# High prevalence of *Clostridium difficile* in the Western Australian environment

Tom Riley

Medical & Health Sciences, Edith Cowan University
Veterinary & Life Sciences, Murdoch University
Microbiology, PathWest Laboratory Medicine


## ÆTIOLOGY OF ANTIMICROBIAL-AGENT-ASSOCIATED COLITIS


W. Lance George — Vera L. Sutter
Ellie J. C. Goldstein — Shelly L. Ludwig
Sydney M. Finegold


THE LANCET, APRIL 15, 1978

## Identification of Clostridium difficile as a cause of pseudomembranous colitis

(Accepted 16 February 1978) BRITISH MEDICAL JOURNAL


**Department of Microbiology, Birmingham Children's Hospital, Birmingham**
R H GEORGE, MB, MRCPATH, consultant microbiologist
JANE M SYMONDS, MB, BS, senior registrar in microbiology

**Departments of Microbiology and Surgery, General Hospital, Birmingham B4 6NH**
FRANCES DIMOCK, FIMLS, research technician
J D BROWN, FIMLS, senior chief technician
Y ARABI, FRCS, senior registrar
N SHINAGAWA, MD, senior registrar
M R B KEIGHLEY, MS, FRCS, consultant surgeon and senior lecturer
J ALEXANDER-WILLIAMS, MD, FRCS, consultant surgeon
D W BURDON, MB, MRCPATH, consultant microbiologist


## Clindamycin-Induced Enterocolitis in Hamsters as a Model of Pseudomembranous Colitis in Patients


TE-WEN CHANG,†* JOHN G. BARTLETT,[1] SHERWOOD L. GORBACH[2] AND ANDREW B. ONDERDONK[1]

*Department of Medicine,[2] New England Medical Center, Tufts University School of Medicine, and Infectious Disease Research Laboratory,[1] Veterans Administration Hospital, Boston, Massachusetts 02111*



Received for publication 16 November 1977

INFECTION AND IMMUNITY, May 1978, p. 526–529


## CLOSTRIDIUM DIFFICILE AND THE ÆTIOLOGY OF PSEUDOMEMBRANOUS COLITIS


H. E. Larson — A. B. Price
P. Honour

*Clinical Research Centre and Northwick Park Hospital, Watford Road, Harrow, Middlesex HA1 3UJ*

S. P. Borriello

*Bacterial Metabolism Research Laboratories, Public Health Laboratory Service, Colindale, London NW9 5HT*


THE LANCET, MAY 20, 1978

# Urgent Threats

CDC, 2013

- *Clostridium difficile*
- Carbapenem-resistant Enterobacteriaceae (CRE)
- Drug-resistant *Neisseria gonorrhoeae*


*Clostridium difficile (C. difficile)* causes life-threatening diarrhea. These infections mostly occur in people who have had both recent medical care and antibiotics. Often, *C. difficile* infections occur in hospitalized or recently hospitalized patients.


Antibiotics

# The Epidemiology of Community-Acquired *Clostridium difficile* Infection: A Population-Based Study

Sahil Khanna, MBBS[1], Darrell S. Pardi, MD, MS, FACG[1], Scott L. Aronson, MD[1,2], Patricia P. Kammer, CCRP[1], Robert Orenstein, DO[3], Jennifer L. St Sauver, PhD[4], W. Scott Harmsen, MS[5] and Alan R. Zinsmeister, PhD[5]

## Study highlights

### What is current knowledge?

- *Clostridium difficile infection* is increasing worldwide with hospitalization and antibiotic exposure as the most common risk factors.
- The epidemiology and characteristics of community-acquired *Clostridium difficile* infection are not well defined.

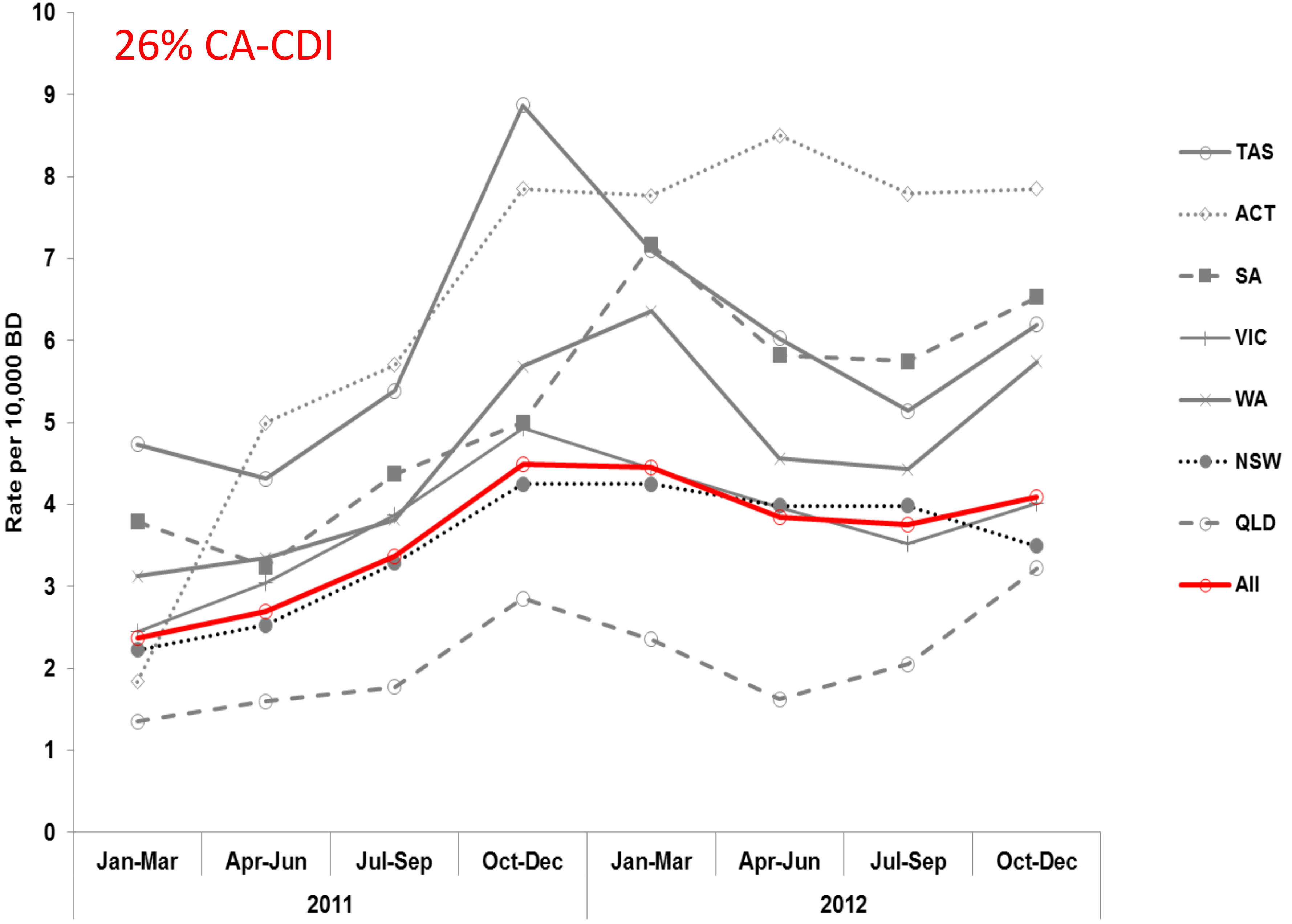
### What is new here?

- A major proportion of *Clostridium difficile* infection patients is community-acquired.
- These patients are younger, often lack traditional risk factors, and have less severe disease than patients with hospital-acquired infection.

*Am J Gastroenterol.* 2012 January ; 107(1): 89–95. doi:10.1038/ajg.2011.398.

# Hospital identified CDI in Australia, 2011-2012

(Slimings et al. *Med J Aust* 2014; 200: 272-6)

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ESTABLISHED IN 1812 SEPTEMBER 26, 2013 VOL. 369 NO. 13

# Diverse Sources of *C. difficile* Infection Identified on Whole-Genome Sequencing

David W. Eyre, B.M., B.Ch., Madeleine L. Cule, Ph.D., Daniel J. Wilson, D.Phil., David Griffiths, B.Sc., Alison Vaughan, B.Sc., Lily O'Connor, B.Sc., Camilla L.C. Ip, Ph.D., Tanya Golubchik, Ph.D., Elizabeth M. Batty, Ph.D., John M. Finney, B.Sc., David H. Wyllie, Ph.D., Xavier Didelot, D.Phil., Paolo Piazza, Ph.D., Rory Bowden, Ph.D., Kate E. Dingle, Ph.D., Rosalind M. Harding, Ph.D., Derrick W. Crook, M.B., B.Ch., Mark H. Wilcox, M.D., Tim E.A. Peto, D.Phil., and A. Sarah Walker, Ph.D.

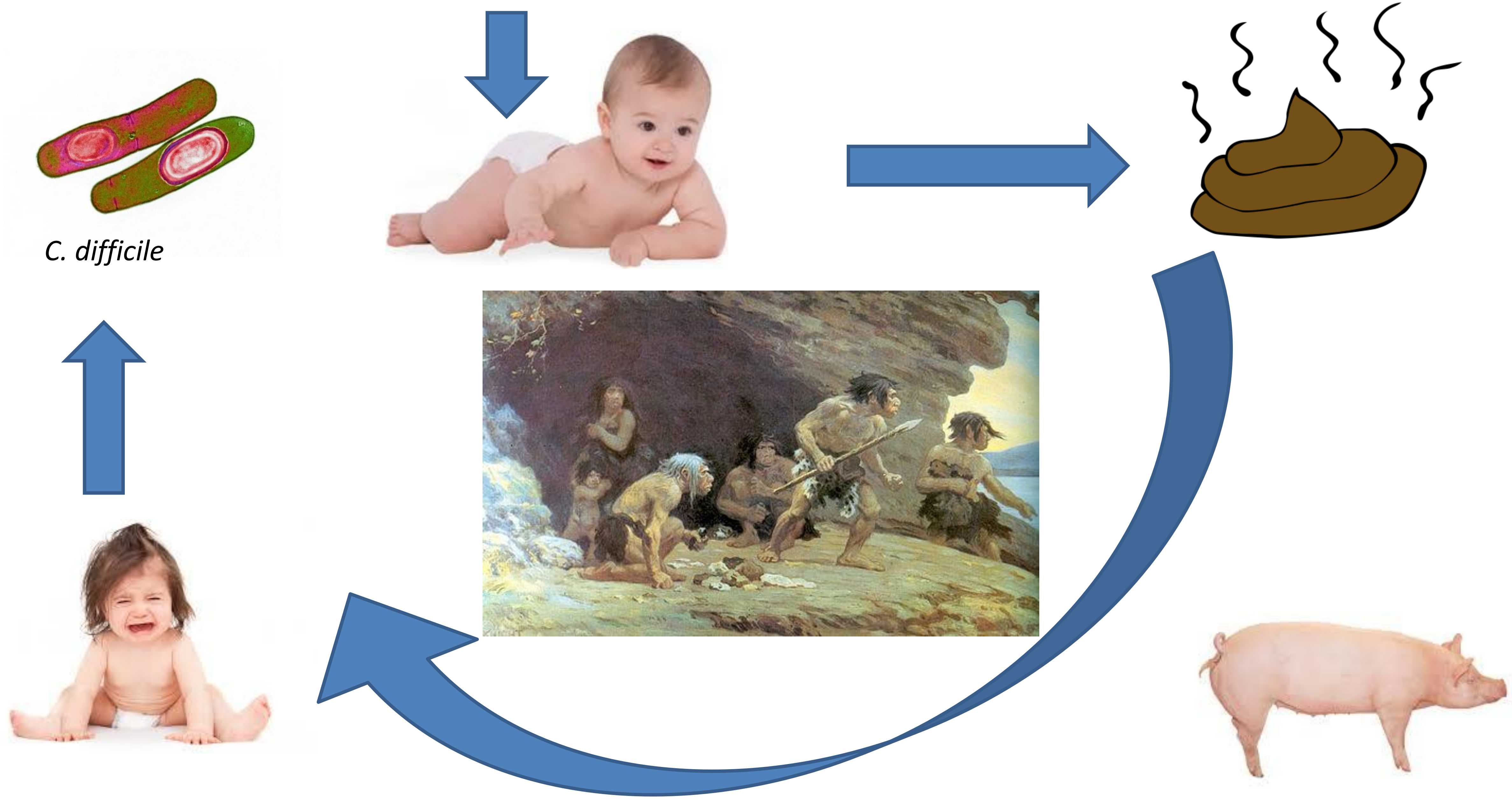
CONCLUSIONS

Over a 3-year period, 45% of *C. difficile* cases in Oxfordshire were genetically distinct from all previous cases. Genetically diverse sources, in addition to symptomatic patients, play a major part in *C. difficile* transmission. (Funded by the U.K. Clinical Research Collaboration Translational Infection Research Initiative and others.)

# Risk factors for CDI ?

- Exposure to the organism
- Anything that alters normal gut microflora: exposure to antibiotics – clindamycin, then cephalosporins, some fluoroquinolones
- Others - IBD

# The natural history of *C. difficile*



# DanMap 2007

“This change in prescription habits suggests that the consumption of cephalosporins in pigs is changing from occasional prescription to more systematic prescription in herds producing 14-29% of the weaned pigs.”

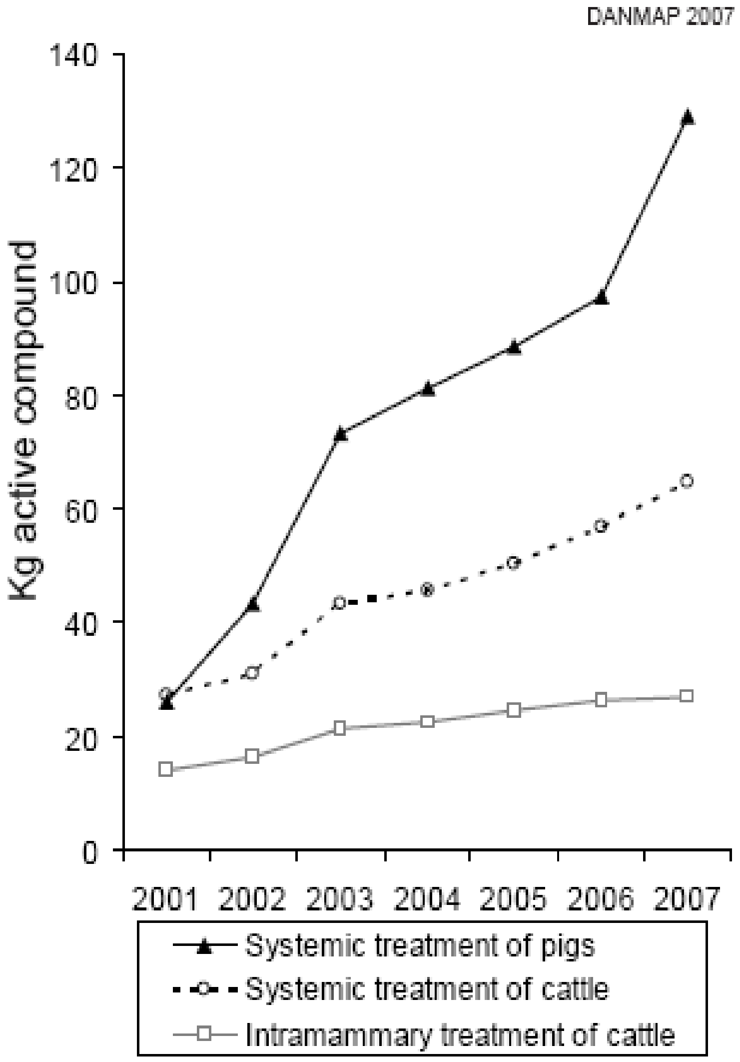



*Figure 7. Use of 3rd and 4th generation cephalosporins in pigs and cattle, 2001-2007, Denmark*

# Antimicrobial use in the Australian pig industry: results of a national survey

D Jordan,[a]* JJ-C Chin[a], VA Fahy,[b] MD Barton,[c] MG Smith[d] and DJ Trott[e]

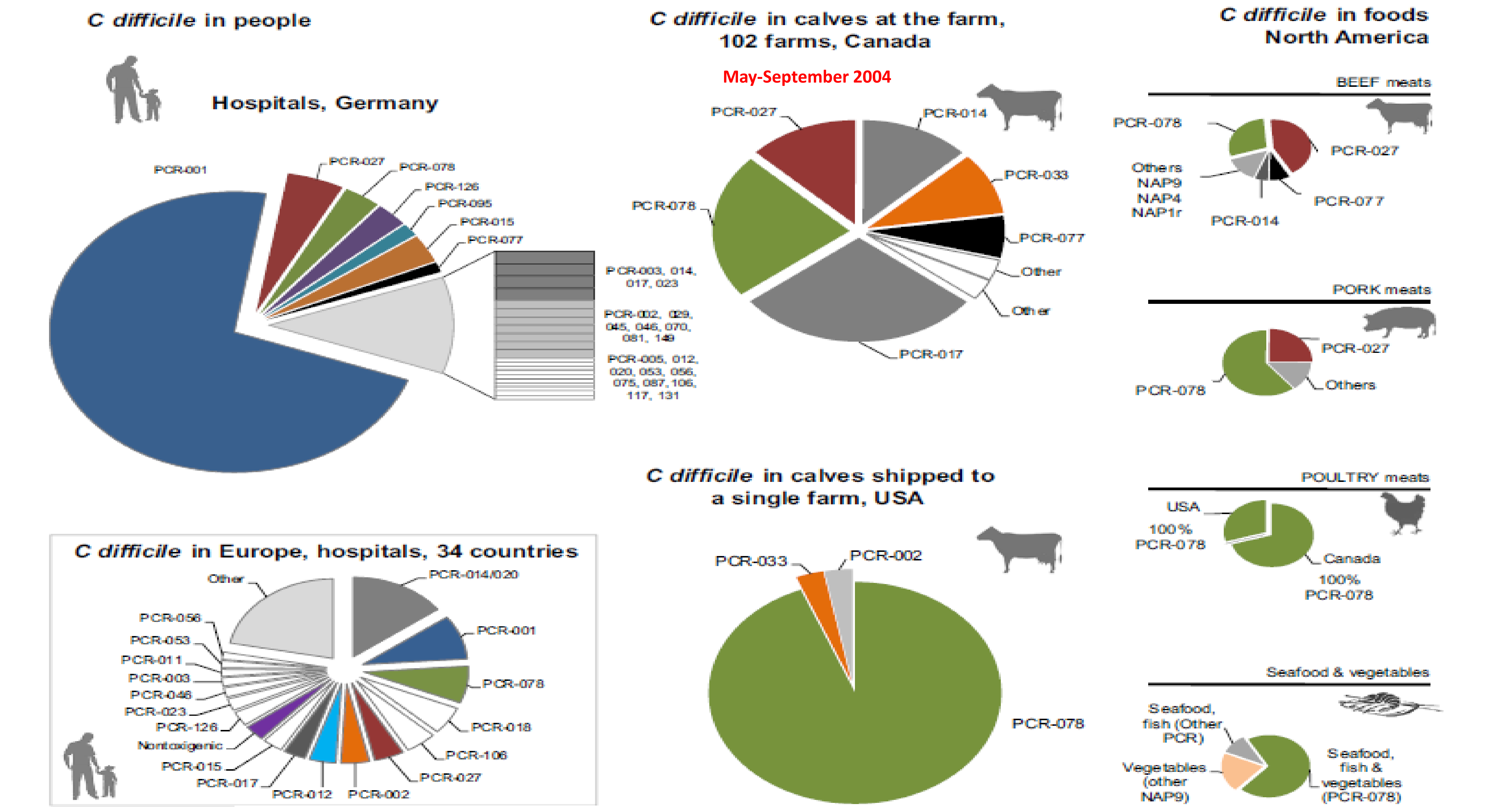
**Table 2. Percent of pig herds (n = 197) reported as having used particular antimicrobials in the 12 months prior to survey and the route of administration of those drugs**

| Antimicrobial | Importance rating for human health | Percent of herds within each category of use | | | | |
|---|---|---|---|---|---|---|
| | | Unanswered | Not used | Injection/oral | Oral only | Injection only |
| Apramycin/neomycin | Medium/low | 1.0 | 47.3 | 2.5 | 42.1 | 7.1 |
| Florfenicol (for respiratory disease) | Low | 1.0 | 95.4 | 0.5 | 0.0 | 3.1 |
| Florfenicol (for gut disease) | Low | 2.5 | 93.4 | 0.0 | 0.5 | 3.6 |
| Lincomycin and spectinomycin | Medium | 2.0 | 64.5 | 6.1 | 19.3 | 8.1 |
| Macrolide | Low | 2.0 | 25.4 | 32.0 | 27.9 | 12.7 |
| Penicillins[a] | Low | 1.0 | 3.6 | 22.8 | 4.6 | 68.0 |
| Ceftiofur | High | 1.5 | 73.7 | 2.0 | 0.5 | 22.3 |
| Tiamulin | Not yet rated | 1.0 | 88.4 | 1.0 | 7.1 | 2.5 |
| Olaquindox | Low | 1.0 | 46.7 | 0.0 | 52.3 | 0.0 |
| Virginiamycin | High | 1.5 | 98.5 | 0.0 | 0.0 | 0.0 |
| Dimetridazole | Medium | 2.0 | 85.3 | 0.0 | 12.7 | 0.0 |
| Sulfonamides | Low | 2.0 | 28.9 | 5.6 | 10.7 | 52.8 |
| Tetracyclines | Low | 1.0 | 15.2 | 50.8 | 10.7 | 22.3 |
| Other antimicrobials | | 3.1 | 86.2 | 0.0 | 7.6 | 3.1 |

[a]Includes amoxicillin and ampicillin.

Covered about half the large herds in Australia in 2006.

*Aust Vet J* 2009;87:222–229




Rodriguez et al Infect Dis Clin N Am 27 (2013) 675–685

# Animal strains in Australia

- Ribotype 127 60%
- Ribotype 126 16%
- Ribotype 033 13%


5-7days old

- Ribotype 014 23%
- Ribotype 033 13%
- Ribotype QX009 12%
- Ribotype 237 10%


- Many new ribotypes from animals – CDT+

Knight *et al. Appl Environ Microbiol* 2013, 2014

# Contamination of Australian newborn calf carcasses at slaughter with *Clostridium difficile*

**D. R. Knight[1], P. Putsathit[1], B. Elliott[2] and T. V. Riley[1,2]**

1) *Microbiology & Immunology, School of Pathology and Laboratory Medicine, The University of Western Australia* and 2) *Department of Microbiology, PathWest Laboratory Medicine, Queen Elizabeth II Medical Centre, Nedlands, WA, Australia*

266.e3 *Clinical Microbiology and Infection*, Volume 22 Number 3, March 2016 CMI

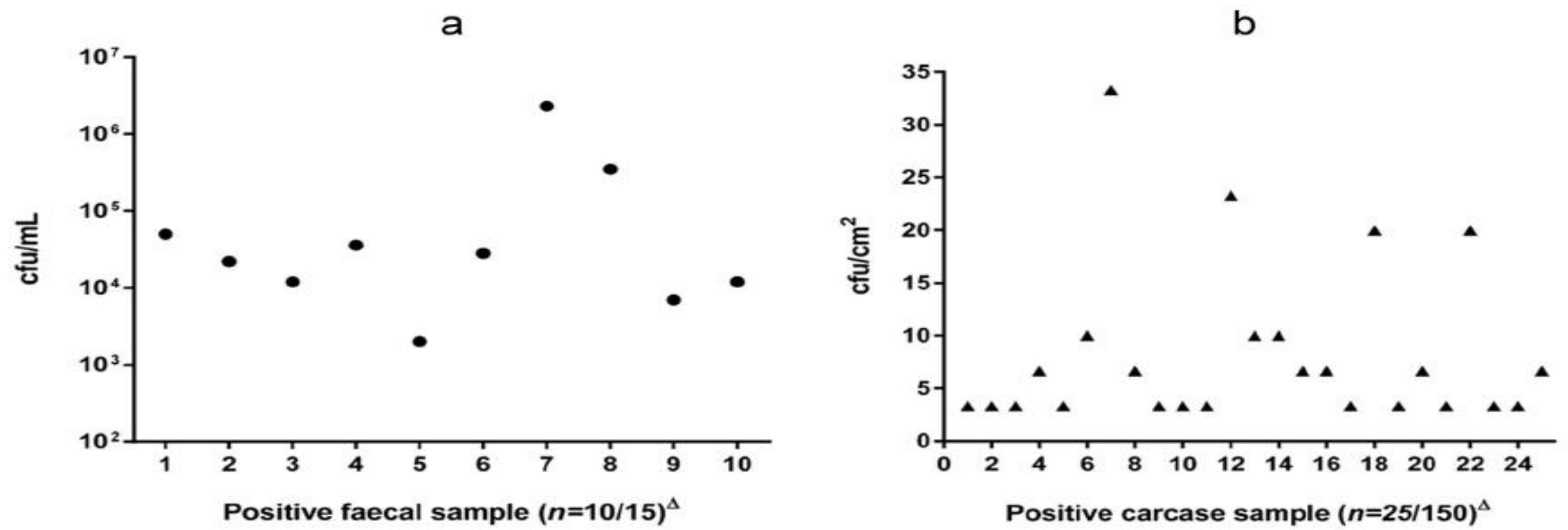



**FIG. 1.** Concentration of viable *Clostridium difficile* in faeces (a) and on carcase sponges (b). $^\Delta$Number of isolates above the limit of detection.

Su-Chen Lim

# Vegetables in WA

| Sample type | Prevalence |
|---|---|
| Carrots | 1.8-5.3% (1/19) |
| Onions | 1.9-5.6% (1/18) |
| Beetroots | 7.4-22.2% (4/18) |
| Potatoes | 16.6-50.0% (8/16) |
| Total | 6.6-19.7% (14/71) |

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## High prevalence of *Clostridium difficile* on retail root vegetables, Western Australia

Journal of Applied Microbiology 124, 585-590 © 2017

S.C. Lim[1], N.F. Foster[2], B. Elliott[3] and T.V. Riley[1,2,3,4]

| PCR ribotype | Toxin gene profile tcdA | tcdB | cdtA/cdtB | n (%) |
|---|---|---|---|---|
| QX 145 | - | - | - | 39 (13.7) |
| UK 101 | + | + | - | 32 (11.2) |
| QX 104 | - | - | - | 30 (10.5) |
| UK 014/020 | + | + | - | 18 (6.3) |
| QX 393 | - | - | - | 18 (6.3) |
| QX 142 | - | - | - | 18 (6.3) |
| UK 056 | + | + | - | 17 (6.0) |
| Novel 3 | + | + | - | 12 (4.2) |
| Novel 2 | - | - | - | 10 (3.5) |
| UK 012 | + | + | - | 10 (3.5) |
| UK 010 | - | - | - | 10 (3.5) |
| QX 072 | - | - | - | 10 (3.5) |
| UK 051 | - | - | - | 10 (3.5) |
| QX 518 | - | - | - | 10 (3.5) |
| QX 519 | + | + | - | 10 (3.5) |
| UK 002 | + | + | - | 10 (3.5) |
| Novel 4 | - | - | - | 7 (2.5) |
| UK 237 | - | + | + | 4 (1.4) |
| Novel 1 | - | - | - | 4 (1.4) |
| UK 137 | + | + | - | 3 (1.1) |
| QX 274 | + | + | + | 2 (0.7) |
| UK 033 | - | - | + | 1 (0.4) |
| Total | | | | 285 |

# Gardening centres

~30% of samples positive for *C. difficile*

Some obvious like animal manures

Some less obvious like compost/mulch

But expired vegetables from large stores going into compost/mulch

Su-Chen Lim

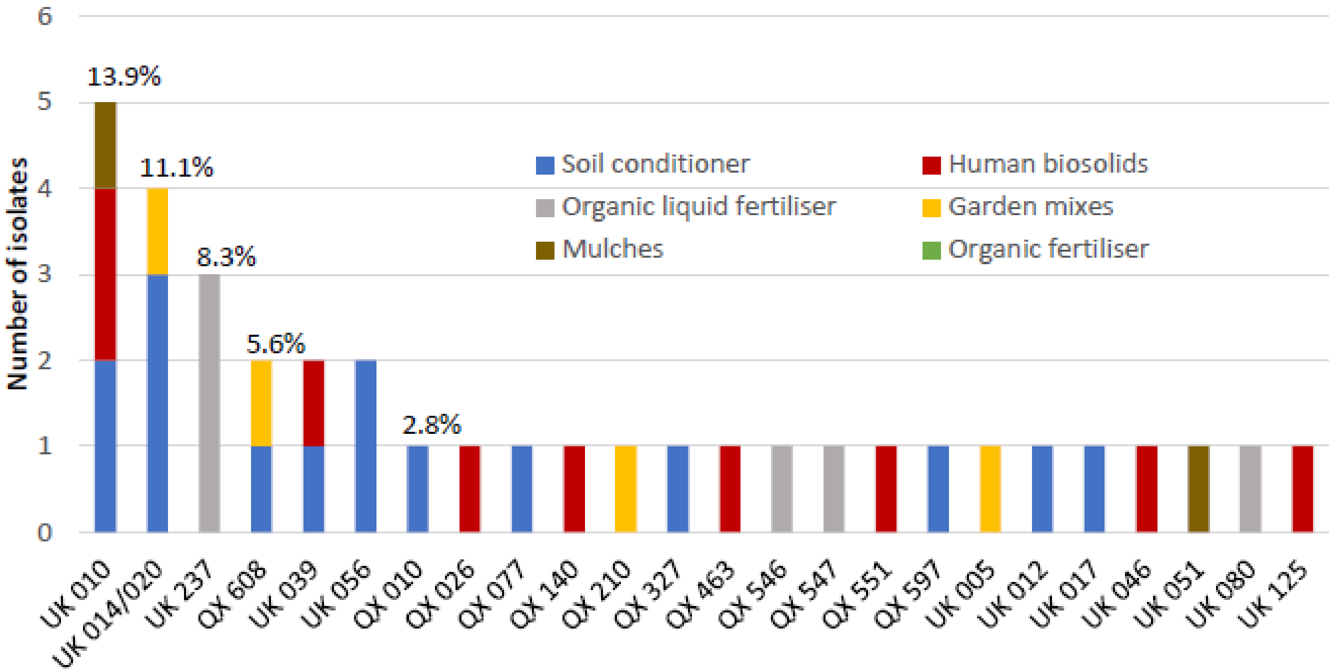


Figure 1. PCR ribotype of *C. difficile* isolates in gardening products

| Variable | Variable categories | *C. difficile* number isolated (%) | Univariable model | Covariate Odds ratios (95% CI)* | |
|---|---|---|---|---|---|
| | | | Odds ratios (95% CI)† | Sampling site | *P value*¶ |
| Age‡ | Old lawn (n = 113) | 53 (47) | Referent | | |
| | New lawn (n = 198) | 129 (65) | 2.11 (1.32–3.4) | 2.30 (1.16–4.57) | 0.015# |
| Area | Extra-large (n = 85) | 53 (62) | Referent | | |
| | Large (n = 53) | 26 (49) | 0.58 (0.28–1.16) | 0.49 (0.16–1.49) | 0.7 |
| | Medium (n = 101) | 60 (59) | 0.88 (0.49–1.59) | 1.02 (0.42–2.51) | 0.7 |
| | Small (n = 72) | 43 (60) | 0.89 (0.47–1.71) | 0.88 (0.32–2.43) | 0.7 |
| Location | North (n = 161) | 98 (60.9) | Referent | | |
| | South (n = 150) | 84 (56) | 1.22 (0.78–1.92) | 1.25 (0.61–2.59) | 0.99 |
| Season | Autumn (n = 224) | 135 (60.3) | Referent | | |
| | Winter (n = 87) | 47 (54) | 0.77 (0.47–1.28) | 0.67 (0.28–1.62) | 0.52 |

**Table 1. The relationship between the prevalence of *C. difficile* in lawn and the age of the lawn, its size, sampling site, location, postcode, and season in Perth.**


Peter Moono[1,*], Su Chen Lim[1,*] & Thomas V. Riley[2,3,4]
SCIENTIFIC REPORTS | 7:41196 | DOI: 10.1038/srep41196
Published: 01 February 2017

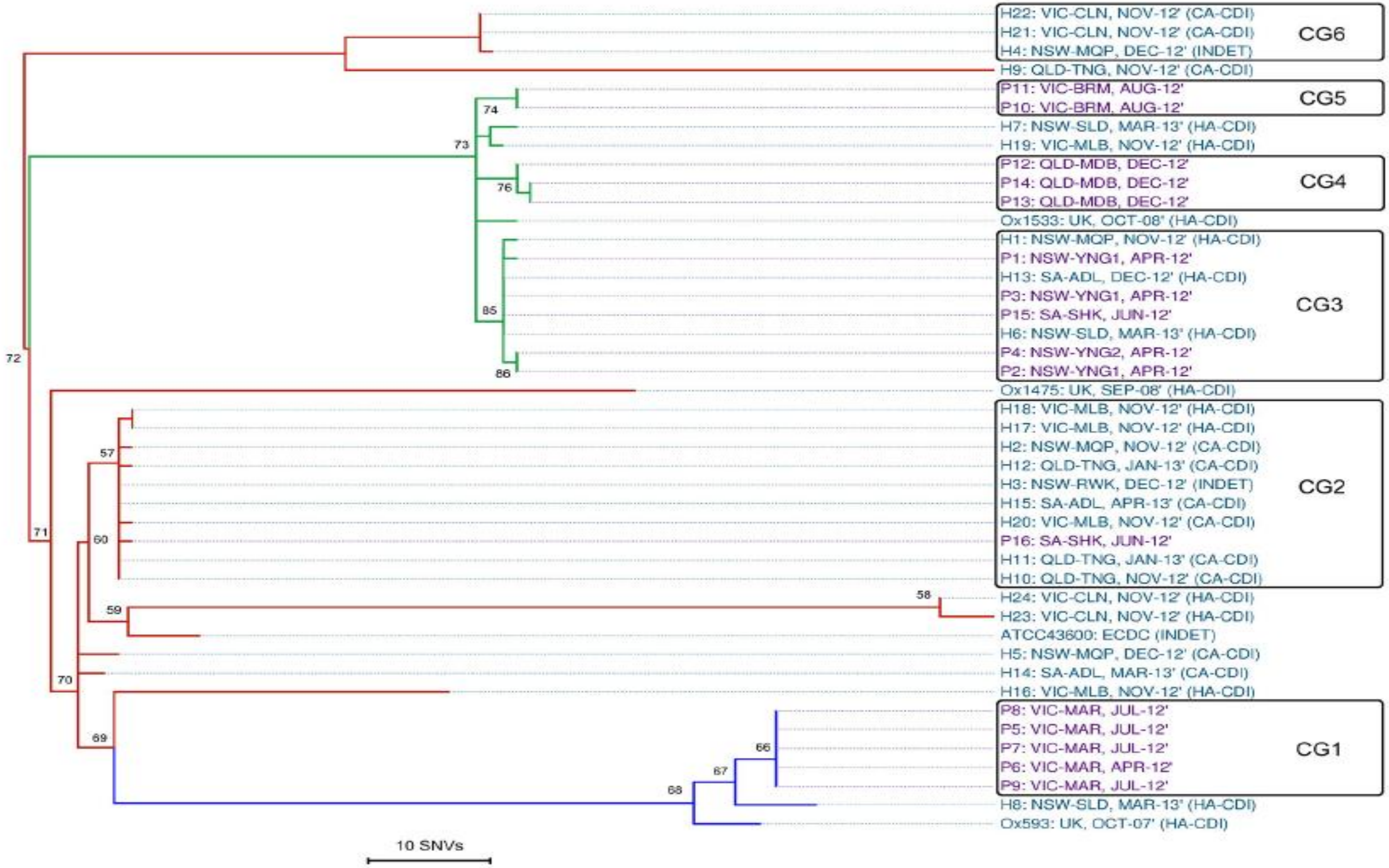


**FIGURE 3 | Single nucleotide variant analysis of 44 *C. difficile* RT014.**


frontiers in Microbiology



*Daniel R. Knight[1*], Michele M. Squire[1], Deirdre A. Collins[1,2] and Thomas V. Riley[2,3,4]*



ORIGINAL RESEARCH
published: 11 January 2017
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# What are the sources/reservoirs for community-acquired CDI?

Food yes, but mainly root vegetables.

Probably more important as a vehicle rather than food *per se*.

Contamination of households – kitchens in particular.

Meat less likely an issue – adult animals OK.

Notwithstanding the above, cooking won't help!

ANIMAL MANURE THE MAIN PROBLEM!

# Transport of *C. difficile* into hospitals

- In patients
- In visitors
- On visitors (hands etc. and on shoe soles)
- On/in food
- Animals
- Hospital gardens and lawns

Therefore the problem remains the same:
reduce environmental contamination.

# The way forward

- Continue to try and engage the veterinarians in One Health
- Explain to farmers/industry groups what is going on
- Involve politicians
- Look for alternative treatment agents/strategies for animals
- Restrict cephalosporin use in human medicine
- Completely ban all cephalosporins from use in production animals

**"Cephalosporins are the work of the devil, send to end the antibiotic era!"**

# Lessons from Western Australia

Many sources of *C. difficile* other than food probably equally or more important (such as lawn).

Each jurisdiction will need to look in its own back yard!

Anywhere there is animal manure there is a problem.

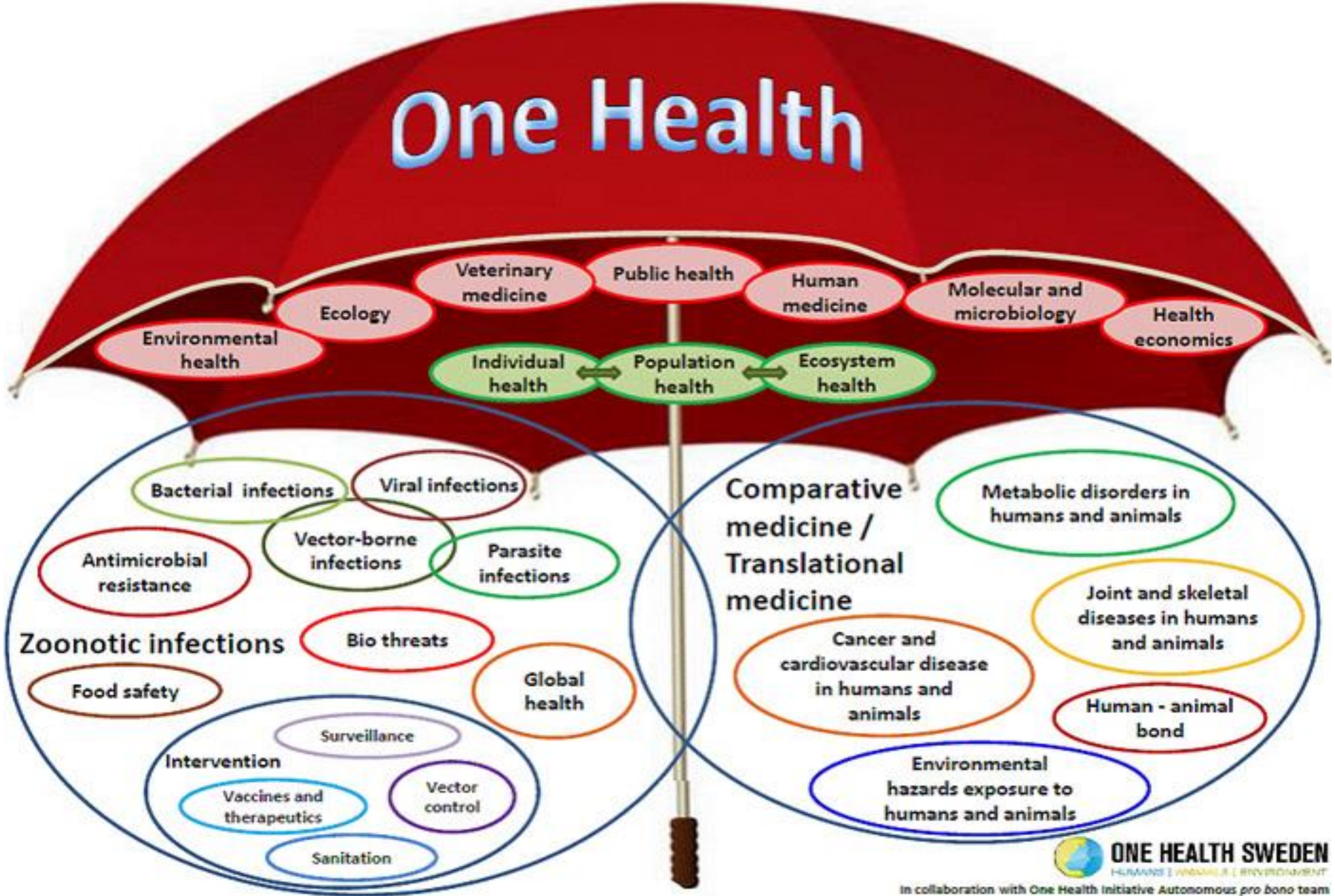
Not just food animals – horses* also, maybe companion animals.

Antimicrobial use in production animals is driving this problem.

Requires a One Health approach.

* Food in France

The One Health concept recognizes that the health of humans is connected to the health of animals and the environment.



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