

**Gut check: equine salmonellosis**

Sarah F. Colmer  
Neurology Fellow  
New Bolton Center, University of Pennsylvania  
School of Veterinary Medicine  
colms@vet.upenn.edu

ANZCVS  
EQUINE WELFARE  
2023

1

**Disclosure statement**

Presenter: Sarah F. Colmer

Disclosure:  
I do not have any relevant financial or non-financial relationships with industry or commerce to disclose

ANZCVS  
EQUINE WELFARE  
2023

2

**Salmonella - what's the big deal?**

BLOODHORSE  
Salmonella Closes New Bolton Center  
By Kimberly S. Brown  
May 13, 2004

THE HORSE  
Salmonella outbreak shuts down New Bolton Center  
July 1, 2004  
By Jennifer Fiala

New Bolton Salmonella Outbreak  
May 13, 2004 • Posted by Kimberly S. Brown  
An outbreak of multiresistant salmonella has occurred at the University of Pennsylvania's New Bolton Center that was reported to have caused an unknown number of animal deaths. The Center and its Widener Hospital closed on Monday, May 10.

ANZCVS  
EQUINE WELFARE  
2023

3

J. Vet Intern Med. 2010 Sep-Oct;24(5):1138-46. doi: 10.1111/j.1939-1676.2010.0546.x. Epub 2010 Jun 24.

**Outbreak of salmonellosis caused by Salmonella enterica serovar Newport MDR-AmpC in a large animal veterinary teaching hospital.**

Dallap-Schaer BL<sup>1</sup>, Acosta H, Rankin SC.

• Failure of  
• 61 animals  
• 54 weeks  
• Case  
• De  
re

**\$4.2 Million and a 4 Month Hospital Closure!!**

• Multid  
• Plasm  
• Profound environmental persistence  
• Hospital closure and remediation cost \$4.2 million

Slide credit:  
Barb Dallap-Schaer

ANZCVS  
EQUINE WELFARE  
2023

4

**What we learned...**

- A nosocomial outbreak resulting in hospital closure has many implications...
  - ❖ Teaching impact
  - ❖ Financial impact
  - ❖ Clinical service
  - ❖ Reputation
- It can happen to you.

Slide credit:  
Barb Dallap-Schaer

ANZCVS  
EQUINE WELFARE  
2023

5



6



7

### Salmonella – what’s the big deal?

- One of the most common causes of epidemic disease in veterinary hospitals
- Leading cause of life-threatening colitis
  - Diarrhea, bacteremia, subclinical infections
- Hurdes: shedding by nonclinical animals, nosocomial infections, zoonotic potential, diagnostic challenges
- **Salmonellosis:** shedding of Salmonella enterica in feces




8

### Salmonella enterica

- Gram-negative facultative anaerobe
- Colonizes small intestine, cecum, colon
- Thousands of serotypes (>2500)
  - Determined by variable surface antigens
  - O (polysaccharide) and H (flagella filament)
- Trends of increasing resistance

> Appl Environ Microbiol. 2018 Jun 18;84(13):e02829-17. doi: 10.1128/AEM.02829-17. Print 2018 Jul 1.

#### Serotype Diversity and Antimicrobial Resistance among Salmonella enterica Isolates from Patients at an Equine Referral Hospital

W Leahy<sup>1</sup>, S D Laflour<sup>1</sup>, K N Norman<sup>2</sup>, D S Threlkitt<sup>1</sup>, N Ohta<sup>1</sup>, J Vivasco<sup>3</sup>, H M Scott<sup>4</sup>

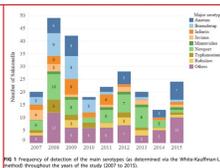


Fig 1. Frequency of detection of the main serotypes (as determined on the White-Kaufman-Letterer method) throughout the years of the study (2007 to 2017).



9

### Salmonella transmission

- Fecal-oral
- Ubiquitous in environment
- Fomite- and caretaker-spread
- Contaminated feedstuffs/water
- Opportunist
  - Increased susceptibility
  - Increased dose





10

### Equine epidemiology

#### Salmonella in Horses

Review > Vet Clin North Am Equine Pract. 2023 Apr;39(1):25-35. doi: 10.1016/j.cveq.2022.11.005. Epub 2023 Feb 1.

Brandy A Burgess<sup>1</sup>

- Extremely variable between health status, season, geographic region
- **Healthy** horses in genpop: ~0.8%
- Horses **admitted** to hospital: ~0.5-7% (admit through hospitalization)
- In North America, seasonality: late summer, early fall > springtime
- Climate: warmer and wetter > cooler and dryer regions



11

### Shedding risk factors

#### Salmonella in Horses

Review > Vet Clin North Am Equine Pract. 2023 Apr;39(1):25-35. doi: 10.1016/j.cveq.2022.11.005. Epub 2023 Feb 1.

Brandy A Burgess<sup>1</sup>

- **Infectious agent**
  - Serovar – influences time to shedding (~1-5 days; variable)
- Dose
- Environmental persistence (months to years!)
  - Damp environments
  - Organic debris




12

### Shedding risk factors

**Salmonella in Horses**  
Brandy A Burgess<sup>1</sup>

- The host**
  - Classic triad: diarrhea, fever, leukopenia → shedding
    - Pyrexia 1.5 days, diarrhea 1.7 days, shedding 1.3 days
    - Probably already shedding when they become febrile/diarrhea-ridden**
    - Systemic illness attributed to shedding (regardless of body system)



Review: J Vet Clin North Am Equine Pract. 2023 Apr;39(1):25-35. doi: 10.1016/j.cveq.2022.11.005. Epub 2023 Feb 1.

13

### Shedding risk factors

**Risk factors for fecal shedding of Salmonella from horses in a veterinary teaching hospital**  
Catherine A Aksoy<sup>1</sup>, Michael P Ward, Laurent L Coulib, Qing Cheng Wu

- The host**
  - Severity of disease may not influence shedding
  - Potential increase of shedding with GI disease
    - Estimated shedding prevalence: 4.3-13%
    - Consider managing separately from genpop
  - ICU patients – perfect storm
  - Foals
  - Antimicrobials?

**Risk factors associated with fecal Salmonella shedding among hospitalized horses with signs of gastrointestinal tract disease**  
Nicola P O'Neil<sup>1</sup>, Sarah S Hernandez, Robert J Morley, Murray P Brown, Jack M Quinn, Aidan O'Quinn, Steven O'Connell, Patrick T Conboy, Mark R Trethewey, Gregory H Holmes, Ian McMillan, Neil C O'Boyle

**Factors associated with Salmonella shedding among equine colic patients at a veterinary teaching hospital**  
Liz Kay<sup>1</sup>, P S Morley, C L Treth-Geary, M G Salmer, C Denney-Meads

**Salmonella in Horses**  
Brandy A Burgess<sup>1</sup>

Review: J Vet Clin North Am Equine Pract. 2023 Apr;39(1):25-35. doi: 10.1016/j.cveq.2022.11.005. Epub 2023 Feb 1.

14

### Shedding risk factors

**Salmonella in Horses**  
Brandy A Burgess<sup>1</sup>

- Duration of shedding**
  - Early report: ~30 days
  - More recently:
    - Clinical: 54 days median (14-121 days)
    - Subclinical: 31 days median (4-138 days)



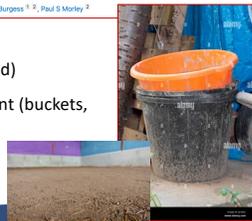
Review: J Vet Clin North Am Equine Pract. 2023 Apr;39(1):25-35. doi: 10.1016/j.cveq.2022.11.005. Epub 2023 Feb 1.

15

### Shedding risk factors

**Risk factors for shedding of Salmonella enterica among hospitalized large animals over a 10-year period in a veterinary teaching hospital**  
Brandy A Burgess<sup>1</sup>, Paul S Morley<sup>2</sup>

- Environment**
  - Damaged floors
  - Porous surfaces (unsealed concrete, wood)
  - Contamination of common-use equipment (buckets, NG tubes, rectal thermometers)
  - Association with demand on personnel?
  - Resistance to freezing



Review: J Vet Intern Med. 2019 Sep;53(3):2239-2248. doi: 10.1111/jvim.15278. Epub 2019 Aug 18.

16

### Who gets salmonella?

**Bacterial and viral enterocolitis in horses: a review**  
Francisco A Lizal<sup>1</sup>, Luis G Arroyo<sup>2</sup>, Mauricio A Navarro<sup>1</sup>, Diego E Gomez<sup>2</sup>, Javier Asin<sup>1</sup>, Eileen Henderson<sup>1</sup>

- Horses of any age
- Enteric forms may be more common in older horses
- Foals and young horses – systemic salmonellosis
- Other risk factors:
  - Transportation
  - Poor sanitation
  - Overcrowding
  - Foaling
  - Colic
  - Parasitism



Review: J Vet Diagn Invest. 2022 May;34(3):354-375. doi: 10.1177/10406387211057469. Epub 2021 Nov 11.

17

### Pathogenesis

**Bacterial and viral enterocolitis in horses: a review**  
Francisco A Lizal<sup>1</sup>, Luis G Arroyo<sup>2</sup>, Mauricio A Navarro<sup>1</sup>, Diego E Gomez<sup>2</sup>, Javier Asin<sup>1</sup>, Eileen Henderson<sup>1</sup>

- Colonization, attachment, invasion
- Large dose needed to produce septicemia ( $10^7 - 10^9$  cfu)
- Evasion of host defenses
- Intestinal mucosa and lymph nodes
- Replication in macrophages to produce septicemia



Review: J Vet Diagn Invest. 2022 May;34(3):354-375. doi: 10.1177/10406387211057469. Epub 2021 Nov 11.

18

### Pathology

Review > J Vet Diagn Invest. 2022 May;34(3):354-375. doi: 10.1177/10406387211007469. Epub 2021 Nov 11.

**Bacterial and viral enterocolitis in horses: a review**

Francisco A Lizal<sup>1</sup>, Luis G Arroyo<sup>2</sup>, Mauricio A Navarro<sup>1,3</sup>, Diego E Gomez<sup>2</sup>, Javier Asin<sup>1</sup>, Eileen Henderson<sup>1</sup>

4 5

2023

19

### Diagnosis

Review > J Vet Diagn Invest. 2022 May;34(3):354-375. doi: 10.1177/10406387211007469. Epub 2021 Nov 11.

**Bacterial and viral enterocolitis in horses: a review**

Francisco A Lizal<sup>1</sup>, Luis G Arroyo<sup>2</sup>, Mauricio A Navarro<sup>1,3</sup>, Diego E Gomez<sup>2</sup>, Javier Asin<sup>1</sup>, Eileen Henderson<sup>1</sup>

- Presumptive diagnosis:
  - Clinical signs
  - Gross findings
  - Microscopic findings
- Definitive diagnosis
  - Detection of *Salmonella* spp in feces, intestinal contents and/or liver of animals with CS & lesions
- Detection:
  - Culture
  - PCR assay

2023

20

### Clinical presentation and diagnosis

Image credit: Dr. Barb Dallap

2023

21

### Clinical presentation and diagnosis

- Abnormal Leukogram
  - Leukopenia
    - Neutropenia/Lymphopenia
  - Leukocytosis
- Electrolyte abnormalities:
  - Hypochloremia
  - Hyponatremia
  - +/- Hypokalemia
- Hyperlactatemia

2023

22

### Clinical presentation and diagnosis

- Ancillary diagnostics
  - Palpation per rectum
  - Ultrasonography
  - Abdominocentesis
  - Exploratory celiotomy (it happens!)

2023

23

Review > Aust Vet J. 2010 Mar;88(3):96-100. doi: 10.1111/j.1751-0813.2010.01111.x

### Rib osteomyelitis in three foals

K M Neil<sup>1</sup>, R E Charman, J R Vasey

- *Salmonella typhimurium*
  - Subcutaneous abscess
  - Feces

2023

24

> N Z Vet J. 2001 Aug;49(4):159-61. doi: 10.1080/00480169.2001.36224.

### Meningoencephalomyelitis in a foal due to *Salmonella agona* infection

J C Patterson-Kane <sup>1</sup>, F T Bain, J M Donahue, L R Harrison

- Presentation:** rib fractures, LF lameness post-dystocia
- Hospitalization:** head tilt, seizures, diarrhea; death at 7 days
- Postmortem:** Suppurative meningoencephalomyelitis, vasculitis, and numerous intralesional, gram-negative bacilli



25

AUSTRALIA




Vaccination Programme	Priming Dose	Secondary Dose	Booster Dose
Foals less than 1 year of age	From 4 months of age	4 weeks later	6 months after second dose then annually
Vaccinated pregnant mares			6 weeks before foaling
Pregnant mares not previously vaccinated	Not later than 10 weeks before foaling	Not later than 6 weeks before foaling	Annually
Non-pregnant mares not previously vaccinated	Anytime	4 weeks later	Annually

26

### Therapeutic plan

- Aggressive crystalloid resuscitation
- Volume replacement
- Current electrolyte imbalance
- Colloidal therapy (as needed)




27

### Monitoring

- Physiologic/CV status
  - HR, RR, Temperature
  - PCV, TS
  - Serum lactate
  - CVP
  - Blood pressure
- Progression of endotoxemia?
  - Mucous membrane color
  - Scleral injection
- Comfort level, GI motility, volume of diarrhea, urine production




28

### Salmonella control – NBC approach

- **Testing:** PCR with culture on PCR detections
- **Follow up testing: NOT mandatory**
  - 3 negatives at least 24 hours apart
  - Ask for “to-go bag” ahead of time
    - Contains labeled sample cups, submission forms, gloves, bags, instructions




FACULTY DIRECTORY  
Clinical Studies-New Bolton Center  
**Aliza Simeone, VMD**  
Assistant Professor of Clinical Infectious Diseases and Biosecurity

29

### Salmonella control – NBC approach

- **Keys to control:**
  - isolation/separation of high-risk animals
  - manure management
- **Housing considerations**
  - Paddock by themselves or with healthy adult friend
  - Environmental exposure GOOD for patient
  - Away from water source for others
  - Away from babies




30



Review > Vet Clin North Am Equine Pract. 2014 Dec;30(3):623-40.  
doi: 10.1016/j.cveq.2014.08.005. Epub 2014 Oct 3.

### Managing Salmonella in equine populations

Brandy A Burgess <sup>1</sup>, Paul S Morley <sup>2</sup>

- **Managing salmonella risk in the field:**
  - A survey of CO boarding facilities: only 50% managers report isolating new horses from resident horses; 6.6% isolated resident horses returning from travel
  - US operations >5 horses: 78% had nonresident horses arriving
  - Increased risk with increased operation size



37

Review > Vet Clin North Am Equine Pract. 2014 Dec;30(3):623-40.  
doi: 10.1016/j.cveq.2014.08.005. Epub 2014 Oct 3.

### Managing Salmonella in equine populations

Brandy A Burgess <sup>1</sup>, Paul S Morley <sup>2</sup>



- **Managing salmonella risk in the field:**
  - Ambulatory practitioners:
    - Maintain high levels of hygiene within practice vehicles
    - Clean multi-use equipment
    - PPE/attire changes as needed



38

Front Vet Sci. 2022 Dec 15;9:1017452. doi: 10.3389/fvets.2022.1017452. eCollection 2022.

### Willingness to adopt personal biosecurity strategies on thoroughbred breeding farms: Findings from a multi-site pilot study in Australia's Hunter Valley

Kirilly Thompson <sup>1,2</sup>, Joanne Taylor <sup>1,2</sup>, Diana Mendez <sup>3</sup>, Catherine Chicken <sup>4</sup>, Joan Carrick <sup>5</sup>, David N Durrheim <sup>1,2</sup>

TABLE 3 The top three zoonoses about which participants thought they should be aware during routine equine reproduction work.

Zoonotic disease	Mentions
Chlamydia (Chlamydia psittaci)	15
Salmonellosis	12
Hendra Virus (HeV)	10
Cryptosporidiosis	6
Leptospirosis	5
Australian bat lyssavirus (ABLV)	1
Escherichia coli	1
Dermatophytosis	1
Methicillin-resistant Staphylococcus aureus (MRSA)	1

- Salmonellosis – routine concern for workers mentioned during exit interviews
- Australian prevalence – unclear



39

Equine Veterinary Education / Volume 34, Issue 12 / pp. e554-e557  
Original Article Full Access

### Prevalence of salmonella faecal shedding in at-risk hospitalised cases in an equine hospital in New Zealand: A pilot study

H. Lambie, B. W. Sykes

- 2 year retrospective (2018-2020)
- Selection criteria: at-risk of developing salmonellosis, >=3 fecal culture PCRs
- 28 horses; prevalence = 10.7%



40

Aust Vet J. 2025 Jun;103(6):314-318. doi: 10.1111/avj.13437. Epub 2025 Mar 14.

### The prevalence, serotypes and antibiograms of Salmonella isolates on Thoroughbred stud farms in New South Wales and Victoria

S P McTernan <sup>1</sup>, J Heller <sup>1</sup>, J R Clulow <sup>1</sup>, L Gannon <sup>2</sup>, R Huang <sup>1</sup>, N Tidd <sup>1</sup>, A Blisshen <sup>2</sup>, K J Hughes <sup>1</sup>

- The objectives of this study were to:
  - Estimate the prevalence of Salmonella in stud farm horse populations
  - Determine serotypes and antibiograms for isolates
  - Determine whether seasonal, animal, farm or management factors are associated with Salmonella shedding



41

Aust Vet J. 2025 Jun;103(6):314-318. doi: 10.1111/avj.13437. Epub 2025 Mar 14.

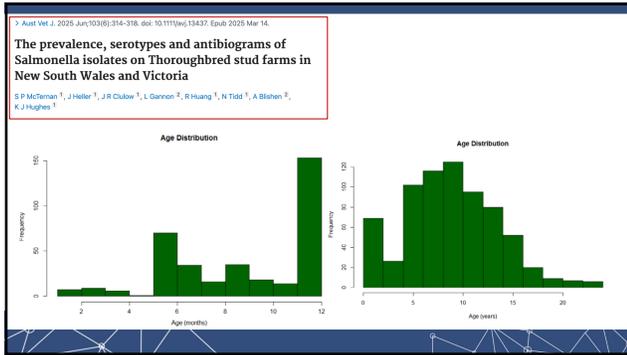
### The prevalence, serotypes and antibiograms of Salmonella isolates on Thoroughbred stud farms in New South Wales and Victoria

S P McTernan <sup>1</sup>, J Heller <sup>1</sup>, J R Clulow <sup>1</sup>, L Gannon <sup>2</sup>, R Huang <sup>1</sup>, N Tidd <sup>1</sup>, A Blisshen <sup>2</sup>, K J Hughes <sup>1</sup>

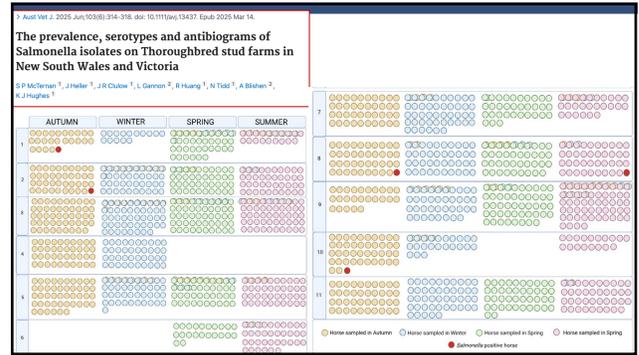
- Relatively low prevalence
- 0 MDR
- 1476 fecal samples from 1330 horses
- Salmonella isolated from 5 horses (0.4%) on four farms during summer (1) and autumn (3)
- *S. Mbandaka* (2), *S. Typhimurium* (2) and *S. Wandsbek*



42



43



44

> Russ Agric Sci. 2020;46(5):530-533. doi: 10.3103/S1068367420050158. Epub 2020 Nov 4.

**Developmental Results of a Vaccine against Salmonella-Induced Equine Abortion**

M P Neustroev<sup>1</sup>, S G Petrova<sup>1</sup>

- Inactivated vaccine based on *Salmonella abortus equi* BN-12 strain; immunomodulator
- Preclinical and clinical trials

45

> Prev Vet Med. 2025 Apr;237:106424. doi: 10.1016/j.prevetmed.2025.106424. Epub 2025 Jan 17.

**A retrospective case-control study of pregnancy failure in Thoroughbred horses in Australia**

Cara S Wilson<sup>1</sup>, Joan Carrick<sup>2</sup>, Patrick Shearer<sup>3</sup>, Jane Heller<sup>3</sup>, Victoria J Brookes<sup>4</sup>

- Retrospective, case-control study
- Hunter Valley, 2021-2022
- Early, mid and late gestation
- Annual incidence risk=5.4/100 45-day pregnancies
- Full-term losses 24% of cases

46

> Prev Vet Med. 2025 Apr;237:106424. doi: 10.1016/j.prevetmed.2025.106424. Epub 2025 Jan 17.

**A retrospective case-control study of pregnancy failure in Thoroughbred horses in Australia**

Cara S Wilson<sup>1</sup>, Joan Carrick<sup>2</sup>, Patrick Shearer<sup>3</sup>, Jane Heller<sup>3</sup>, Victoria J Brookes<sup>4</sup>

- Control mares: ~6x higher odds of being vaccinated against Salmonellosis (*Salmonella enterica* subsp *enterica* serovar Typhimurium) compared to case mares
- (OR 5.92, 95 % CI 1.2-29.7).

47

> Prev Vet Med. 2025 Apr;237:106424. doi: 10.1016/j.prevetmed.2025.106424. Epub 2025 Jan 17.

**A retrospective case-control study of pregnancy failure in Thoroughbred horses in Australia**

Cara S Wilson<sup>1</sup>, Joan Carrick<sup>2</sup>, Patrick Shearer<sup>3</sup>, Jane Heller<sup>3</sup>, Victoria J Brookes<sup>4</sup>

48

**Equine salmonellosis**

- Diarrhea, septicemia, osteomyelitis, abortion
- **Biosecurity risk** – in-hospital and on-farm!
- Difficult disease control due to non-clinical spread



49



50



51

**Questions?**  
**Sarah F. Colmer, VMD DACVIM-LAIM**  
Neurology Fellow  
New Bolton Center, University of Pennsylvania  
School of Veterinary Medicine  
[Colms@vet.upenn.edu](mailto:Colms@vet.upenn.edu)



52