Clostridium difficile, One Health, and the rise of community-associated infection

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Hosted by Jane Barnett
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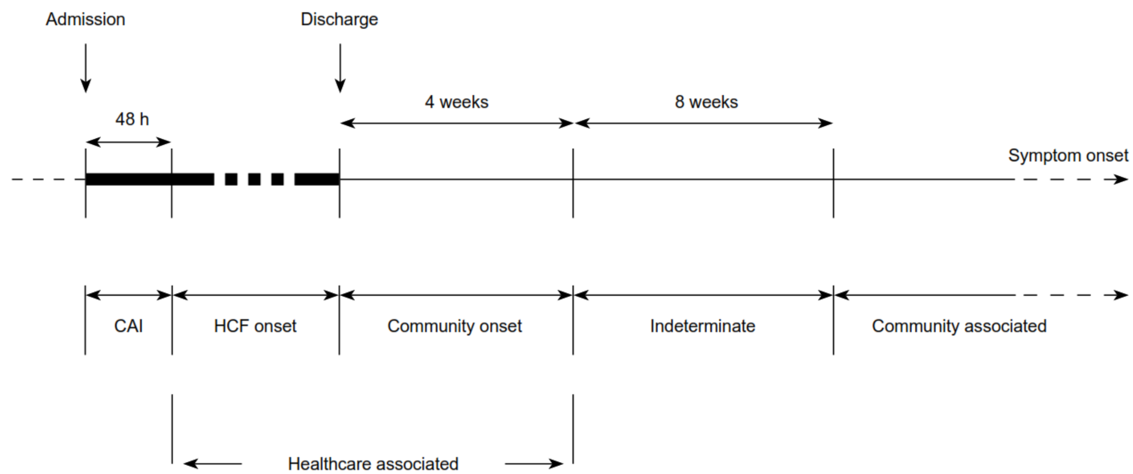
Outline

- Definitions
- History
- Asymptomatic carriers
- Animal reservoirs
- Food sources
- Environmental sources
- One Health

Community-associated vs community-acquired

Adapted with permission from McDonald LC, Coignard B, Dubberke E, et al. Recommendations for surveillance of Clostridium difficile-associated disease. Infect Control Hosp Epidemiol 2007;28:140–45.

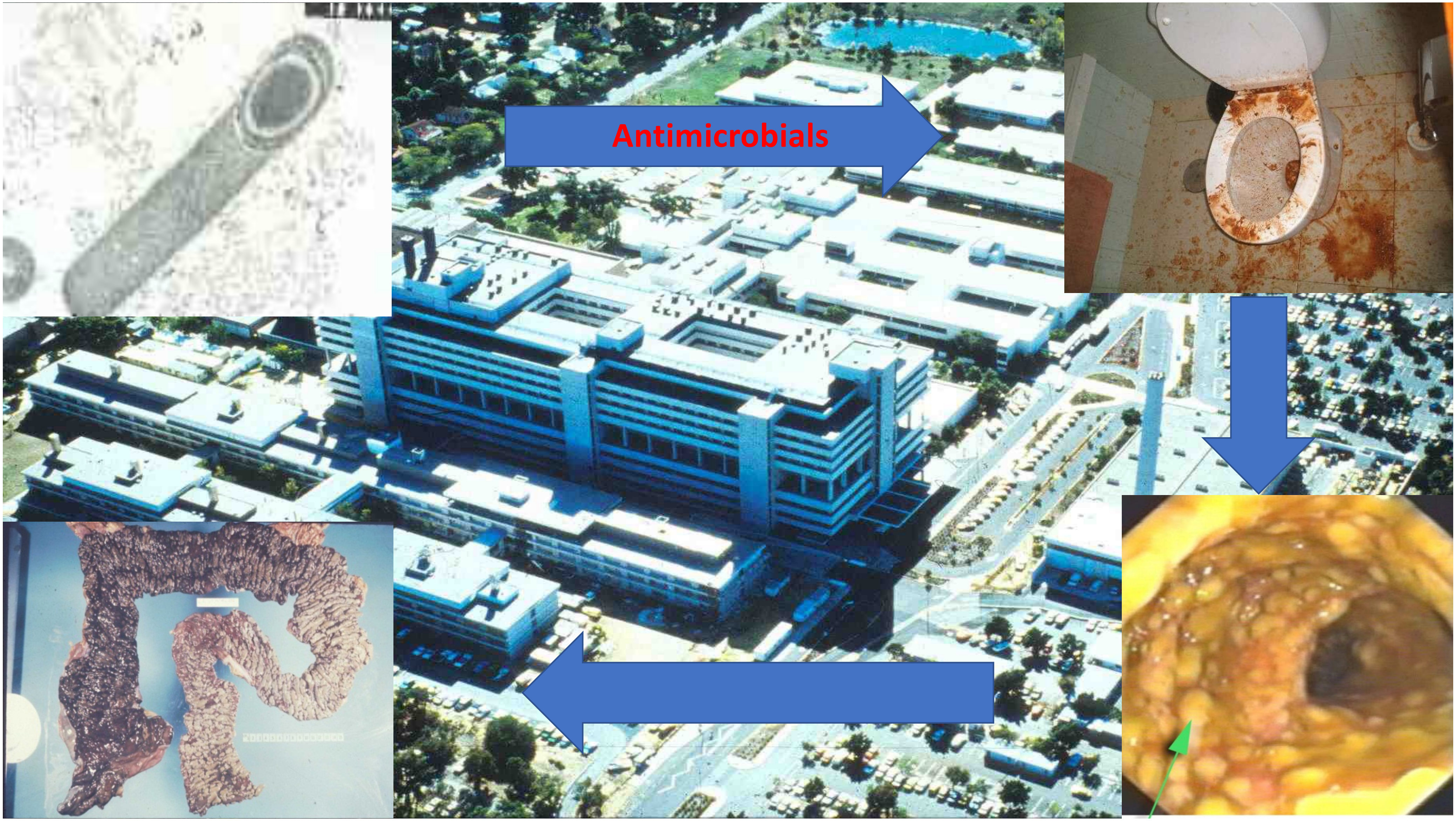


CAI, community-associated infection; HCF, healthcare facility

Source vs reservoir

The reservoir of an organism is the site where it resides, metabolizes, and multiplies. The source of the organism is the site from which it is transmitted to a susceptible host, either directly or indirectly through an intermediary object.

<u>The reservoir may or may not be the source from which an agent is transferred to a host.</u> (Brachman P, *Medical Microbiology* Ed. S Baron 1996)


Antimicrobials

Eur J Clin Microbiol Infect Dis (1998) 17:137–141

Editorial

Clostridium difficile: A Pathogen of the Nineties

Community-associated infection

Several recent studies, including that of Hirschhorn et al. [10], have focused on CDAD in the community or general practice [15, 16]. In the first of these studies, *Clostridium difficile* or its cytotoxin was found in 16 (5.5%) of 288 stool samples from patients with diarrhoeal illness consulting their general practitioners and was the most common enteric pathogen detected [15]. Most patients had only mild to moderate diarrhoea; however, in the majority of cases the diarrhoea was protracted. In a later study a larger group of 580 specimens was investigated following a campaign to educate general practitioners about CDAD [16]. There were 75 positive samples (10.7%) from 61 patients and *Clostridium difficile* was the second most frequent enteric pathogen following *Campylobacter* spp.

Pathology (1991), 23, pp. 346-349

DIARRHEAL DISEASE DUE TO *CLOSTRIDIUM DIFFICILE* IN GENERAL PRACTICE

Thomas V. Riley,* Frances Wetherall,† Jacinta Bowman,* Jillian Mogyorosy† and Clayton L. Golledge‡

*Department of Microbiology, University of Western Australia and Sir Charles Gairdner Hospital, Queen Elizabeth II Medical Centre, Nedlands, †Clinipath Laboratories, Wembley, ‡Department of Microbiology, Fremantle Hospital, Fremantle, Western Australia

5.5%

Community-Acquired *Clostridium difficile*-Associated Diarrhea. Thomas V. Riley, Margaret Cooper, Bryan Bell, and Clayton L. Golledge. *From the National Centre for Epidemiology and Population Health, The Australian National University, Canberra, Australian Capital Territory; and the Epidemiology and Health Statistics Section, Health Department of Western Australia, East Perth, and Western Diagnostic Pathology, Myaree, Western Australia, Australia*

10.7%

Clinical Infectious Diseases 1995;20(Suppl 2):S263–5

1058–4838/95/2006–0080$02.00

This clearly meant that there were sources/reservoirs of *C. difficile* in the community.

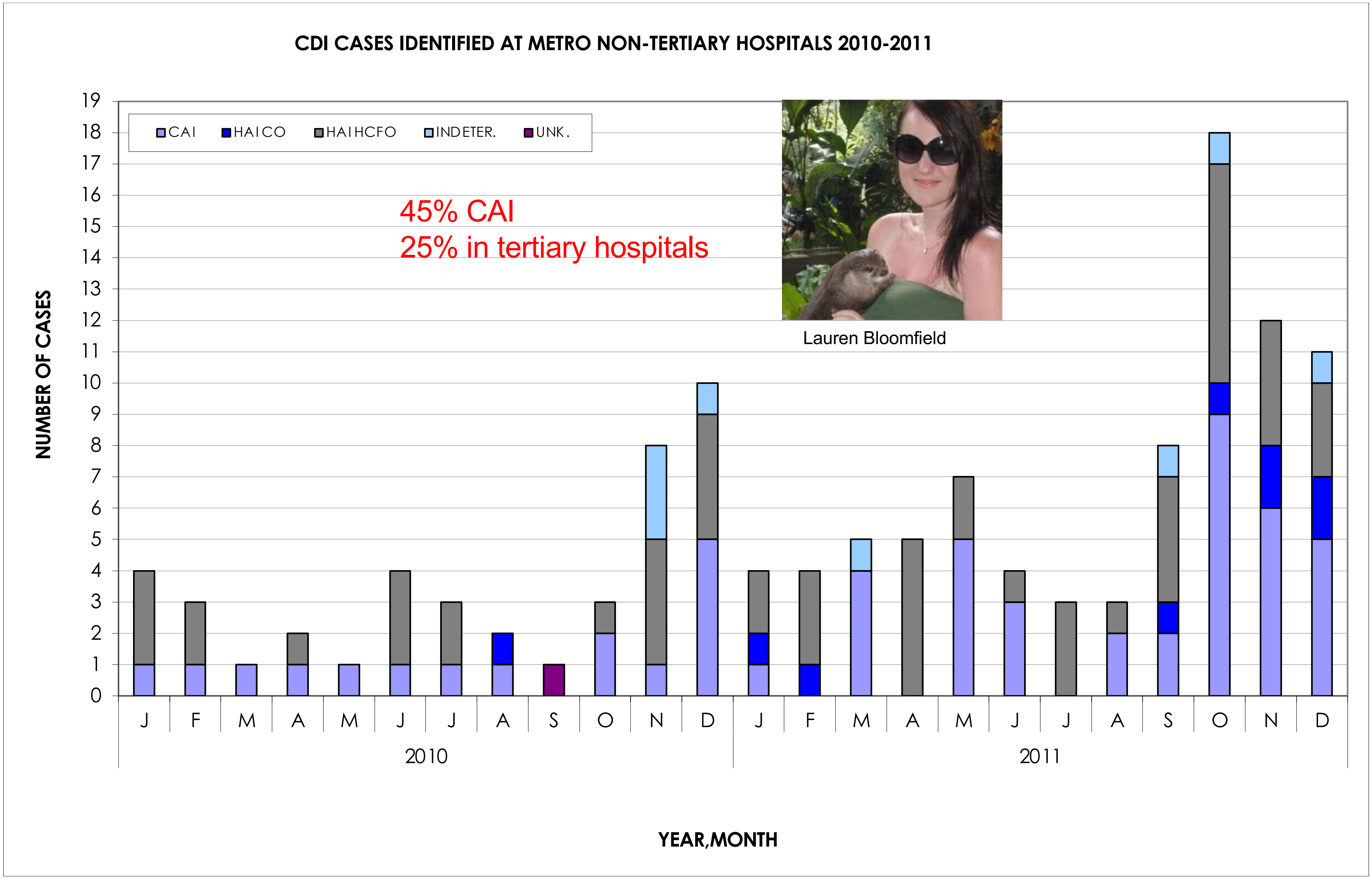
Epidemiology of Community-Acquired *Clostridium difficile*–Associated Diarrhea

Lisa R. Hirschhorn,* Yvona Trnka, Andrew Onderdonk, Mei-Ling T. Lee, and Richard Platt

Channing Laboratory, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, and Harvard Community Health Plan, Boston, Massachusetts

The epidemiology of clinically recognized community-acquired *Clostridium difficile*–associated diarrhea was assessed in a retrospective cohort study of members of a health maintenance organization (HMO). Potential cases were identified through positive toxin assay results and confirmed by review of automated full-text medical records. Of 51 cases identified (7.7 per 100,000 person-years), 42 (82%) were diagnosed and treated exclusively in the ambulatory care setting; 33 cases occurred within 42 days after 494,491 exposures to antibiotics dispensed by an HMO pharmacy. Antibiotic-specific attack rates varied from 0 to 2040 cases per 100,000 exposures. Increased age was associated with *C. difficile*–associated diarrhea ($P < .001$). Age-adjusted antibiotic-specific attack rates were at least 10-fold higher ($P < .05$) for nitrofurantoin, cefuroxime, cephalexin plus dicloxacillin, ampicillin/clavulanate plus cefaclor, and ampicillin/clavulanate plus cefuroxime than for ampicillin or amoxicillin; several other antibiotics were associated with similar but not significantly increased risks.

The Journal of Infectious Diseases 1994;169:127–33


CDI CASES IDENTIFIED AT METRO NON-TERTIARY HOSPITALS 2010-2011
CAI
HAI CO
HAI HCFO
INDETER.
UNK.
45% CAI
25% in tertiary hospitals
Lauren Bloomfield
NUMBER OF CASES
0
1
2
3
4
5
6
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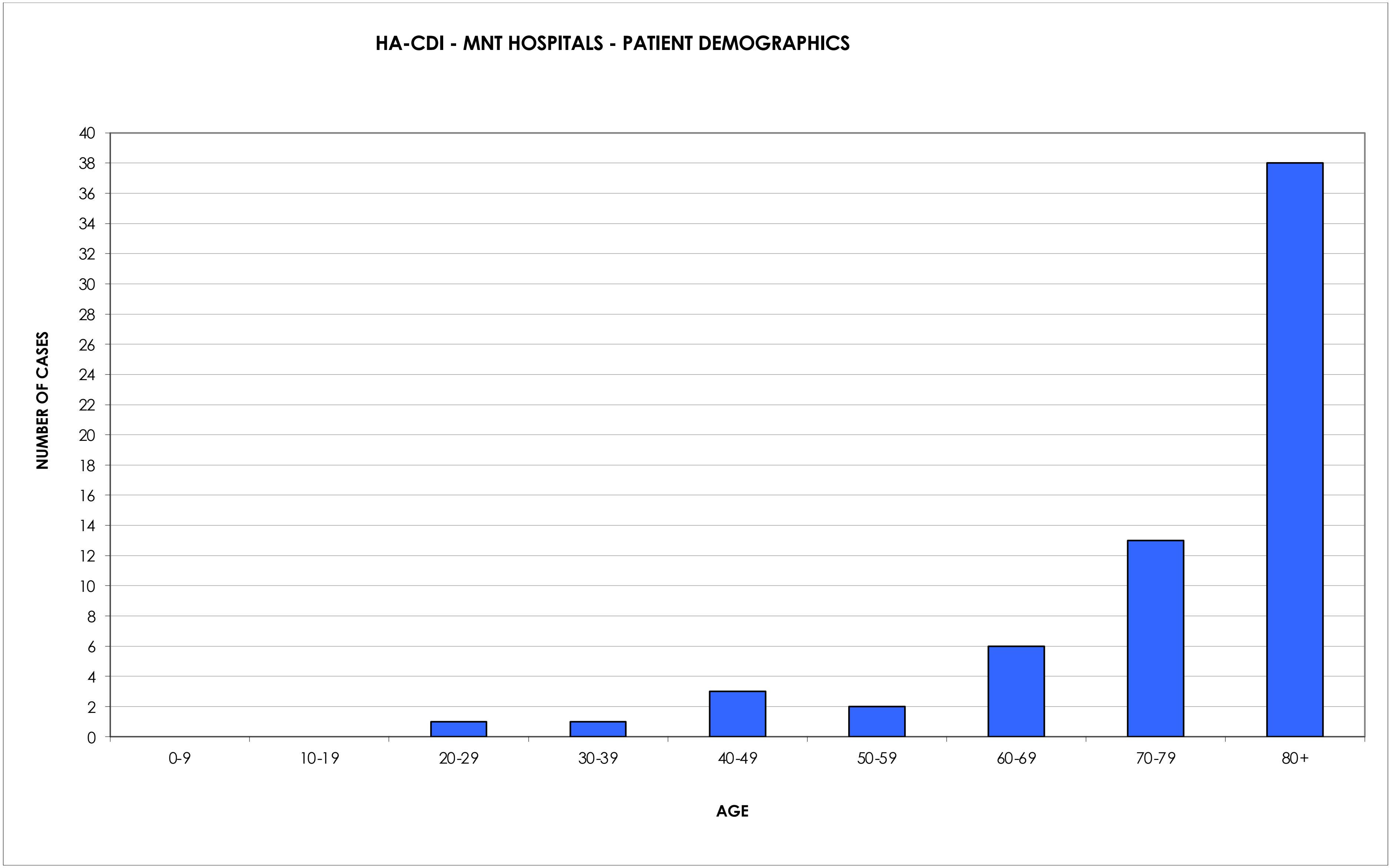
J F M A M J J A S O N D
2011
YEAR,MONTH


HA-CDI - MNT HOSPITALS - PATIENT DEMOGRAPHICS
NUMBER OF CASES
0
2
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24
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28
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32
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20-29
30-39
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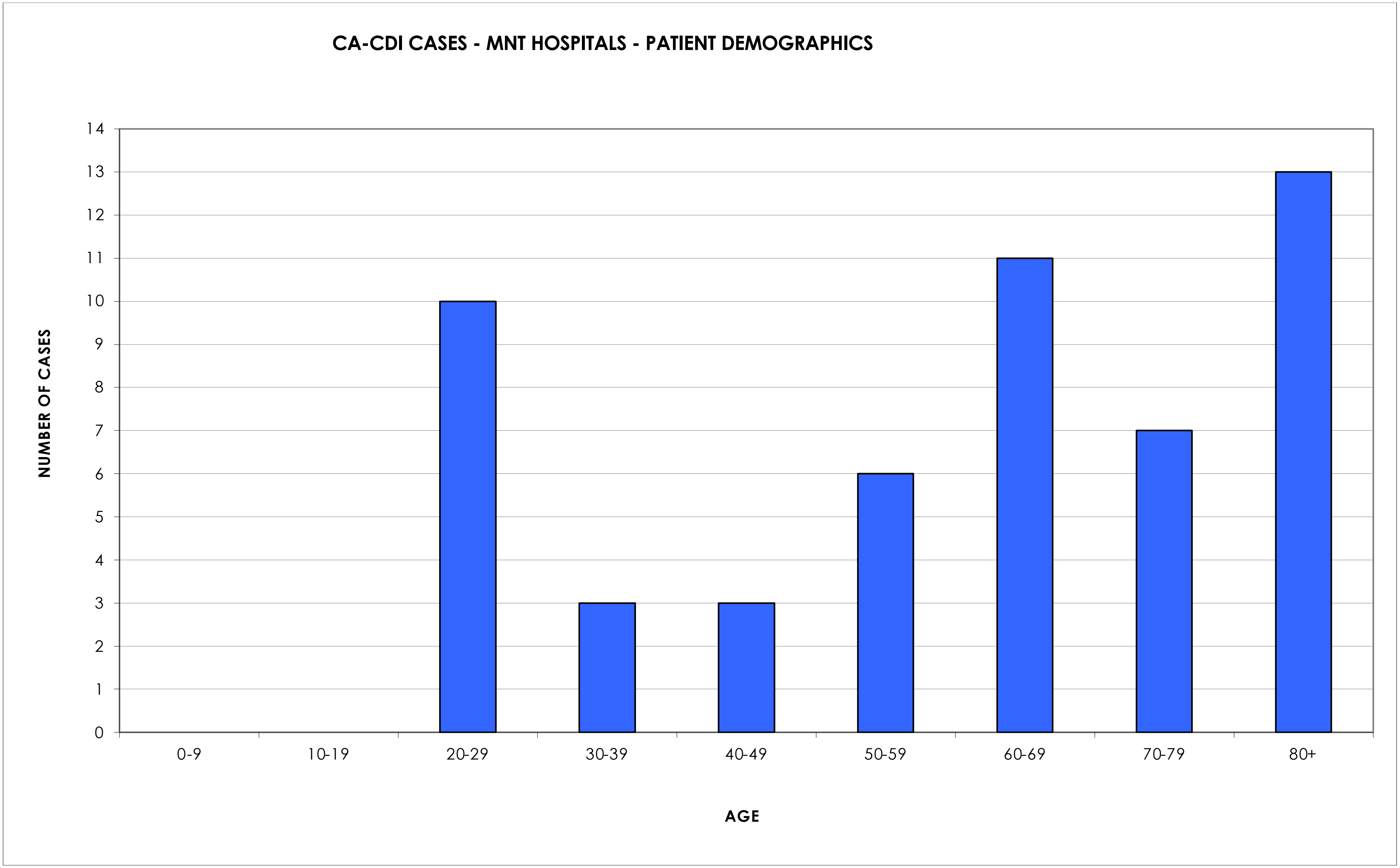
60-69
70-79
80+
AGE


CA-CDI CASES - MNT HOSPITALS - PATIENT DEMOGRAPHICS
NUMBER OF CASES
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10-19
20-29
30-39
40-49
50-59
60-69
70-79
80+
AGE

C. difficile infection in Australia

Deirdre Collins

Surveillance

- Mandatory since 2010
- Counts numbers of "hospital identified" CDI
- Includes a proportion of CA-CDI
- No requirement to determine source but many hospitals do
- But use McDonald "interim" definitions from 2007!
- No estimation of severity
- This all needs revision

Incidence:	4.00/10,000 patient days (PD)
	23.8/100,000 population
Prevalence:	7% of all diarrhoeal specimens
Mortality:	7%
Length of stay:	16.8 days
Costs:	$12,000-19,000 per case

- ➢ **>8,500 cases** per year*
- ➢ ~**600 deaths** per year
- ➢ **≥$107 million per year** in costs
- ➢ 14% of all hospital-associated infections

*This is an underestimation of case numbers in Australia, since counts are of hospital-identified CDI alone, not accounting for CDI cases detected or undiagnosed in the community.

ACSQH, 2022
Cheng et al., 2016
Putsathit et al., 2015
Collins et al., 2016
Chen et al., 2017
Bond et al., 2017

Claudia Slimings

Research

Increasing incidence of *Clostridium difficile* infection, Australia, 2011–2012

Claudia Slimings
BSc, PGDipHlthSci, PhD,
Associate Professor[1]

Global rates of hospital-associ-
ated *Clostridium difficile* infec-

Abstract

(Slimings et al Med J Aust 2014; 200: 272–276)

In some parts of the world 50% of CDI is now community-associated - ~25% in Australia in 2011/12

AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

Clostridioides difficile infection: Data snapshot report: 2020 and 2021

What do the analyses show about CDI in Australia?

In Australian public hospitals:

- separations with a CDI diagnosis increased by 29% from 2020 and 2021
- community-onset CDI (pre-existing CDI symptoms on admission) accounted for over 80% of separations
- healthcare-associated hospital-onset CDI accounted for less than 20% of all CDI diagnoses.

What do these findings mean and why are they important?

The findings from this report suggest that:

- community-onset CDI is a significant health problem in Australia
- hospital-based strategies to prevent healthcare-associated hospital-onset CDI are effective
- changes in CDI rates coinciding with the response to COVID-19 may be linked to improved IPC strategies and changes in access to healthcare during the pandemic.

AUSTRALIAN COMMISSION ON SAFETY AND QUALITY IN HEALTH CARE

D24-15872

INFORMATION
for clinicians

Clostridioides difficile infection (CDI) - Information for primary health providers

Published on
9 October 2024

CDI is a community health issue

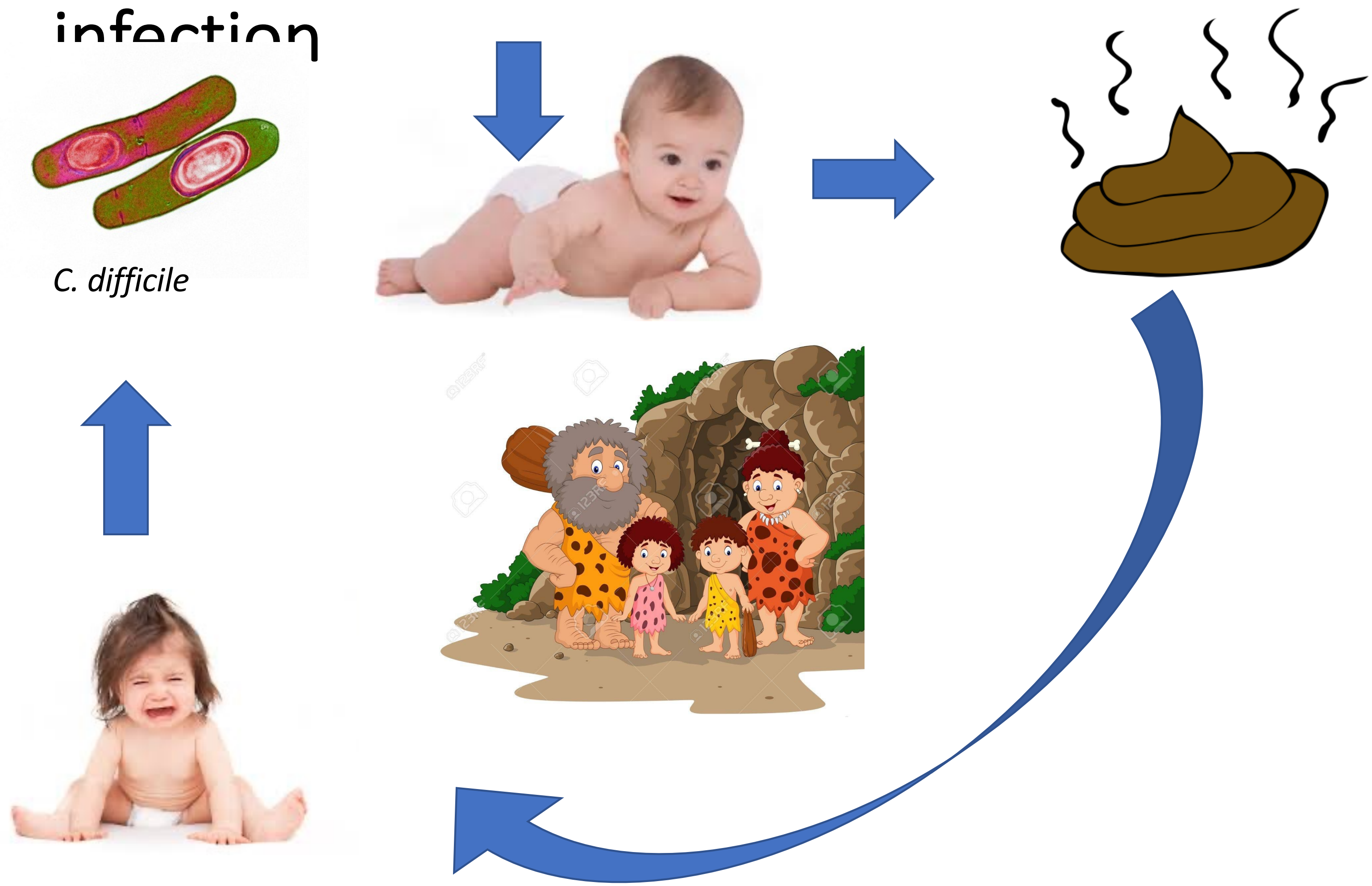
Background information for clinicians

Clostridioides difficile (*C. difficile*) is a spore-forming bacterium that causes diarrhoea, commonly after exposure to antimicrobial agents.[3] Exposure to other medications, such as proton pump inhibitors and immunosuppressant agents can independently contribute to CDI for some patients.[4, 5] *C. difficile* is typically found in the gastrointestinal tracts of many young animal species, humans, and contaminates the natural environment including agriculture and food production, as well as in built environments.[6, 7] Transmission of *C. difficile* occurs by ingestion of spores, either through person-to-person contact, or animal-to-person contact. *C.difficile* spores can also survive on environmental surfaces for extended periods of time and can be transferred from person-to person by contaminated hands or equipment.[7]

Asymtomatic carriers

- Infants
- Adults
- Healthcare workers

The natural history of *C. difficile* infection



Friedman *et al. BMC Infectious Diseases* 2013, **13**:459
http://www.biomedcentral.com/1471-2334/13/459

BMC Infectious Diseases

RESEARCH ARTICLE Open Access

Prevalence of *Clostridium difficile* colonization among healthcare workers

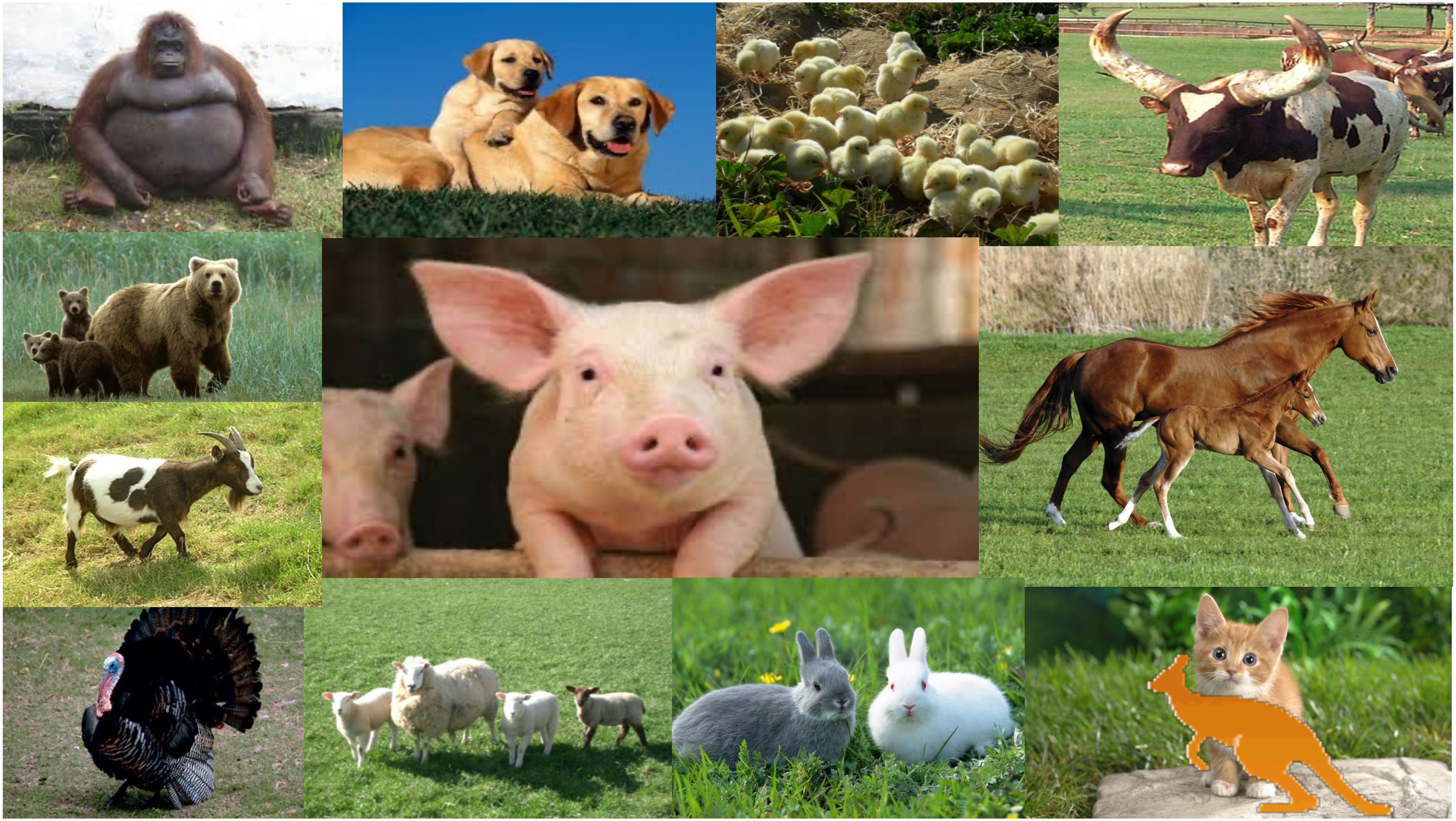
N Deborah Friedman[1*], James Pollard[1], Douglas Stupart[2], Daniel R Knight[3,4], Masoomeh Khajehnoori[5], Elise K Davey[1], Louise Parry[1] and Thomas V Riley[3,4]

Results: Among 128 healthcare workers, 77% were female, of mean age 43 years, and the majority were nursing staff (73%). Nineteen HCWs (15%) reported diarrhoea, and 12 (9%) had taken antibiotics in the previous six weeks. Over 40% of participants reported having contact with a patient with known or suspected CDI in the 6 weeks before the stool was collected. *C. difficile* was not isolated from the stool of any participants.

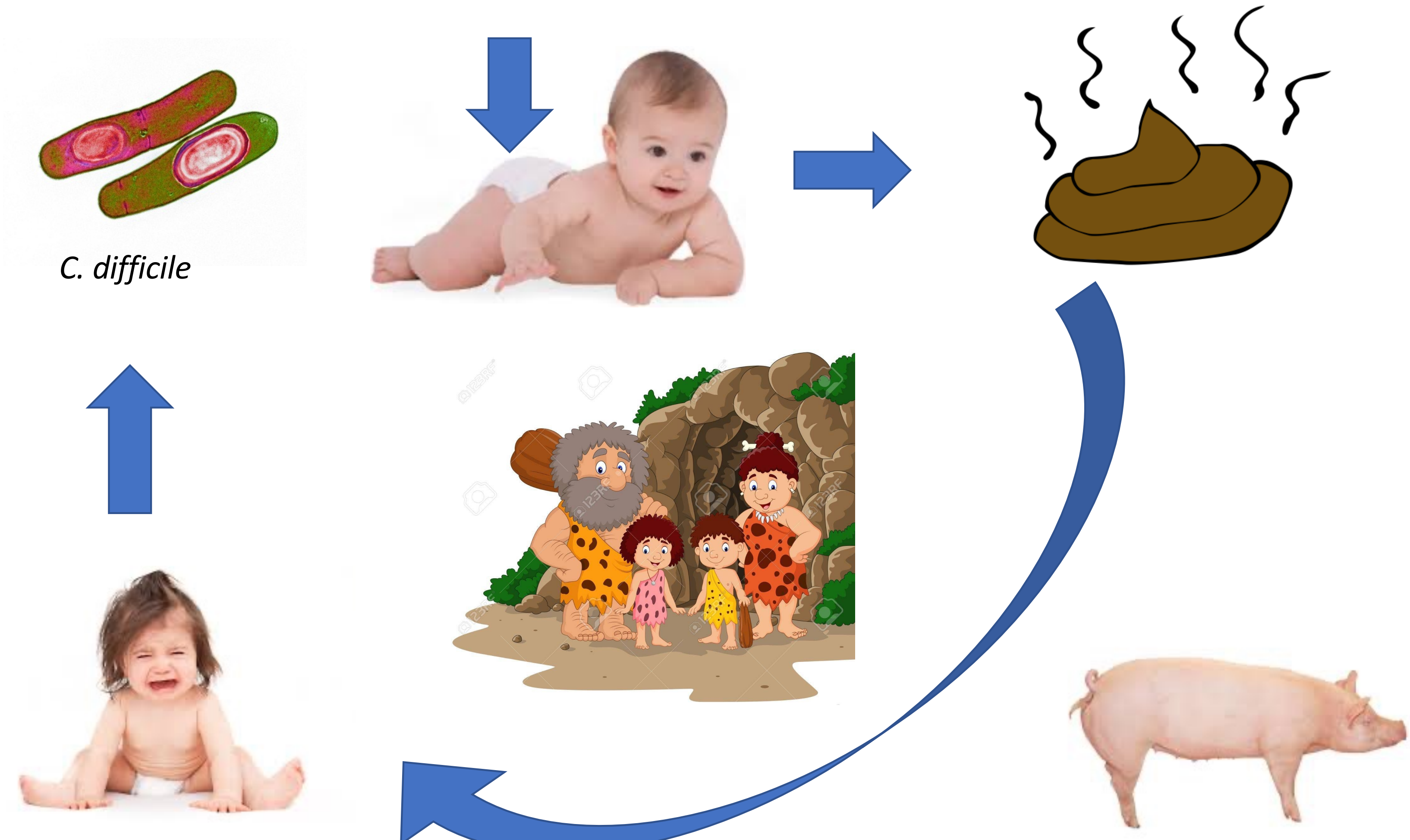
Conclusion: Although HCWs are at risk of asymptomatic carriage and could act as a reservoir for transmission in the hospital environment, with the use of a screening test and culture we were unable to identify *C. difficile* in the stool of our participants in a non-outbreak setting. This may reflect potential colonization resistance of the gut microbiota, or the success of infection prevention strategies at our institution.

Animal reservoirs

- Companion animals
- Food animals
- Horses
- Wild animals
- Reptiles
- Birds



The natural history of *C. difficile* infection



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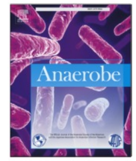


Persistence of *Clostridium difficile* RT 237 infection in a Western Australian piggery

Peter Moono [a], Papanin Putsathit [a], Daniel R. Knight [a], Michele M. Squire [a], David J. Hampson [c], Niki F. Foster [a, b], Thomas V. Riley [a, b, *]

[a] Microbiology & Immunology, School of Pathology and Laboratory Medicine, The University of Western Australia, Nedlands, Western Australia, Australia
[b] Department of Microbiology, PathWest Laboratory Medicine (WA), Queen Elizabeth II Medical Centre, Nedlands, Western Australia, Australia
[c] School of Veterinary and Life Sciences, Murdoch University, Murdoch, Western Australia, Australia

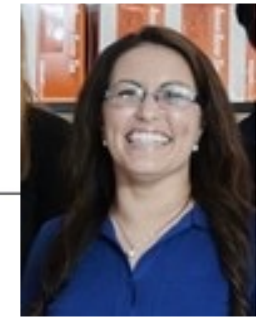
Fecal samples (n = 20) were randomly obtained from 5 piglets from each of 4 litters as described above on days 1, 7, 13 and 20, at the farrow-to-wean holding and on day 42 at the finishing site. One day before weaning, 20 piglets were ear tagged to allow follow-up at the finishing site. Among the four litters studied, two had 10 piglets each and the others had 14 piglets each.

http://dx.doi.org/10.1016/j.anaerobe.2015.11.012

Table 1
Diarrhea and *C. difficile* shedding over time by piglets in relation to their age.

Variable	[a] *C. difficile* positive		
	[b]D+	[c]D−	[d]Total
Intercept			
Day 1	2	6	8
Day 7	3	7	10
Day 13	4	0	4
Day 20	0	0	0
Day 42	0	0	0
Litter size			
Mortality	7	2	9

microorganisms



Article

Genomic Analysis of *Clostridioides difficile* Recovered from Horses in Western Australia

Natasza M. R. Hain-Saunders [1], Daniel R. Knight [2,3], Mieghan Bruce [1,4], David Byrne [4] and Thomas V. Riley [1,2,3,5,*]

Overall totals:	**387**	**123**	**31.8%**
No GI signs	336	104	30.9%
Foals 4–12 months	15	7	46.7%
Adults > 12 months	321	97	30.2%
GI signs	51	19	37.2%
Foals 4–12 months	5	3	60.0%
Adults > 12 months	46	16	34.8%

Of the 123 horses that *C. difficile* was isolated from, 68 (55.3%) harboured one or more toxigenic strains. In total, 95 of the 148 strains isolated (64.2%) contained *tcdA* and *tcdB* genes (A+B+), with 1 additional strain also possessing the binary toxin genes *cdtA* and *cdtB* (CDT+).

A combination of novel (42.6%) and previously described (57.4%) *C. difficile* RTs were identified

Dan Knight

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+ but no RT078

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

The NGO Eurogroup for Animals (2021) estimated that in 2019, over 1.6 billion livestock (mainly ovine, bovines, poultry and pigs) were transported alive across the EU and beyond its borders by road, sea, rail, and air for trade purposes.

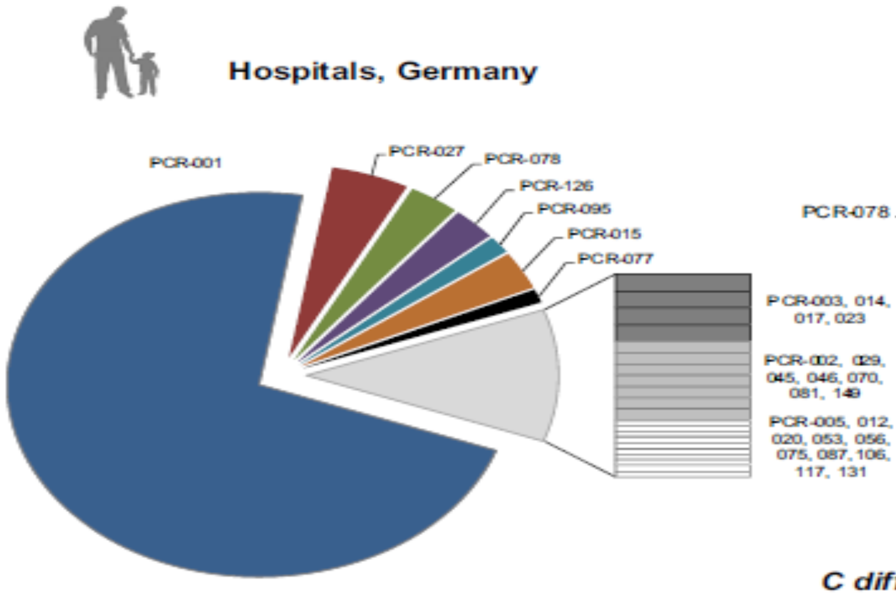
Animal transport as regulated in Europe: a work in progress as viewed by an NGO

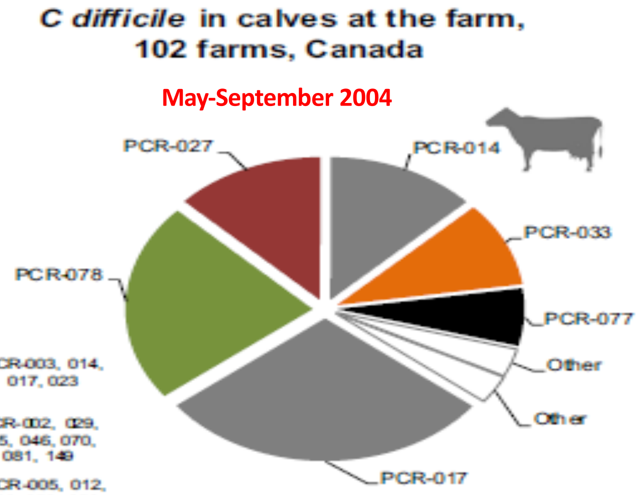
Nikita Bachelard

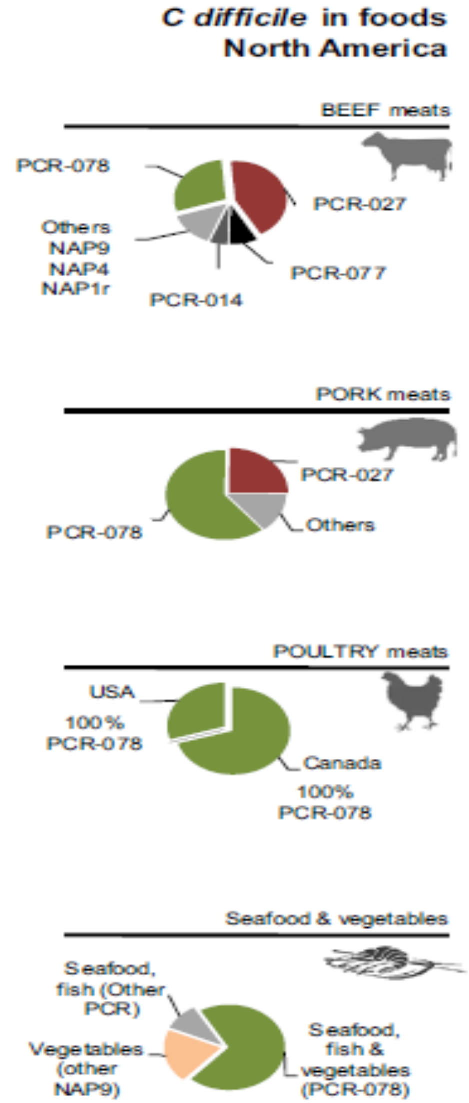
La Fondation Droit Animal, Ethique et Sciences (LFDA), Paris, France

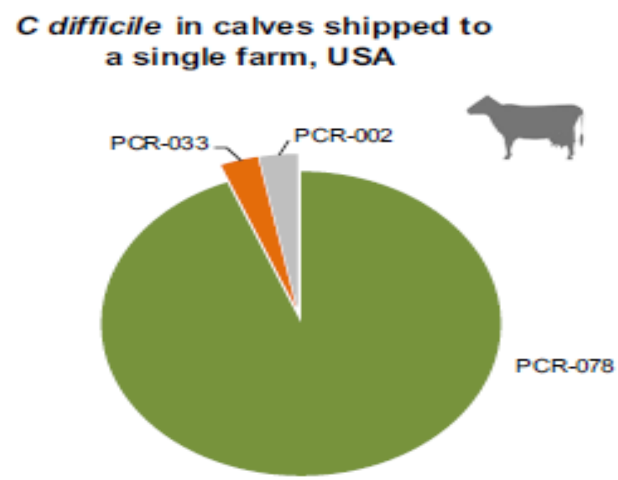
Animal Frontiers, Volume 12, Issue 1, February 2022, Pages 16–24, https://doi.org/10.1093/af/vfac010

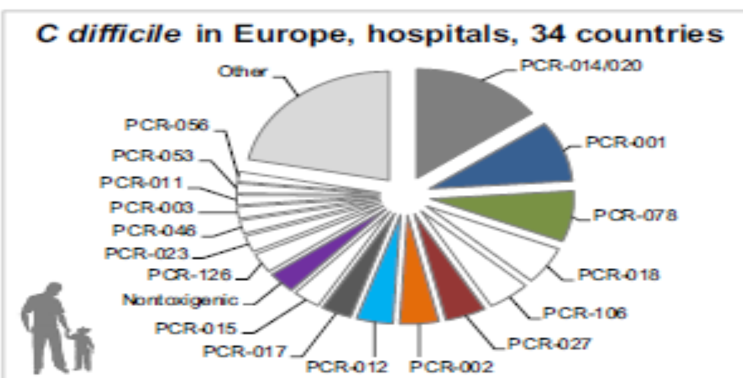
Food sources



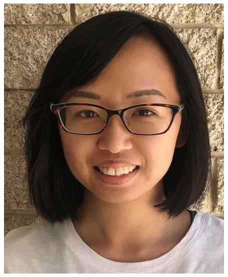








Infect Dis Clin N Am 27 (2013) 675–685



Su-Chen Lim

Journal of Applied Microbiology 124, 585–590 © 2017

Journal of Applied Microbiology

Journal of Applied Microbiology ISSN 1364-5072

ORIGINAL ARTICLE

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

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

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)

	Toxin gene profile			
PCR ribotype	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

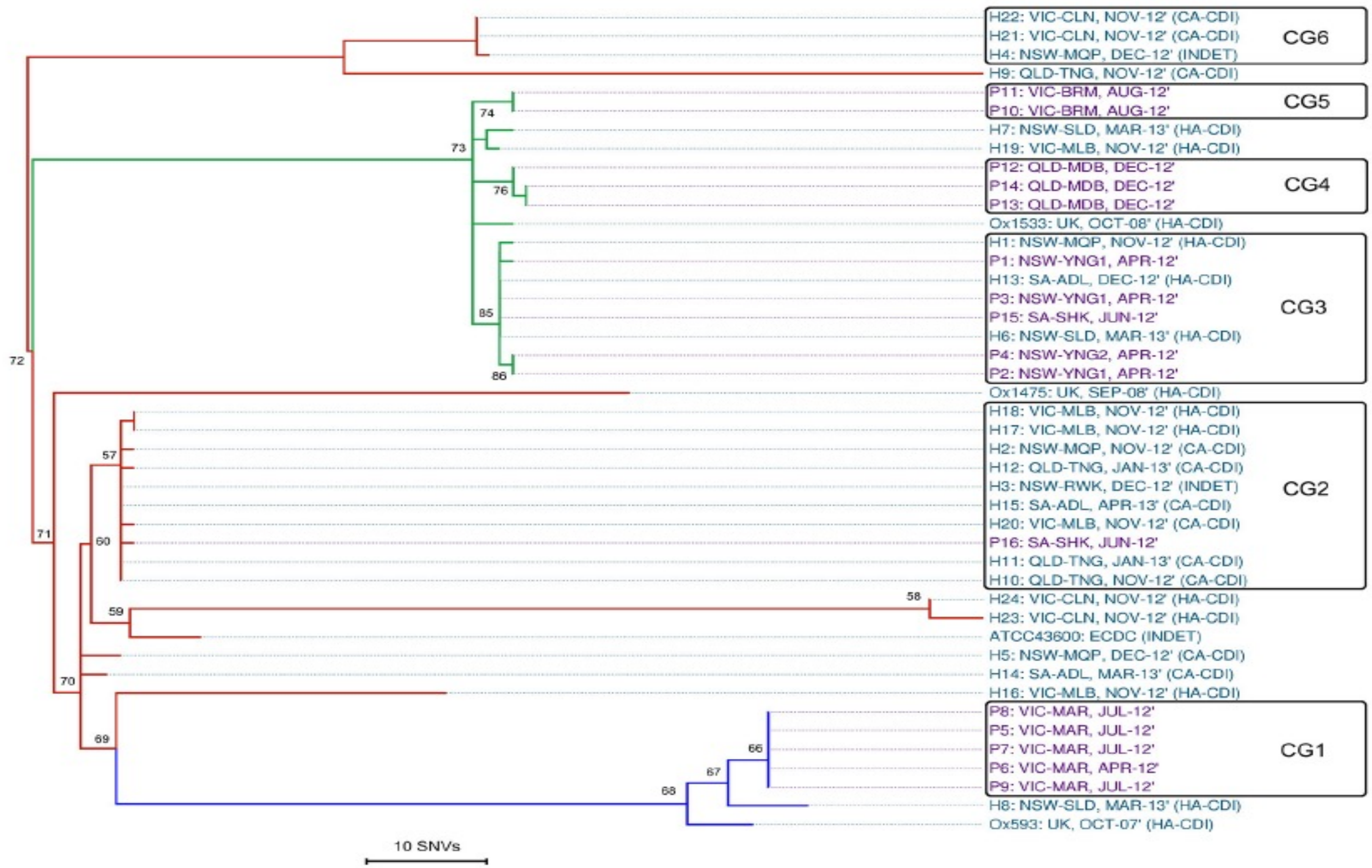


FIGURE 3 | Single nucleotide variant analysis of 44 *C. difficile* RT014.

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
doi: 10.3389/fmicb.2016.02138

Environmental sources

- Soil
- Water
- Wastewater
- Gardens – home
- Gardens – vegetable (home or commercial)
- Parks

October 2023 Volume 89 Issue 10

AMERICAN SOCIETY FOR MICROBIOLOGY | Applied and Environmental Microbiology

Environmental Microbiology | Full-Length Text

Biogeographic distribution and molecular epidemiology of *Clostridioides* (*Clostridium*) *difficile* in Western Australian soils

Karla Cautivo-Reyes,[1] Daniel R. Knight,[2,3] Deborah Bowie,[4] Benjamin Moreira-Grez,[4] Andrew S. Whiteley,[5] Thomas V. Riley[1,2,3,6]

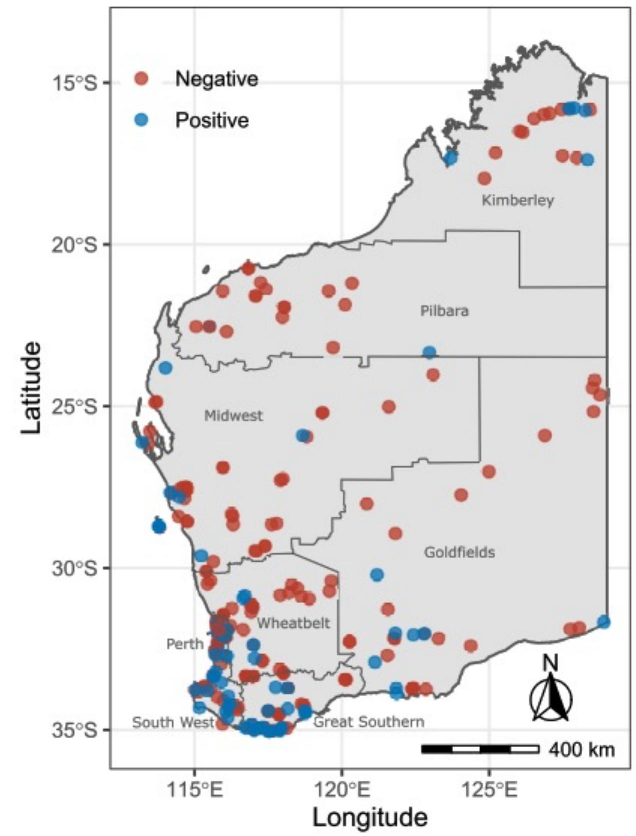


FIG 1 Biogeographic distribution of *C. difficile* positive soil samples (n = 100/321)

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High Prevalence of *Clostridium difficile* in Home Gardens in Western Australia

Nirajmohan Shivaperumal,[a] Barbara J. Chang,[a] Thomas V. Riley[a,b,c,d]

TABLE 1 Overview of sampling locations, types, months, *C. difficile*-positive samples, and differences between direct culture and enrichment

				Enrichment broth		Direct culture		
Post code	Sampling date (mo-day)	Sample type	No. of samples	House positive	% positive	House positive	% positive	Ribotype(s)[a]
6006	Jun-18	Soil, soil, manure, shoe	4	3	75	1	25	QX 597, 010, 014/020, 103
6009	Jun-18	Soil, soil, manure, shoe	4	3	75	1	25	QX 638, QX 601, QX 639, 010
6010	May-18	Soil, compost, manure, soil, shoe	5	2	40	0	0	125, QX 639, 039
6014	Jun-18	Soil, compost, manure, shoe	4	4	100	4	100	056, 125, 076, QX 189
6018	Jun-18	Soil, compost, manure, shoe	4	4	100	3	75	054, Unique, 125, 056
6019	May-18	Soil, compost, soil, shoe	4	1	25	0	0	QX 077
6020	Jun-18	Soil, soil, soil, shoe	4	3	75	1	25	125, 014/020, 051
6024	Jun-18	Soil, compost, manure, shoe	4	2	50	2	50	125, 014/020, QX 597, 125
6026	Jun-18	Soil, soil, soil, soil, soil, compost, compost, manure	8	6	75	4	50	010, 081, 014/020, 051
6054	Jun-18	Soil, soil, soil, shoe	4	4	100	3	75	QX 597, 014/020, 286, 125
6059	Jun-18	Soil, compost, soil, shoe	4	3	75	1	25	125, Unique, 286, 010, 014/020
6062	Jun-18	Soil, soil, soil, shoe	4	4	100	0	0	010, 287, 014/020
6066	Jun-18	Soil, compost, manure, shoe	4	3	75	3	75	QX 141, 125014/020
6066	Jun-18	Soil, compost, manure, shoe	4	3	75	2	50	106, 125, 014/020
6076	Jun-18	Soil, compost, manure, shoe	4	4	100	4	100	Unique, 054, 014/020
6101	Jul-18	Soil, soil, manure, shoe	4	3	75	2	50	051, 125
6112	Jun-18	Soil, soil, soil, shoe	4	2	50	1	25	014/020
6150	Jun-18	Soil, compost, soil, shoe	4	2	50	2	50	010, 287
6151	Jun-18	Soil, compost, soil, shoe	4	3	75	2	50	014/020, 125
6162	Jun-18	Soil, soil, soil, shoe	4	0	0	0	0	0
6152	Jun-18	Soil, soil, soil, shoe	4	3	75	2	50	QX 639, QX 400, QX 637, Unique, 054
6163	Jun-18	Soil, compost, manure, shoe	4	1	25	1	25	QX 077, 125, QX 189
6163	Jul-18	Soil, compost, soil, shoe	4	2	50	1	25	51
		Total	97	65	67	40	41	

[a]QX, internally assigned ribotype; Unique, novel ribotype pattern isolated for the first time in the laboratory.

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]

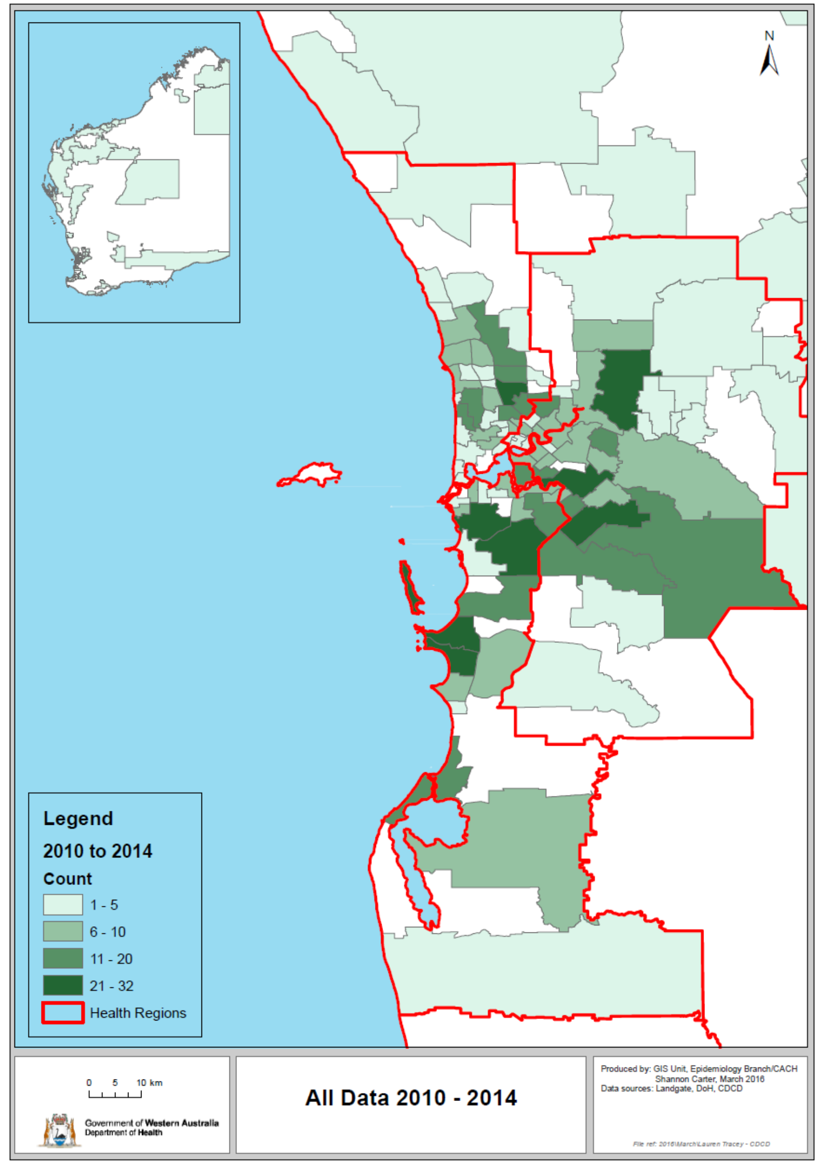
SCIENTIFIC REPORTS | 7:41196 | DOI: 10.1038/srep41196
Published: 01 February 2017

Community- and healthcare-associated infections in females in WA, by age group, 2010 – 2014

Age group	CAI n (%)	HAI HCFO n (%)	OR (CI_{95})
2 - 19 years	29 (43.9)	37 (56.1)	0.92 (0.48 – 1.76)
20 - 39 years	109 (67.2)	53 (32.7)	1.90 (1.19 – 3.05)
40 - 59 years	100 (39.3)	154 (60.6)	1.13 (0.77 – 1.67)
60 - 79 years	141 (31.8)	303 (68.2)	1.18 (0.88 – 1.58)
80+ years	116 (27.9)	300 (72.1)	0.86 (0.61 – 1.21)
Total	495 (57.0)	847 (52.8)	1.09 (0.93 – 1.30)

Maybe confounded by young families.

Food preparation
Washing, creating aerosols!
Contaminating benches
Preliminary study of 30 kitchens in affluent part of Perth - 10% positive



PREVALENCE AND MOLECULAR TYPES OF CLOSTRIDIUM DIFFICILE ON AUSTRALIAN RETAIL VEGETABLES AND HOUSEHOLD SURFACES

Deirdre A Collins[1,2], Su Chen Lim[1,2], Jessica Chisholm[2], Molly Lattin[3], Linda Selvey[3], Simon Reid[3], Thomas V Riley[1,2,4]
[1] Edith Cowan University, Joondalup, Western Australia; [2] University of Western Australia, Crawley, Western Australia; [3] University of Queensland, St Lucia, Queensland; [4] PathWest Laboratory Medicine WA, Nedlands, Western Australia

Overall prevalence of *C. difficile*

229 households

QLD n=105, WA n=124

679 sponge samples collected from chopping board, fridge/pantry and stored potatoes

2.2%

5.8%

8.8%

43 retailers

QLD n= 23, WA n=20

255 samples of peels collected from potatoes and 305 root samples of onions

35.3%

20.3%

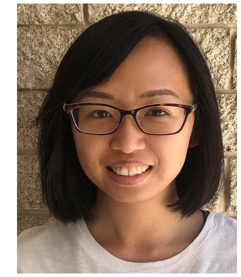
Gardening centres

~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

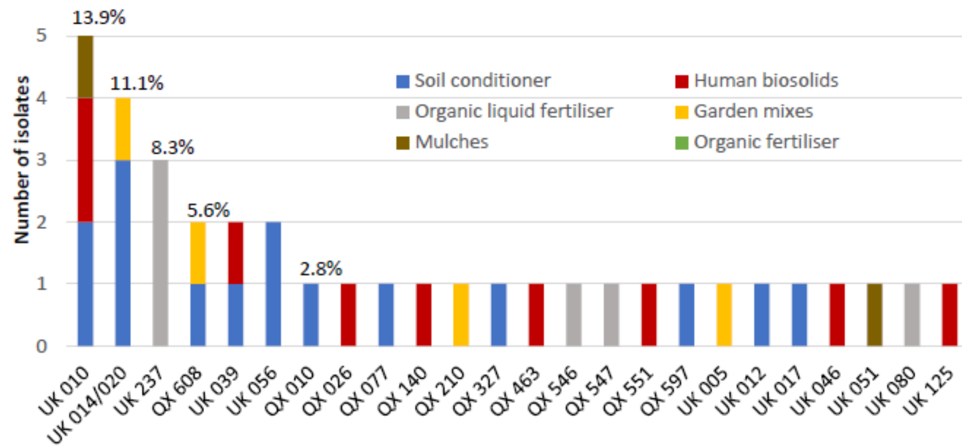


Figure 1. PCR ribotype of *C. difficile* isolates in gardening products

DOI: 10.1111/jam.15408

ORIGINAL ARTICLE

J Appl Microbiol. 2022;133:1156–1168.

Journal of Applied Microbiology sfam

Whole-genome sequencing links *Clostridium* (*Clostridioides*) *difficile* in a single hospital to diverse environmental sources in the community

Su-Chen Lim[1] | Deirdre A. Collins[1] | Korakrit Imwattana[2,3] | Daniel R. Knight[2,4] | Sicilia Perumalsamy[2] | Natasza M. R. Hain-Saunders[1,4] | Papanin Putsathit[1] | David Speers[2,5] | Thomas V. Riley[1,2,4,5]

environmental microbiology reports sfam

Environmental Microbiology Reports (2020) **12**(6), 672–680 doi:10.1111/1758-2229.12889

Brief Report

***Clostridium difficile* in soil conditioners, mulches and garden mixes with evidence of a clonal relationship with historical food and clinical isolates**

AMERICAN SOCIETY FOR MICROBIOLOGY | Microbiology Spectrum

January/February 2023 Volume 11 Issue 1

Spore-Forming *Clostridium* (*Clostridioides*) *difficile* in Wastewater Treatment Plants in Western Australia

Jessica M. Chisholm,[a] Papanin Putsathit,[b] Thomas V. Riley,[a,b,c,d] Su-Chen Lim[a,b]

TABLE 1 Characteristics of wastewater treatment plants and the prevalence of *C. difficile*

WWTP[a]	Treatment process	Final effluent receiving body	Final biosolids application	Prevalence, % (*n*)			
				Influent	Effluent	Irrigation	Biosolids
W1	Preliminary, primary, secondary	Ocean		100 (11/11)	54.5 (6/11)		
W2	Preliminary, primary, secondary, anaerobic digestion of biosolids	Ocean, groundwater	Agricultural land	100 (11/11)	75.0 (3/4)		90.0 (9/10)[b]
W3	Preliminary, primary, secondary	Woodlot/wetland		87.5 (7/8)	30.0 (3/10)		
W4	Preliminary, primary, secondary	Groundwater		90.9 (10/11)	45.5 (5/11)		
W5	Preliminary, primary, secondary	Ocean, W7	Agricultural land	81.8 (9/11)	18.2 (2/11)		100 (14/14)[c]
W6	Preliminary, primary, secondary	Groundwater		100 (10/10)	81.8 (9/11)		
W7	Microfiltration, reverse osmosis membrane	Ocean, groundwater	Agricultural land	75.0 (9/12)	0.0 (0/4)		100 (12/12)[c]
W8	Preliminary, primary, secondary	Groundwater	Agricultural land	90.0 (9/10)	60.0 (6/10)		100 (12/12)[c]
W9	Preliminary, primary, secondary, filtration, chlorination, fluoridation, ultraviolet disinfection	Sport grounds, creek		90.9 (10/11)	10.0 (1/10)		
W10	Preliminary, primary	Ocean		90.0 (9/10)	100 (4/4)		
W11	Preliminary, primary, secondary, chlorination, lime amendment of biosolids	Ocean, sport grounds	Agricultural land	90.0 (9/10)	66.7 (6/9)	40.0 (2/5)	72.7 (8/11)[d]
W12	Preliminary, primary, secondary, anaerobic digestion of biosolids	Ocean, W7	Agricultural land	90.9 (10/11)	55.6 (5/9)		100 (11/11)[b]
Total				90.5 (114/126)	48.1 (50/104)	40.0 (2/5)	94.3 (66/70)

[a]WWTP, wastewater treatment plant.
[b]Anaerobically digested biosolids.
[c]Untreated biosolids.
[d]Lime-amended biosolids.

Lessons from Australia

CDI not just a hospital issue anymore, it’s a public health issue.

Many sources of *C. difficile* other than food important (such as gardens/lawn/WWTP effluent in WA).

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

Anywhere there is animal manure there is a problem!

Antimicrobials in production animals (and horses) are driving this problem.

Need a good study of CA-CDI involving GPs.

Need a bigger, better study of food contamination.

Requires a One Health approach.

One Health

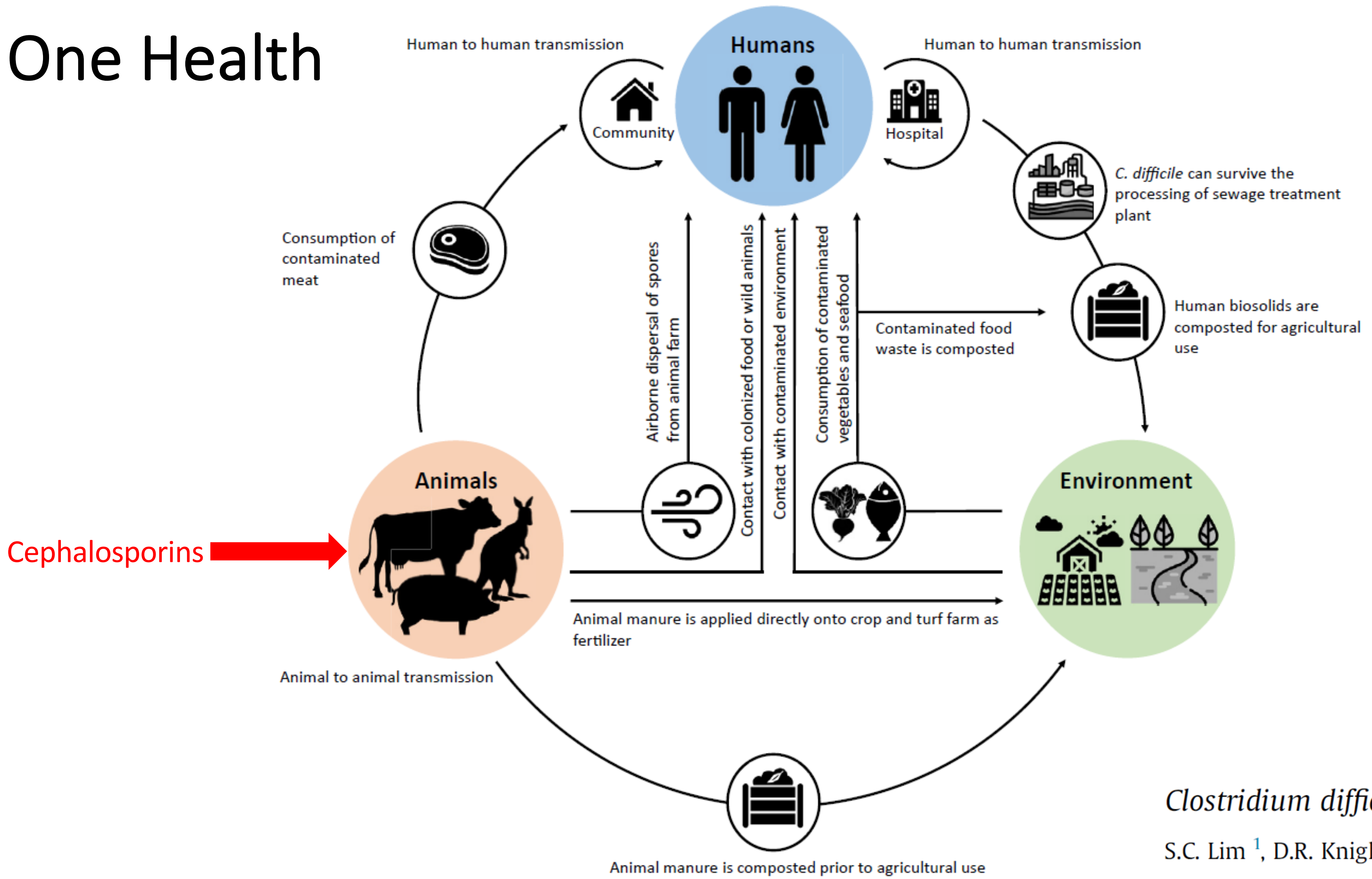
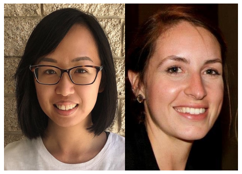


Fig. 2. Transmission of *Clostridium difficile*.

Clostridium difficile and One Health

S.C. Lim [1], D.R. Knight [2], T.V. Riley [1, 2, 3, 4, *]

Clin Microbiol Infect 2020;26:857



Following faeces: a One Health approach to reduce *C. difficile* infection

Su-Chen Lim[1,2], Deirdre Collins[1,2], Oz Sahin[3], Russell Richards[3], Damien Batstone[3], Simon Reid[3], Linda Selvey[3] and Thomas V Riley[1,2,4,5]

[1]School of Biomedical Sciences, The University of Western Australia, WA, Australia; [2]School of Medical & Health Sciences, Edith Cowan University, WA, Australia; [3]School of Public Health, The University of Queensland, QLD, Australia; [4]Medical, Molecular and Forensic Sciences, Murdoch University, WA, Australia; [5]Department of Microbiology, PathWest Laboratory Medicine, WA, Australia.

Human studies*:

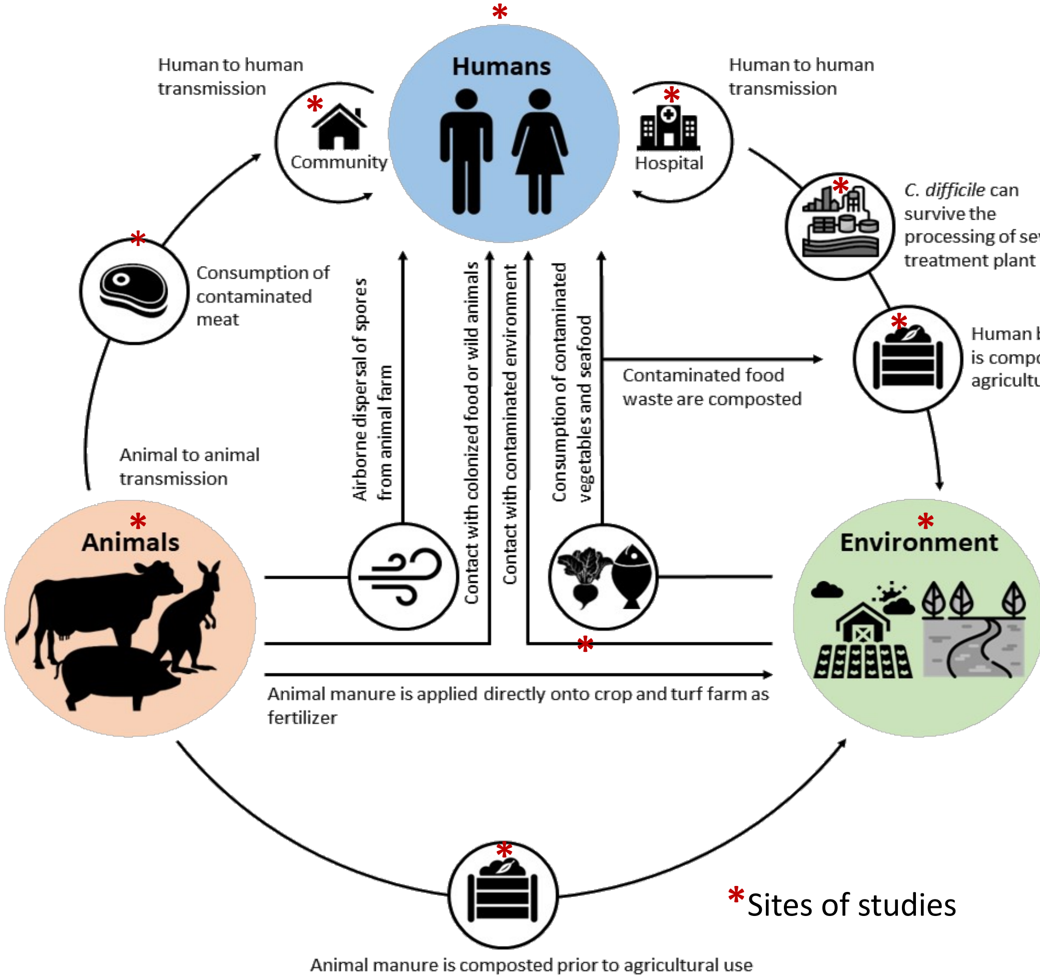
- Descriptive epi, case-control studies, identify risk factors.
- >15 years of clinical and typing data.
- CDI in cancer and CF patients.
- CDI in the community: colonisation and GP studies.

Animal studies*:

- Prevalence and molecular epidemiology of *C. difficile* in:
  - i. Animals and manure
  - ii. Soil around the farms.

Environmental studies*:

- Prevalence and molecular epidemiology of *C. difficile* in:
  - i. Wastewater and biosolids.
  - ii. Garden supplies (soil mix and soil conditioner).
  - iii. Turf.
  - iv. Retail vegetables.
  - v. Hospital bathrooms.
  - vi. Household environment.



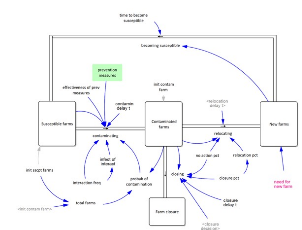
Whole genome sequencing

Disease transmission

AMR & virulence genes

↓

Use modelling to identify low-cost interventions



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Inform policies & prevent CDI

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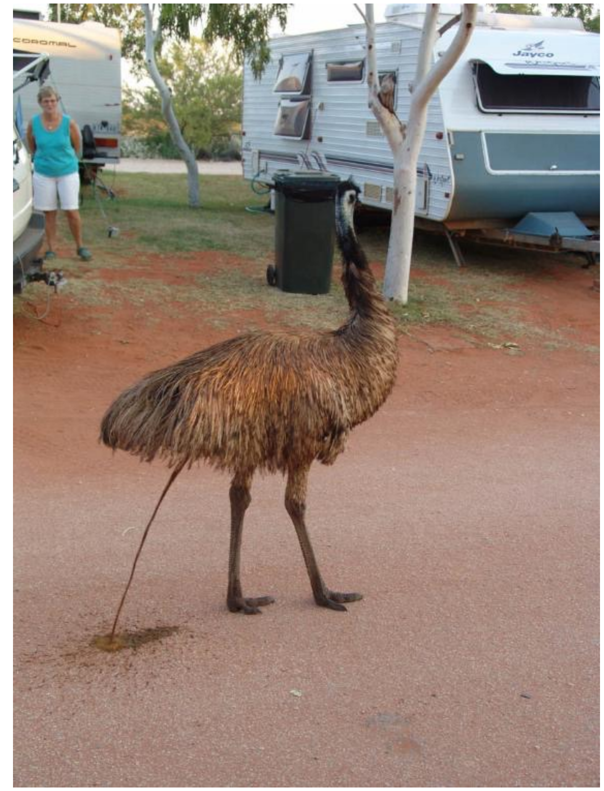
Otsuka Pharmaceuticals







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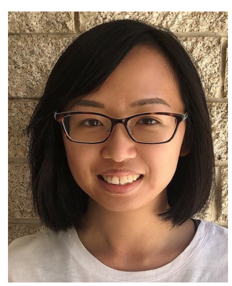


Oxford University/PHL (Derrick Crook, David Eyre, Kate Dingle)
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