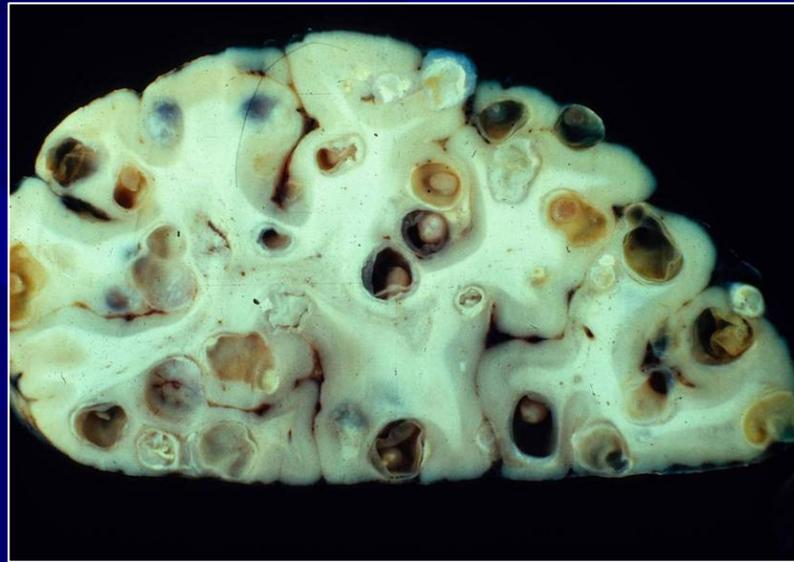


# **Neurocysticercosis in North Carolina: An Emerging Infectious Disease Associated with Immigration**



**Katie M. Kurkjian, DVM, MPH  
2007 One Medicine Symposium  
December 12, 2007**

# Migrant Public Health

- “Hot” topic of immigration
- Migrant
  - a person who moves from one place to another
- 191 million migrants in 2005
- Changing global epidemiology



Photos: U.S. Department of State. Don Bartletti, Los Angeles Times. 2002.

# Why Cysticercosis?

- **Zoonotic disease**
- **Treatable**
- **Preventable**
- **Potentially eradicable**
- **“One Medicine” approach needed for control and prevention**

# Topics for Today

- **Cysticercosis and neurocysticercosis overview**
- **Methods**
- **Results**
- **Conclusions**
- **Future directions**

# Cysticercosis

- **Pork tapeworm (*Taenia solium*)**
- **Worldwide**
- **Primarily rural, developing countries**
- **Most common parasite of central nervous system**
  - **Leading cause acquired epilepsy**
- **Affects 50 million people worldwide**

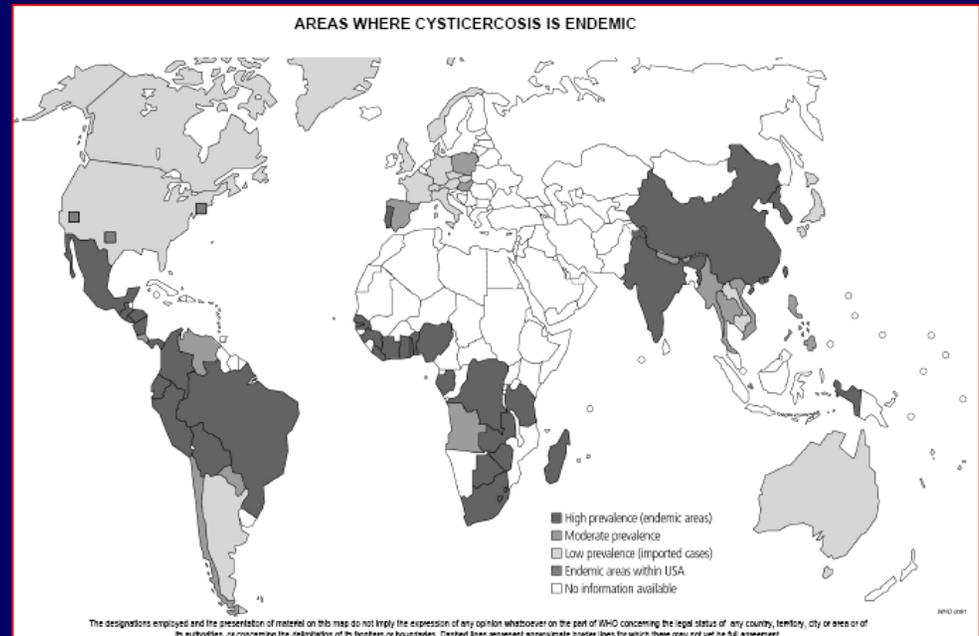


Figure: WHO, 55<sup>th</sup> World Health Assembly, April 2002

# Life Cycle of *Taenia solium*

- 19<sup>th</sup> C. discovery of cysticercosis and adult tapeworm connection
- Definitive hosts = human (carriers)
- Intermediate hosts = human or pig
- 2 forms of disease
  - Taeniasis (adult tapeworm)
  - Cysticercosis (larvae)

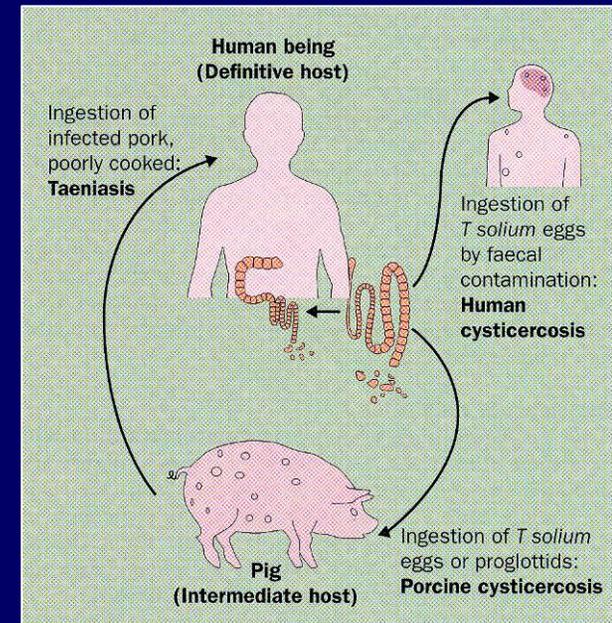
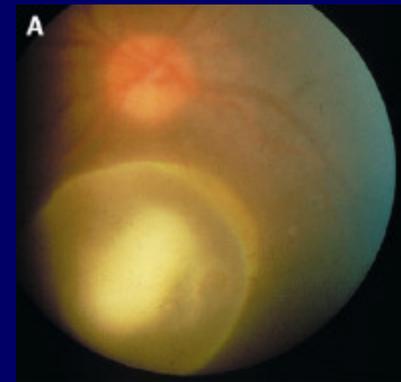
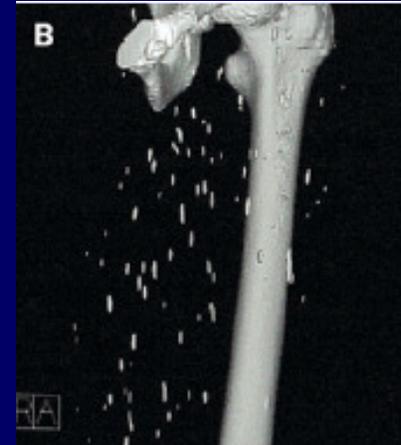


Figure: Garcia HH and Evans CA. The Lancet. 2003.

# Human Cysticercosis

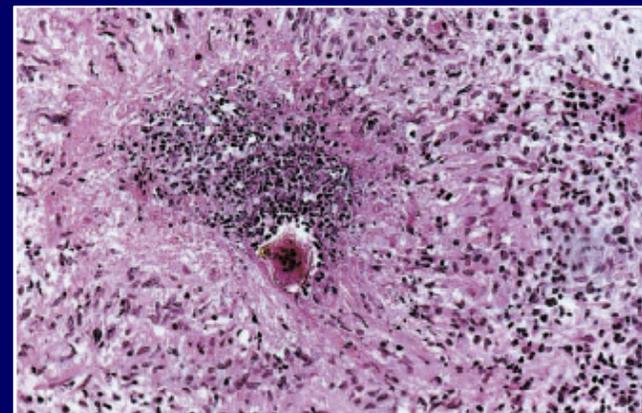
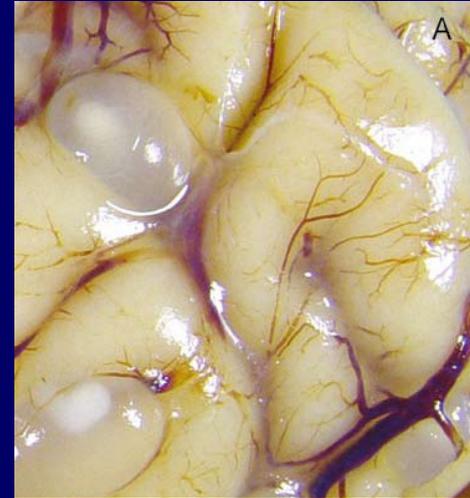
- **Muscular, subcutaneous tissue**
  - Asymptomatic
  - +/- Nodules
- **Ocular**
  - Blurry vision
  - Swelling
  - Detached retina



Photos: Garcia HH and Evans CA. The Lancet, 2003.

# Neurocysticercosis

- Presence of 1 or more cysts in central nervous system
- Pathology
  - Space-occupying lesion
  - When parasite dies
- Dying parasite causes intense inflammatory reaction
  - Can initiate a seizure
- Former cyst calcifies
  - Can serve as focus for recurrent seizures



Photos: Garcia, HH et al. Pract Neurol. 2006.  
Lesprit, P et al. CID. 2001.

# Neurocysticercosis: Clinical Signs and Symptoms

- **Seizures**
  - 50% - 70% cases
- **Chronic headache**
- **Mental deterioration**
- **Focal neurological deficits**
- **Severe complications associated if obstruction of cerebrospinal fluid**

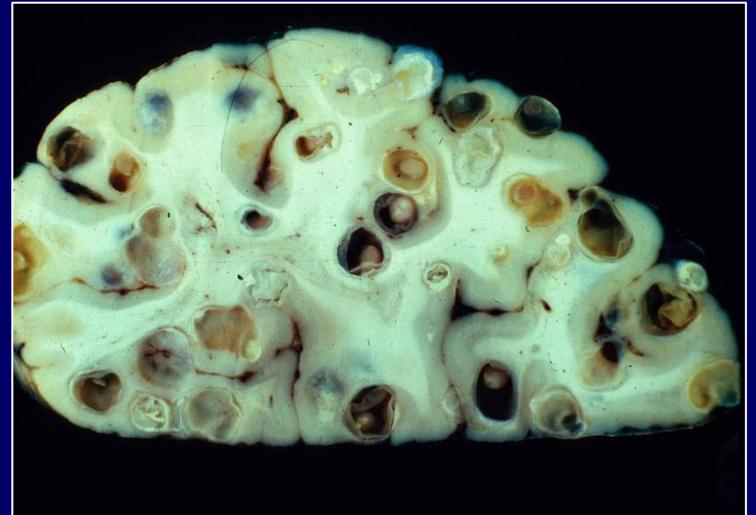
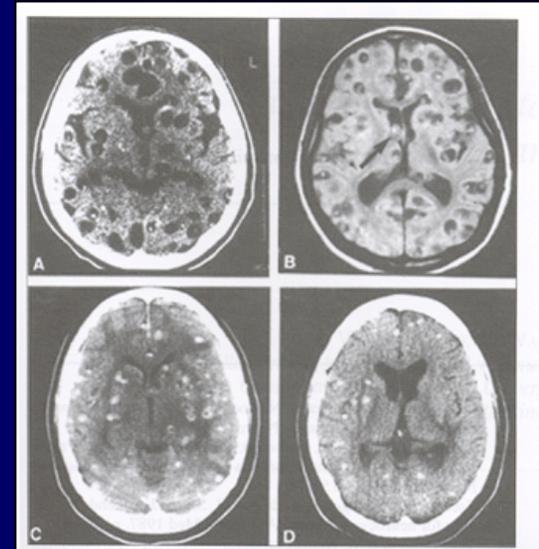


Photo: Dr. Theodore Nash

# Clinical Evaluation

- **Presumptive diagnosis**
  - History, clinical signs, imaging study
- **Additional tests**
- **Treatment**
  - Depends on location, number, stage, and clinical symptoms
  - +/- antiparasitics, steroids, anti-seizure meds, surgery



# Porcine Cysticercosis

- Cysts in muscle, subcutaneous fat
- Rarely associated with symptoms
- Diagnosis
  - Examination of tongue
  - Carcass inspection
- Treatment (oxfendazole)
- Vaccine

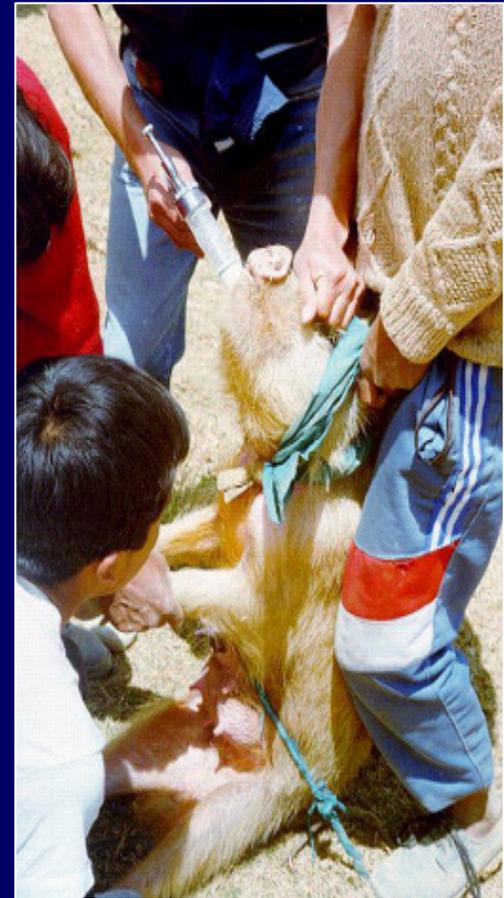
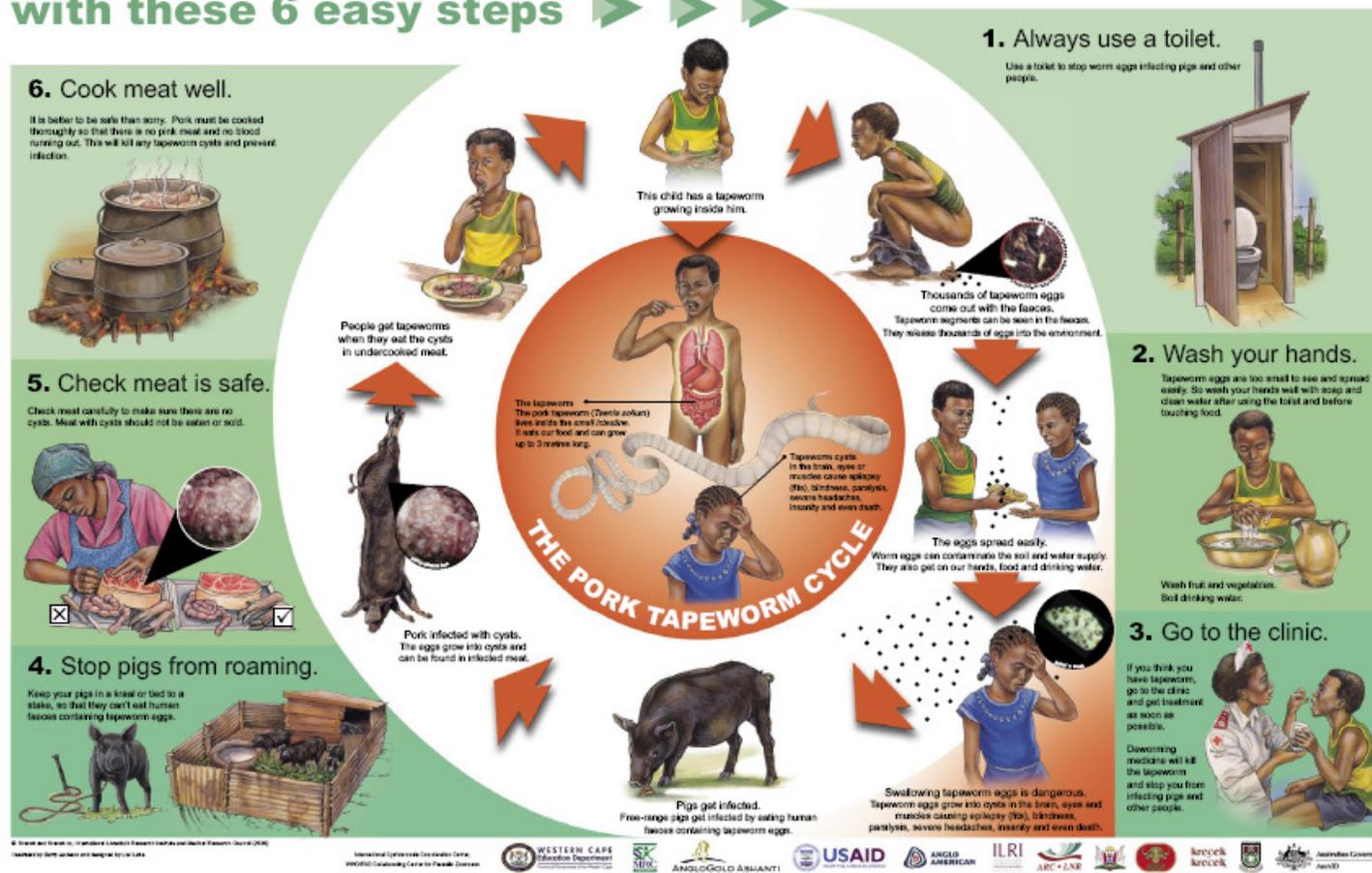


Photo: HH Garcia et al. Journal of Neurological Sciences. 2007.

# Control and Prevention

## LET'S BREAK THE PORK TAPEWORM CYCLE

with these 6 easy steps



© Livestock and Poultry Production, International Livestock Research Institute (ILRI) and the International Centre for Diarrhoeal Disease Research, Dhaka (ICDDR,B)



Figure: International Livestock Research Institute, 2006

# Cysticercosis in the U.S.

- **Nationally**
  - Increase in number of diagnoses
    - Global travel of residents
    - Arrival of migrants from endemic areas
    - Availability and use of CT and MRI
  - Not nationally reportable
    - Reportable in California, Arizona, New Mexico, Texas, Oregon
- **State-wide**
  - Investigations of morbidity and mortality in Oregon, California, Texas
  - Limited information available in North Carolina

# Study Objectives

- **Determine morbidity and mortality associated with neurocysticercosis**
- **Describe and characterize distribution and economic impact on health care system**

# Methods

- **Identified all individuals with cysticercosis discharge diagnosis or deaths in North Carolina from 1995 - 2004**
  - ICD-9CM, ICD-9, ICD-10 codes
- **Reviewed medical records and death certificate information**
- **Collected data**
  - Demographic
  - Clinical
  - Other

# Definitions

- **Incident case**
  - No prior diagnosis in lifetime at least one month prior to the first hospital visit
- **Denominator for rates**
  - U.S. Census Bureau data and bridged population estimates
- **Ethnicity: Hispanic**
  - Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race

# Results

**351 discharges with cysticercosis diagnosis**

**262 unique patients identified**

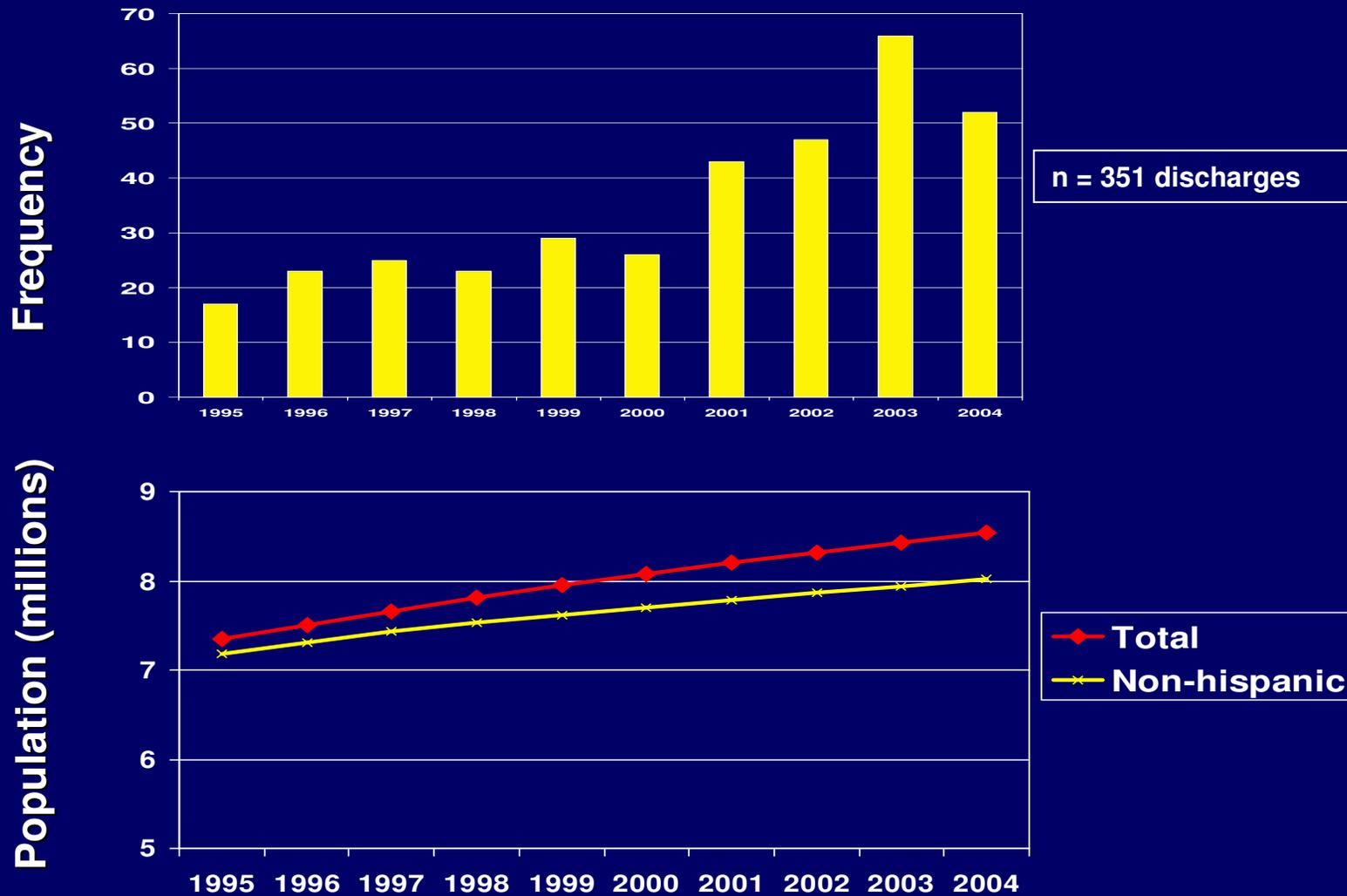
**253 (97%) patients with records available**

**250 (99%) patients with records supporting diagnosis**

**246 (98%) patients survived**

**4 (2%) patients with cysticercosis-related deaths**

# Annual Distribution of Discharges



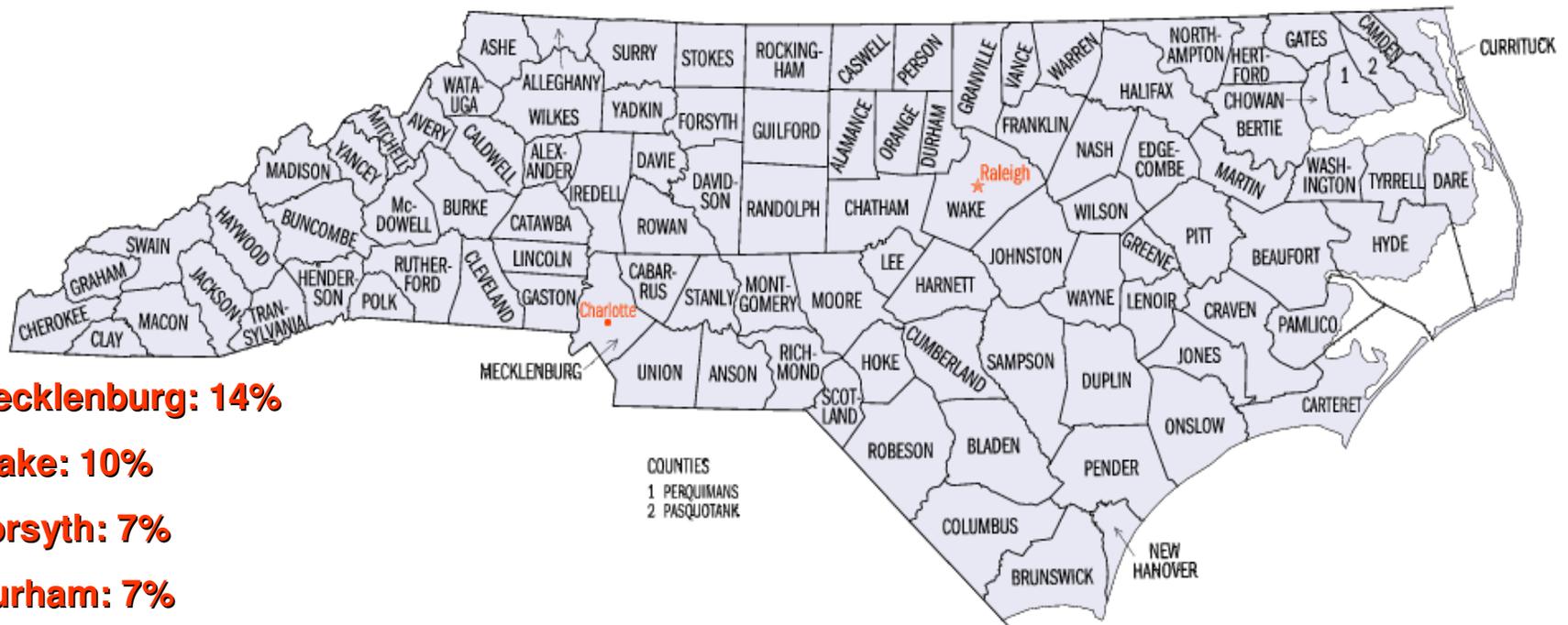
# Distribution at Hospital Facilities

- 43 different hospital facilities
- 5 facilities accounted for 55% of all discharges
  - University of North Carolina, Chapel Hill (16%)
  - Carolinas Health Care System, Charlotte (14%)
  - North Carolina Baptist Hospital, Winston-Salem (10%)
  - Duke University Health System, Durham (8%)
  - Pitt County Memorial Hospital, Greenville (7%)

# Demographics of Study Participants

<b>Characteristic</b>	<b>%</b>
<b>Sex</b>	<b>64 (males)</b>
<b>Median age</b>	<b>27 years (range 3-83)</b>
<b>Race</b>	
<b>Am. Indian</b>	<b>2</b>
<b>Asian</b>	<b>17</b>
<b>Black</b>	<b>3</b>
<b>Other</b>	<b>43</b>
<b>White</b>	<b>5</b>
<b>Missing</b>	<b>30</b>

# Geographical Distribution



**Mecklenburg: 14%**

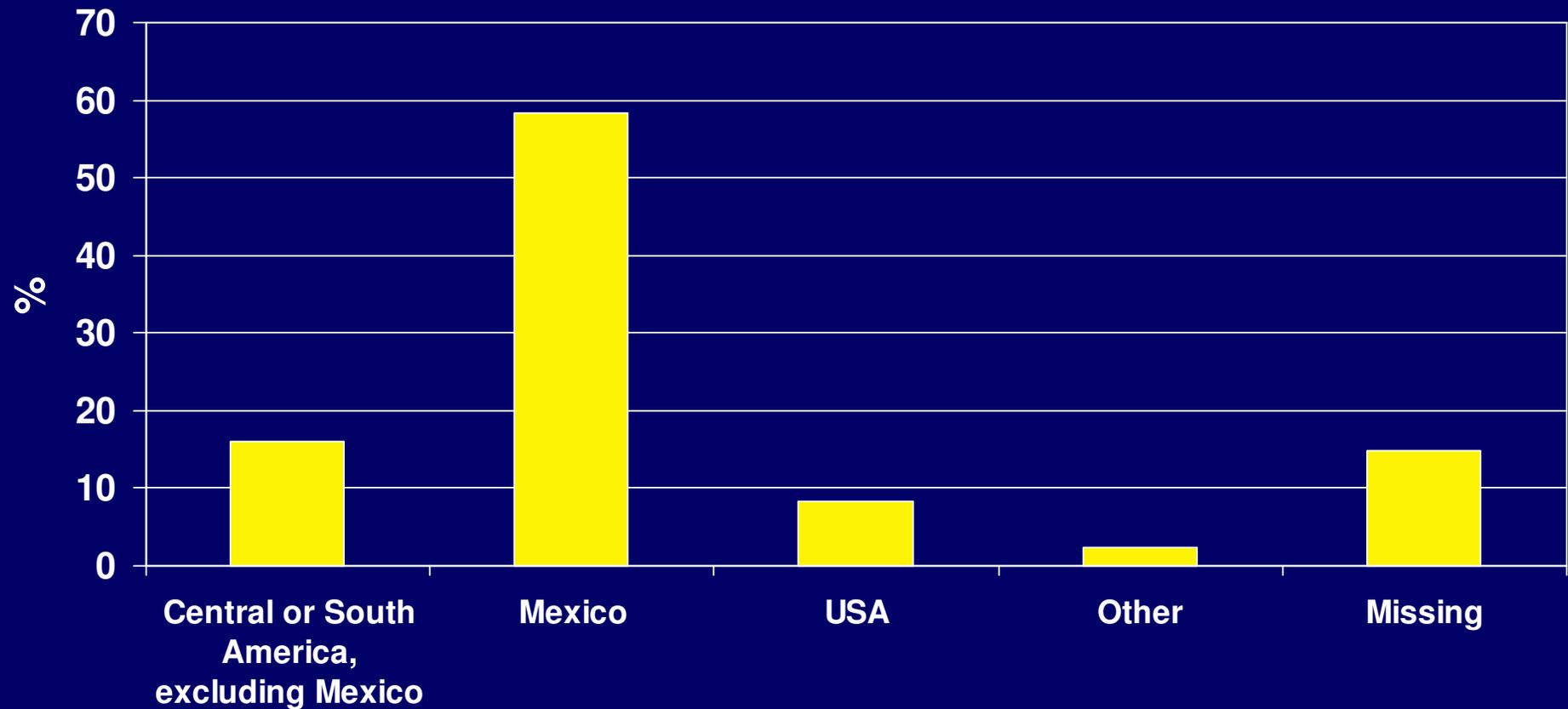
**Wake: 10%**

**Forsyth: 7%**

**Durham: 7%**

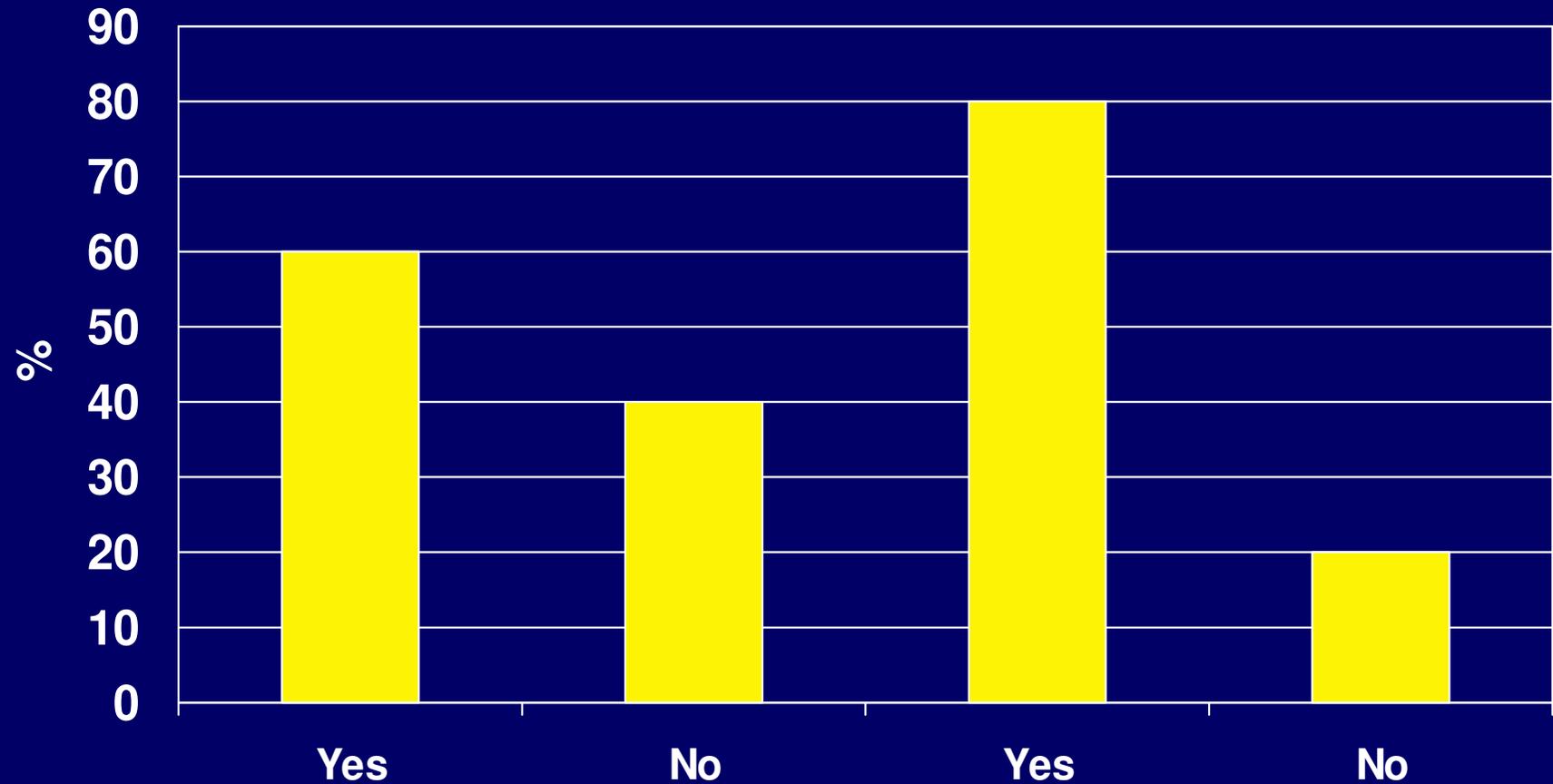
**Alamance: 5%**

# Country of Origin



n=213/250 (85%) with available data  
 $X^2=226.3$ , df=3,  $p<0.0001$  by Fisher's exact test

# Travel Outside the U.S.



**Non-U.S. Born**

n = 62

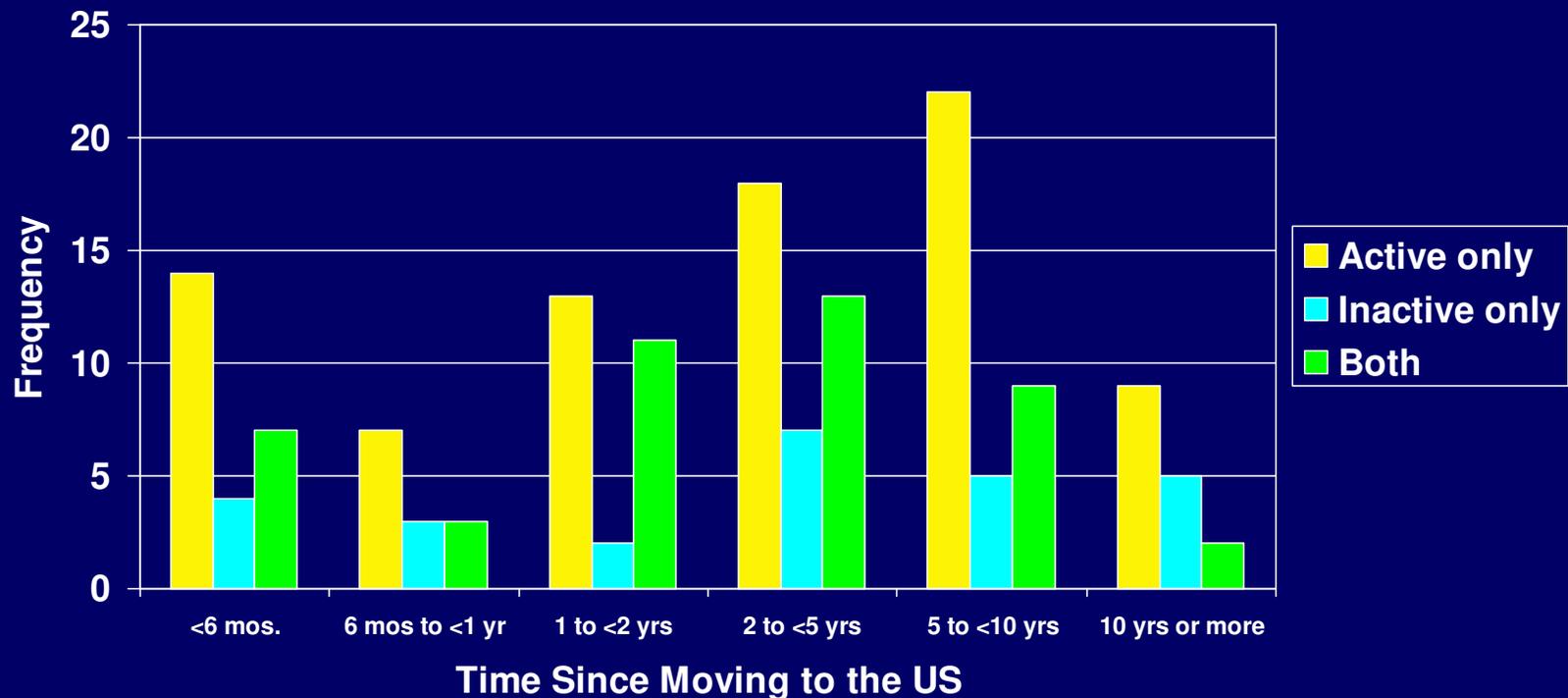
$X^2=3.6$ , df=1, p=0.1

**U.S. Born**

n = 10

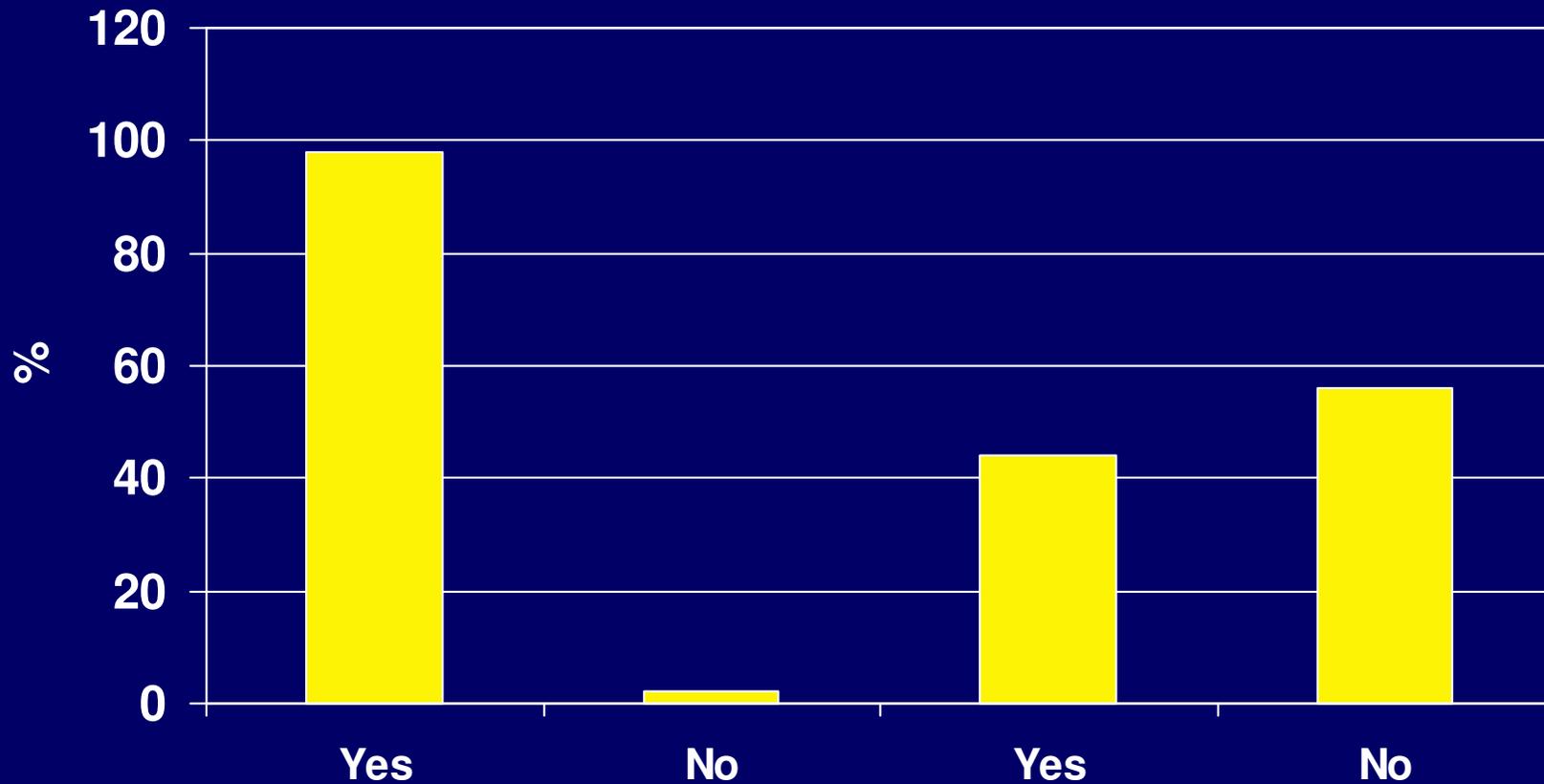
$X^2=2.3$ , df=1, p=0.1

# Type of Brain Lesion By Time Since Moving to the U.S.



n=154 (80%) non-U.S. born residents with classifiable lesions and date of move

# Diet



**Ever Eat Meat**

n=44

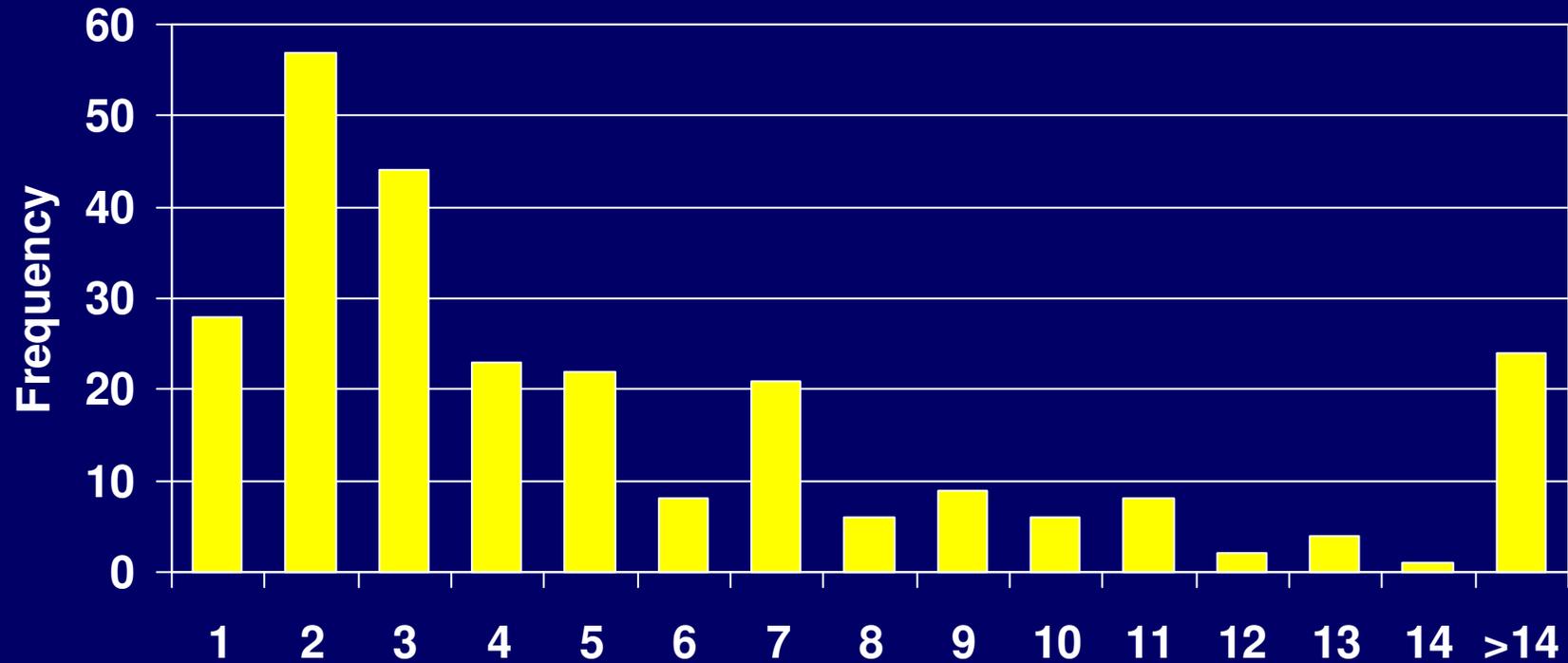
$X^2=40.1$ ,  $df=1$ ,  $p<0.0001$   
by Fisher's exact test

**Ever consumed raw or  
undercooked pork**

n=25,  $X^2=0.4$ ,  $df=1$ ,  $p=0.5$

by Fisher's exact test

# Total Hospitalization Duration



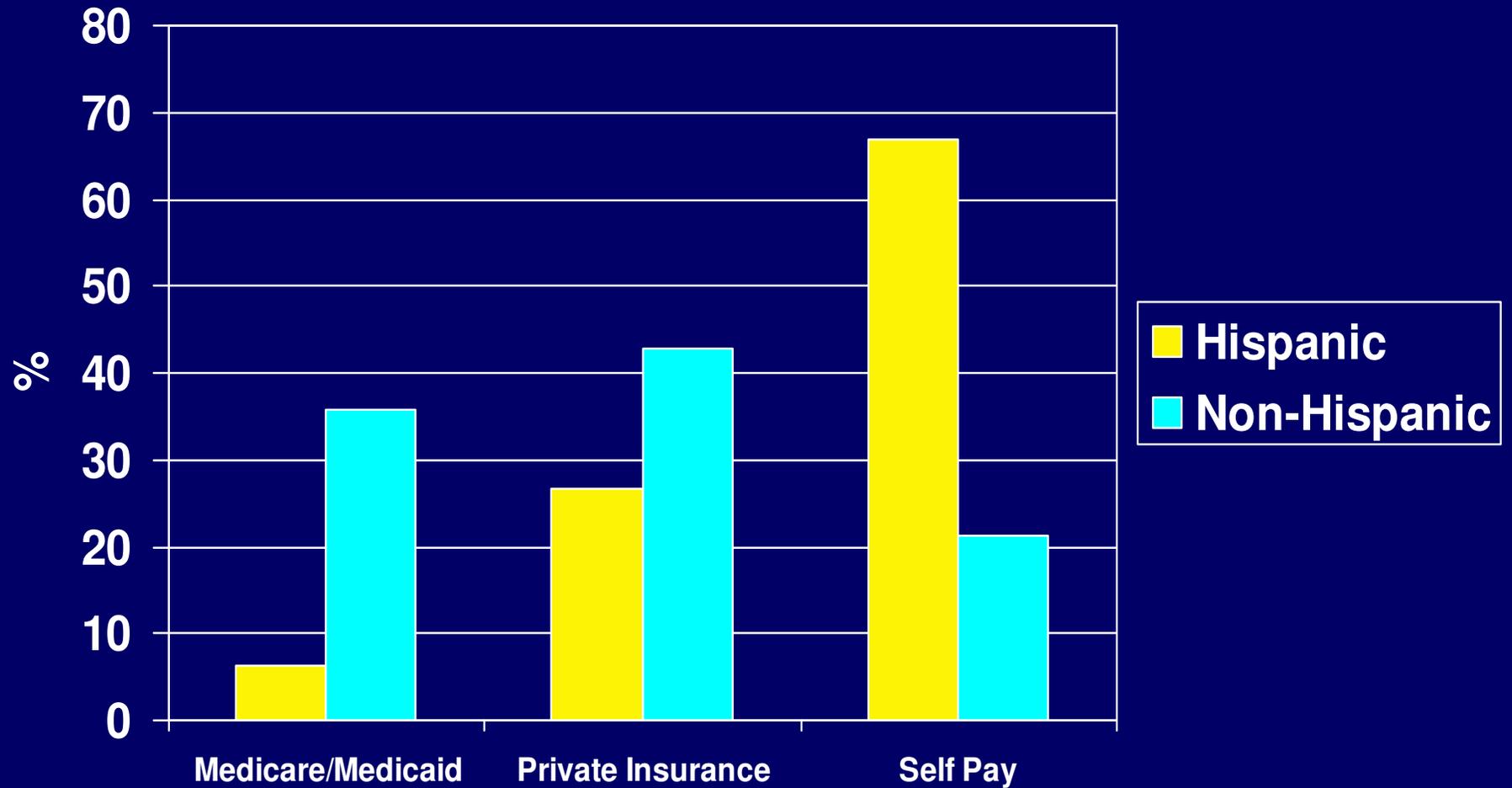
**Median duration per patient: 4 days (1-101)**

**Total hospital duration: 1,810 days**

**Median direct cost per patient: \$ 9,024 (\$611-212,539)**

**Total direct costs: \$4.4 million**

# Insurance



\*190/250 (76%) with available insurance type (54 Hispanics and 6 non-Hispanics missing data)

# Mortality

- **4 (2%) cysticercosis-related deaths**
  - 3 males, 1 female
- **Ages at death ranged from 20 - 46 years old**
- **Race and ethnicity**
  - 1 black, non-Hispanic (born in U.S.)
  - 3 white, Hispanics (not born in U.S.)
- **Complications**
  - 3 with ventricular obstruction
  - 1 with aspiration pneumonia
- **Mortality rate for total population**
  - 0.05 per 1 million population, 95% CI (0.0-0.1 per 1 million population)

# Cysticercosis Rates For 1995 - 2004

Population	Incidence Rate per 1 million person- years (95% CI)	Prevalence Rate per 1 million people (95% CI)
Total	2.6 (2.2 - 2.9) ~1 out of 400,000 person-years	3.1 (2.7 - 3.5) ~1 out of 320,000
Hispanic	55.9 (48.0 – 63.8) ~1 out of 18,000 person-years	66.9 (58.3 – 75.6) ~1 out of 15,000
Non- Hispanic	0.2 (0.1 - 0.3) ~1 out of 5,900,000 person-years	0.3 (0.2 - 0.4) ~1 out of 3,800,000

# Summary of Findings

- **Disproportionate impact among Hispanics**
- **Majority of patients not born in U.S.**
  - Mexico, Central or South America
  - Some continue to travel outside U.S.
  - U.S.-born patients travel to endemic areas
- **Majority were young, males, living in or near large cities**
- **Relatively low mortality rate**
- **Majority do not have health insurance**
- **Median total direct costs per patient = \$9000**

# Limitations

- **Incomplete medical record information and missing data**
  - Country of origin, diet, travel, animal exposure
- **Underestimated Hispanic population**
- **Did not address *where* transmission occurred**

# Future Directions

- **Increase in number of immigrants in North Carolina**
- **Conduct patient interviews**
  - To better understand transmission and risk factors
- **Increase surveillance**
  - Locate additional cases of taeniasis and cysticercosis
  - Stool and serologic testing
  - Reportable disease?
- **Provide education**

# Acknowledgements

- **Medical record department staff**
- **North Carolina Department of Health and Human Services**
  - Paul Buescher
  - Jeff Engel
  - Brenda Horne
  - Pedro Luna-Orea
  - Jean-Marie Maillard
  - Greg Smith
- **North Carolina State University College of Veterinary Medicine**
  - Maria Correa
- **University of North Carolina-Chapel Hill**
  - Emily Sickbert-Bennett
  - Charlie Poole
  - J Richard Seed
  - The Graduate School
- **Others**
  - Pablo Destefanis
  - Sara Forhan
  - John Hubbell
  - Cathryn Jirlds

The findings and conclusions in this presentation are those of the author(s) and do not necessarily represent the views of the North Carolina Department of Health

# Questions?



# Additional References (Websites)

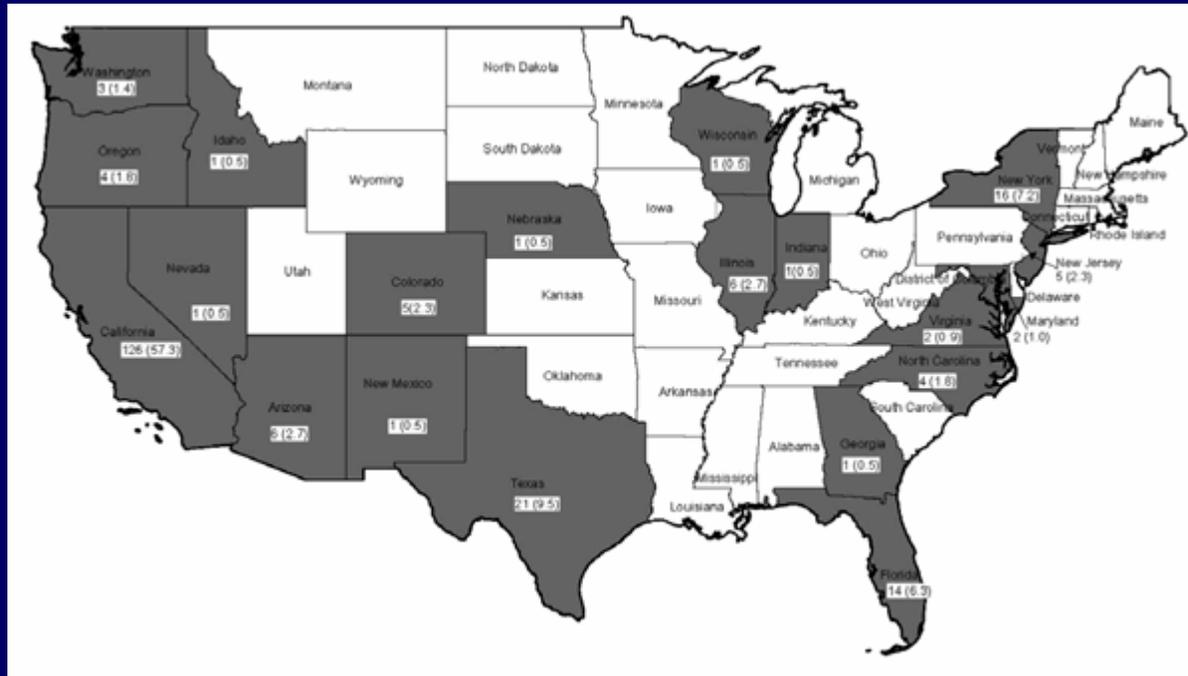
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# Extra Slides

# Deaths from Cysticercosis 1990-2002



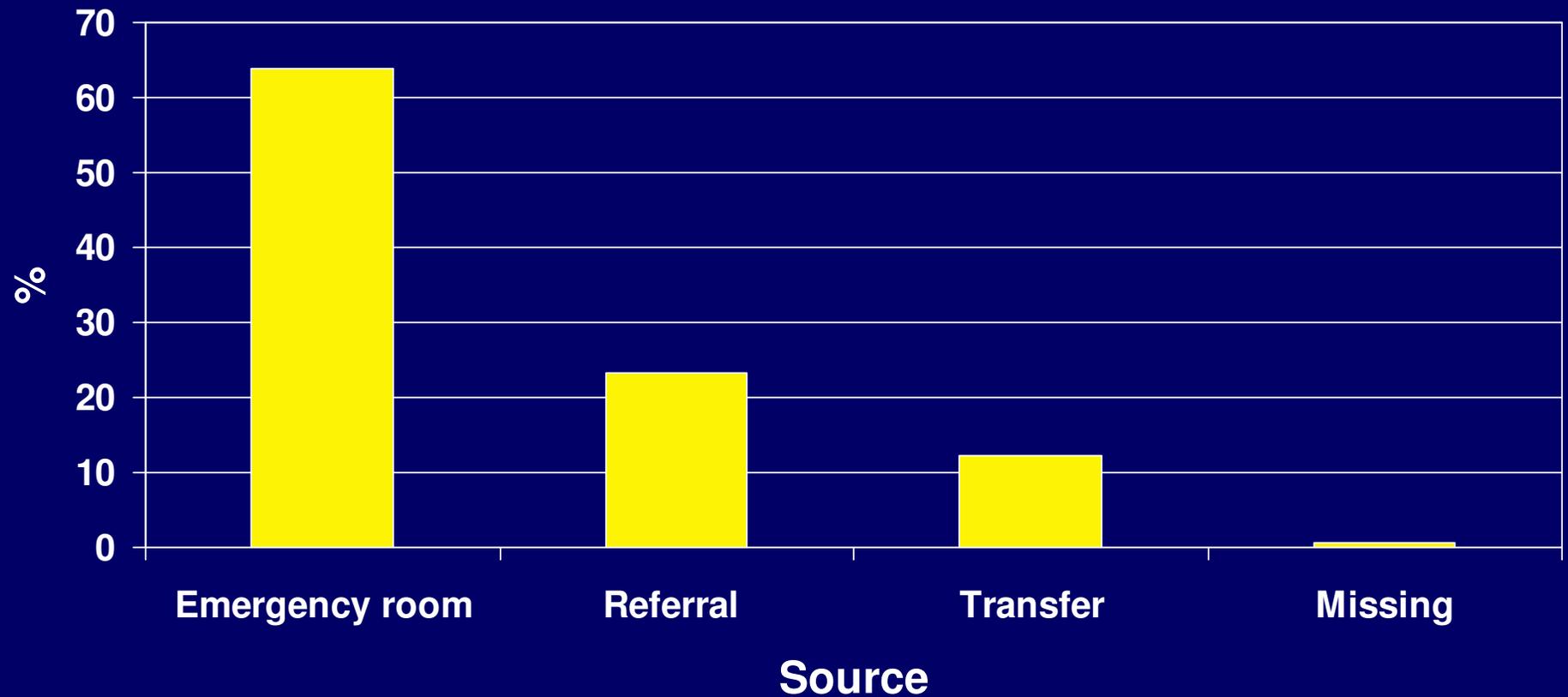
# Race:

## Medical record review vs. Hospital discharge database

	North Carolina Hospital Discharge Database						
Medical Record Review	Am. Indian	Asian	Black	White	Other	Missing	Total
Am. Indian	0	0	0	0	0	0	0
Asian	1	1	0	0	0	1	3
Black	0	0	7	0	0	1	8
White	5	40	0	12	107	73	237
Other	0	1	0	0	0	1	2
Missing	0	0	0	0	0	0	0
<b>Total</b>	<b>6</b>	<b>42</b>	<b>7</b>	<b>12</b>	<b>107</b>	<b>76</b>	<b>250</b>

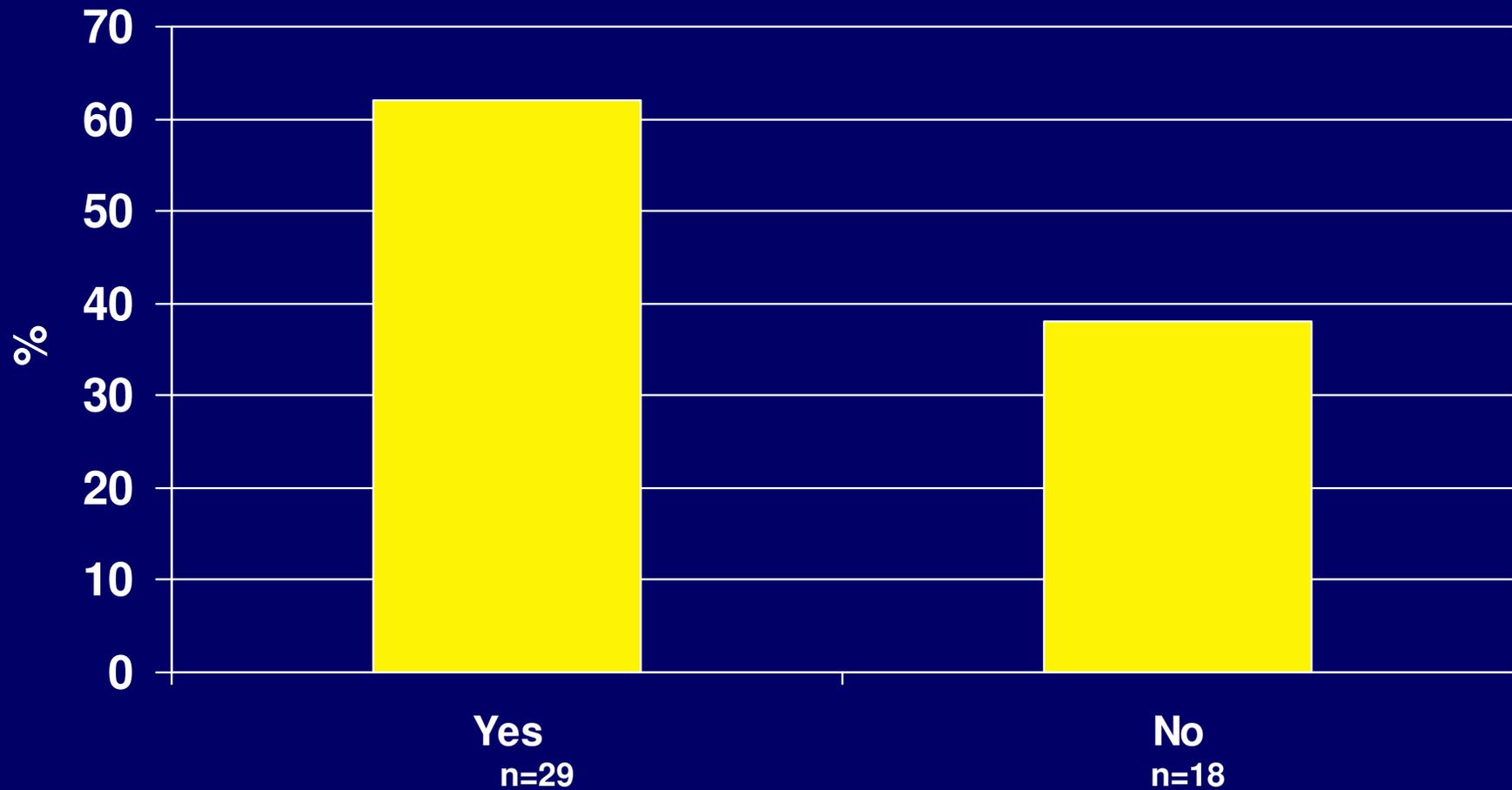
weighted kappa 0.06 (95% CI 0.02-0.11),  $p < 0.0001$

# Source of Admission



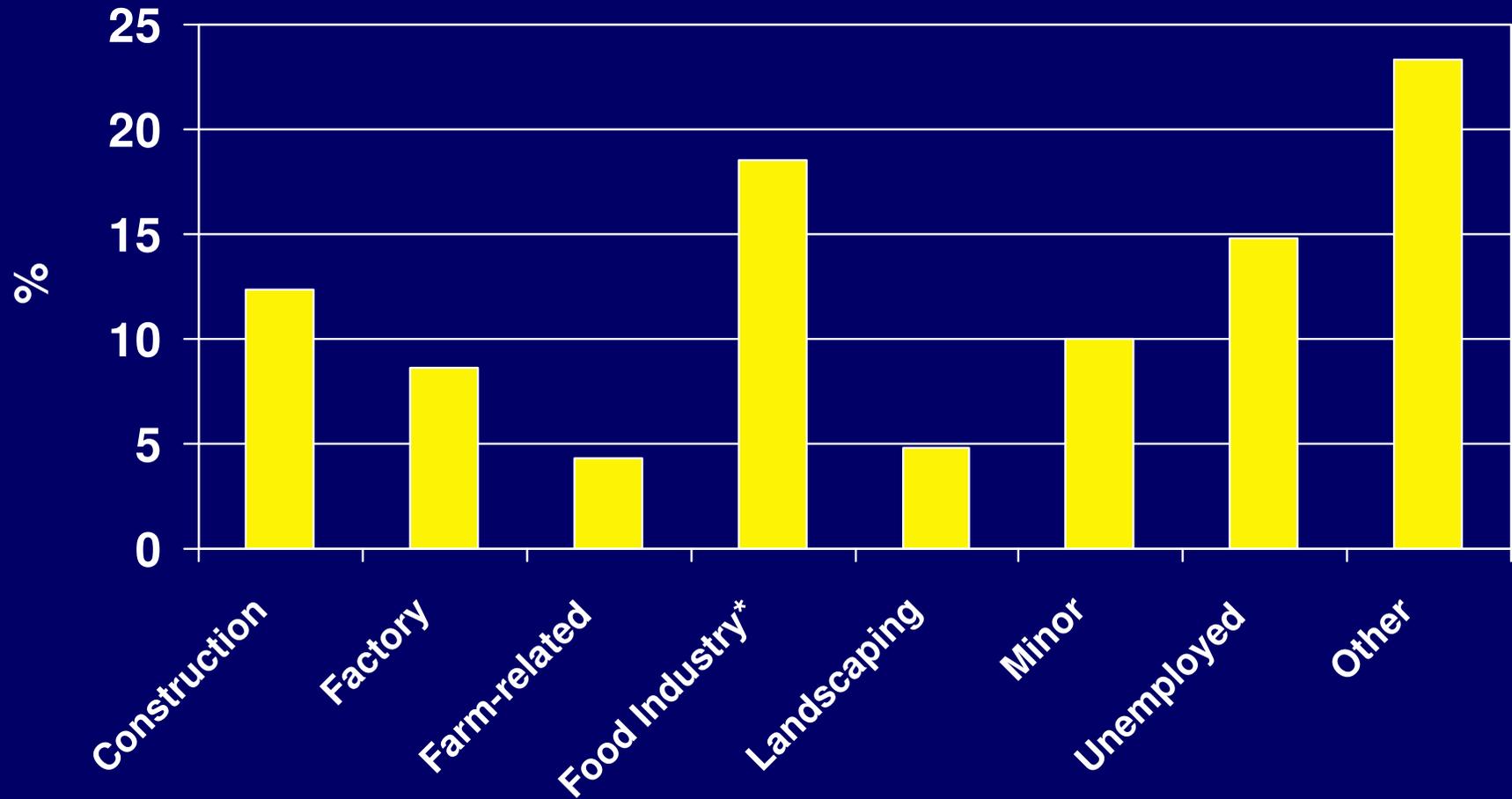
Referrals: HMO, clinical, and general referral  
n=351 discharges  
 $X^2=156.0$ ,  $df=2$ ,  $p<0.0001$

# Animal or Farm Exposure



Data available for 47/250 (19%)  
 $X^2=2.6$ ,  $df=1$ ,  $p=0.1$  by Fisher's exact test

# Occupation



210/250 (84%) with available occupation type

\*Food industry includes industrial (e.g. food processing plants, n=18) and/or restaurants (n=21)

