps (epidemiological and clinical)
3. Transmission dynamics studies are essential to assess the burden of *T. solium*

# Perspectives

**Assessment of the global burden of cysticercosis**

**How to obtain these estimates when only fragmentary data are available?**

**2 approaches**



**Prospective approach**

- more accurate diagnostic tools
- standardise data collection

**Longitudinal age-related immuno-epidemiological and clinical data to estimate:**

- the incidence of the disease
- the proportion of CC-associate symptoms



**Retrospective approach**

- using existing data in innovative ways

**Systematic literature reviews**

**Meta-analyses**

**Simulation models**

**Bayesian modeling**

**Expert elicitation**

**Stochastic models**

## Burden estimates



**Cost-effectiveness of prevention and control programs can be tested and help national and international policy- and decision- makers in setting priorities in public health and veterinary public health policies, services and research**



**CC burden**



**Intervention  
costs**

<http://www.ecriturecreative.net/wp-content/uploads/2009/06/balance2.jpg>