Microbe of the month

Breaking The Chain of Infection

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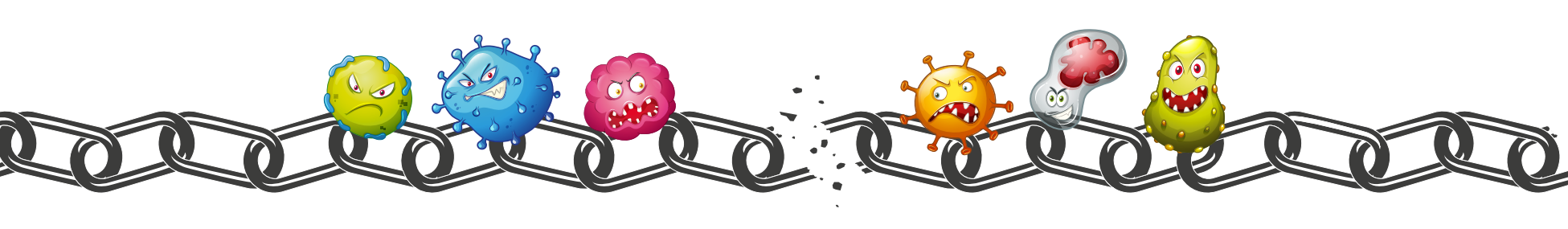

Featured this month:

Serratia marcescens

A common house guest but formidable healthcare pathogen!

Hello readers!

The aim of the Microbe of the Month newsletter is to help create awareness about microorganisms of clinical importance, in an easy to read and understand format. Each newsletter provides insights into prevalent healthcare-related pathogens and those aspects which are relevant to Infection Prevention and Control (IPC), and Antimicrobial Stewardship (AMS) practice.

Please use this newsletter as a teaching tool in your workplace, share it widely with colleagues and start an 'infectious dialogue' about topical issues in infection control!

Since the beginning of the year, I have been focusing on topics which I hope will culminate in a greater understanding and appreciation of the characteristics and innate evolutionary success of microorganisms and what this means for clinical practice and patient safety, as we approach World Antimicrobial Awareness and Resistance Week in November.

Serratia marcescens* *('ser – rah - shia' 'mar – sess - sens') is an opportunistic, Gram-negative bacillus in the large bacterial family of ***Enterobacterales****, which are commonly found in water, soil, animals, plants and insects. *(Formerly referred to as the *Enterobacteriaceae* - the taxonomy for these microorganisms was changed in 2020). Currently 14 species of *Serratia* are recognised within the genus, eight of which are associated with human infection – of these, *Serratia marcescens (S. marcescens), S. liquifaciens,* and *S. odorifera* are the best known.[1,2]

Key words: *'medieval miracles', healthcare-associated infection (HAI), opportunistic pathogen, Enterobacterales, antibiotic resistance (CRE), sources, reservoirs, outbreaks.*

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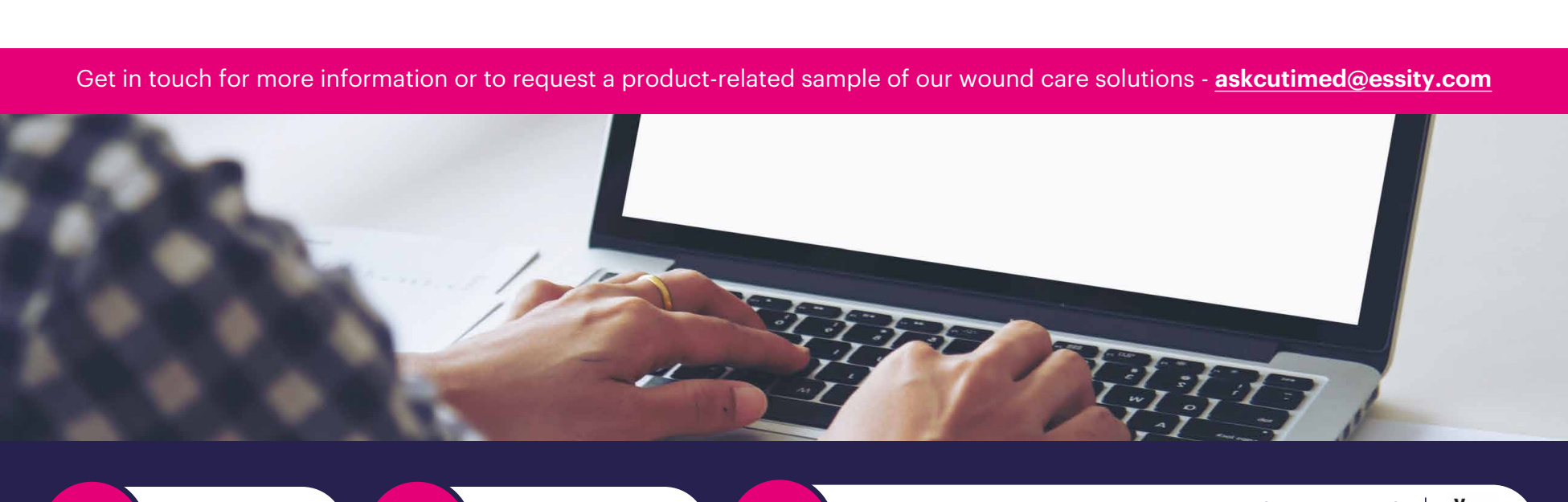

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THE HISTORY AND MICROBIOLOGY OF SERRATIA MARCESCENS [1, 3]

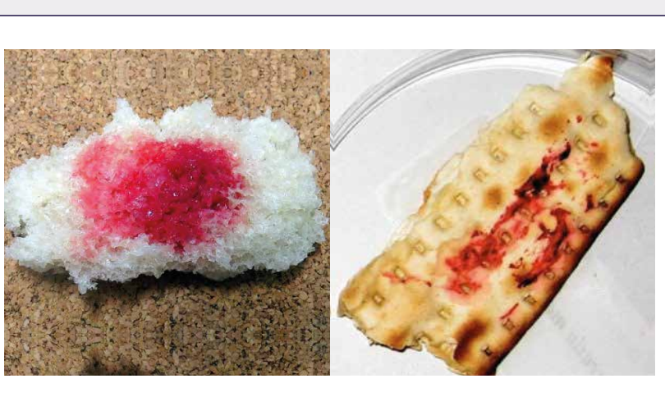
Numerous 'medieval miracles' have described the blood red pigment ('prodigiosin') produced by *S. marcescens* found growing on damp bread and sacramental communion wafers – interpreting it as a sign of blood.

In 1817, a pharmacist Bartholomeo Bizio from Padua, Italy, discovered and named *S. marcescens* as the microbial cause for the "miraculous" bloody discoloration in a cornmeal porridge called polenta.

Bizio moistened some bread and polenta and left them in a warm, damp atmosphere. Twenty-four hours later, both the bread and polenta were covered in red growth. Two years later, Bizio named *Serratia* in honour of an Italian physicist named Serrati – however, the species name *'marcescens'*, is derived from the Latin word for 'decay' or 'putrefaction'.

Due to its abundance in the environment, and its preference for damp conditions, *S. marcescens* is commonly found growing on starchy foodstuffs and in bathrooms (especially on bathroom and shower tile grout, and hand basins), where it manifests as a pink or pink-orange discoloration and slimy biofilm which feeds off phosphorus-containing materials or fatty substances such as soap and shampoo residue.

The characteristic brick red colonies of Serratia marcescens on a laboratory agar plate. The adjacent image illustrates tight clusters of the rod-shaped Gram-negative bacterium, which secretes a viscous biofilm.[3]



The red pigment 'prodigiosin' (from the Latin word 'prodigiosus' for 'miraculous, supernatural, or divine') **secreted by colonies of *S. marcescens* bacteria on bread and a sacramental communion wafer.** [3,4]

GERM WAREFARE [3,5]

- **Because *Serratia marcescens* was believed to be non-pathogenic, it was first used in 1906 as a laboratory marker to trace bacterial activity or transmission – because of its ability to produce a red pigment.**
- **Later, in the 1950s, the US government experimented with *S. marcescens*, and the harmful effects of the bacteria were revealed when a study was carried out to determine the possibility of biological weapons being transmitted by wind current.**
- **In the now famous "Operation Sea Spray ", the US Army filled balloons with *S. marcescens* and exploded them over San Francisco (*S. marcescens* was chosen because it was easily tracked by its pigment).**
- **However, there was an increase in the number of pneumonia and urinary tract infections reported in the region shortly after the experiment was conducted.**

EPIDEMIOLOGY AND PATHOGENESIS [1,3,5,6]

Until the 1950s, *Serratia marcescens* was believed to be a non-pathogenic *saprophyte* (an organism which feeds, absorbs, or grows on decaying organic matter) and was rarely isolated from human patients.

S. marcescens is a 'facultative anaerobe' (meaning that it can thrive in the presence or absence of oxygen) and optimally, grows at 37°C.

However, it can tolerate temperatures which range from 5 - 40°C, and pH levels ranging from 5 – 9. This is unusual for Gram-negative organisms, which normally prefer alkaline environments.

The unique lipopolysaccharide (LPS) membrane which surrounds Gram-negative bacilli is very cytotoxic – when Gram-negative bacteria die, the LPS from the disintegrating cell capsule acts as a potent pro-inflammatory stimulant and may cause lethal endotoxic shock.

Sources of *S. marcescens* outbreaks include contaminated medications, nebulisers, injectables and intravenous solutions, disinfectants, medical equipment, air conditioning units, soap dispensers, and the hands of healthcare workers.

The first report of *S. marcescens* healthcare-associated infections (HAIs) was an outbreak in 1951 at the Stanford University Hospital (USA). This microorganism is now recognised as a formidable pathogen, causing a wide range of serious infections including urinary tract and wound infections, osteomyelitis (intravenous drug users), septic arthritis, eye infections (e.g., corneal keratitis in contact lens wearers), endocarditis, septicaemia, and meningitis.

The mortality rate of Serratia is high and has been reported to be between 33% and 52%. *Serratia* infection linked to meningitis is rare, but its high mortality rate (45%) exceeds that of other Gram-negative bacteria, with affected patients usually surviving with neurological deficits.[2]

Patients most at risk are those with debilitating or immune-compromising disorders, those treated with broad-spectrum antibiotics, and patients in ICUs who have undergone invasive instrumentation (e.g. central vascular lines, catheters etc.). Several outbreaks in neonatal intensive care units (NICUs) have been traced to milk feeds, and contaminated equipment used to reconstitute or administer enteral feeds. [3,7]

Clinical relevance?

- **Manufacturer contamination of pre-filled heparin lock syringes:** In 2008, the U.S. Food and Drug Administration issued a nationwide recall of a pre-filled Heparin Lock Flush Solution. The Centers for Disease Control (CDC) found un-opened heparin IV flush syringes to be contaminated with *S. marcescens*, which had resulted in several bacteraemias.[3]
- **Total parenteral nutrition:** *S. marcescens* was also linked to another outbreak involving 19 cases (with 10 deaths) in Alabama in 2011. All the patients involved were receiving total parenteral nutrition (TPN) at the time, so this was cited as the likely source of the outbreak.[3]
- **Tampering with opioid-containing syringes in a post-anaesthesia care unit:** A 2017 paper by Schuppener *et al* [6] describes how a cluster of 5 patients (from different units in the hospital) developed a *S. marcescens* bacteraemia (identical strains identified by molecular typing) within 48 hours after admission. Exposure to the post-anaesthesia care unit was the common risk factor and a full narcotic diversion investigation was undertaken. A nurse working in the post-anaesthesia care unit was identified as the employee responsible for the drug diversion and was epidemiologically linked to all 5 patients in the cluster. Illicit drug use by healthcare workers remains an important mechanism for the development of bloodstream infections in hospitalised patients – therefore, proactive systems should be in place to prevent, detect, and control narcotic drug diversions and associated patient harm in the healthcare setting.

THE KILLER LURKING IN YOUR SOAP DISPENSERS!

Regardless of the **source** or **reservoir**, the main **route of transmission** of *S. marcescens* is considered to be hand-to-hand transmission by healthcare personnel. The recovery of epidemic strains of *S. marcescens* from hand cultures have been consistently reported in epidemiological studies.

In one hospital, almost 50% of hand cultures from staff were positive at the end of their working shift! Cross infection risks included nursing patients with debilitating conditions, lengthy ward stays, and exposure to frequent medical interventions and direct contact with personnel's hands. [1]

A study conducted by Sartor *et al* [8] examined the role of contamination of non-medicated liquid soap dispensers which had been 'topped up'. **Soap dispensers from 5 out of the 7 different hospital units tested were contaminated with *S. marcescens*; and after handwashing from these contaminated dispensers, healthcare workers' hands were 54 times more likely to be contaminated with *S. marcescens*.**

Similarly, an outbreak of *S. marcescens* in a neonatal intensive care unit (NICU) was investigated by Bouffet-Betallion *et al* [9] in which five infants became colonised or developed infections with identical strains of *S. marcescens*. All the infants were intubated and had percutaneous and central catheters – laboratory culture and pulse-field gel electrophoresis identified a bottle of liquid soap as the source.

Clinical significance? In both cases, it was suspected that the contents had become contaminated when air was 'sucked up' into the refillable wall-mounted dispenser and bottle respectively, when healthcare personnel 'pumped out' the liquid soap.
This potential risk is avoided by the use of sealed sachets in wall-mounted soap dispensers which do not permit 'topping up' or the entry of air during use. Additionally, there should be emphasis on the regular use of alcohol-based hand rubs in between hand washing to further reduce the risk of transmission.

ANTIBIOTIC RESISTANCE [1,2,3,5,7,10]

S. marcescens is **intrinsically resistant** to several classes of antibiotics (e.g., ampicillin, macrolides, fluoroquinolones and first generation cephalosporins).

Strains of *S. marcescens* involved in hospital and long-term care outbreaks have frequently proved to be multi-drug resistant.

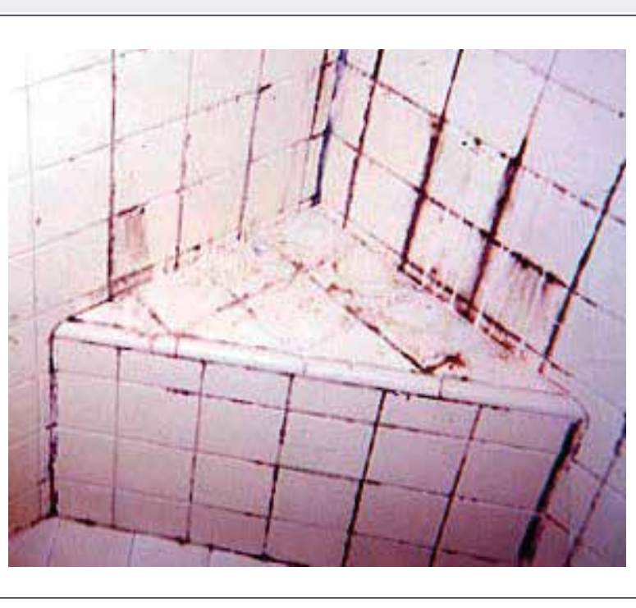
The chief mechanisms of resistance appear to be **the ability to encode genes for the production of antibiotic modifying enzymes** (these genes are on plasmids which can be transferred to other bacteria) which confer resistance to specific antibiotics, as well as sophisticated **efflux pumps** which remove toxic substances (including disinfectants) that may be fatal to the microorganism.

Infection control tips for cleaning and disinfecting bathrooms and shower cubicles [11,12]

- ✓ The use of household cleaners which are ammonia-based or contain a QAC (quaternary ammonium compound - also referred to as 'quats', e.g., benzalkonium chloride) are adequate for routine cleaning and disinfection in the home.
- ✓ The above disinfectant cleaning agents are referred to as **'low-level disinfectants'** and are appropriate for use in baths, hand basins and shower cubicles, because these are classified as **'semi-critical surfaces'.**
- ✗ **'More is not better' – never mix products!**
- ✓ 'Thick bleach' concentrates **(sodium hypochlorite pre-mixed with a pH buffered detergent by the manufacturer)** are indicated for the control and removal of fungi and biofilm growing on tile grout, especially in damp corners and the shower floor.
- ✓ 'Bleach-based' cleaners should always be diluted with COLD water, as **hot water destabilises (inactivates) chlorine!**
- ✗ Do not attempt to make your own sodium hypochlorite cleaner by mixing a bleach concentrate (e.g., 'Jik'®) with a detergent. **The alkaline pH of the detergent will inactivate the chlorine disinfectant!**
- ✓ Store cleaners in their original containers, away from heat and sunlight.
- ✗ **Never decant cleaners into other bottles!**

WARNING!

- ! Many cleaning products will irritate skin and cause rashes or serious eye injury if not used in accordance with the instructions on the container.
- ! Always use protective gloves and other **PPE** appropriate for the task, and ensure good ventilation of the area.
- ! Inhalation of the fumes may cause irritation of the nose and throat, and in some cases, respiratory distress.
- ! The two types of QAC disinfectants that most commonly cause asthma are *benzalkonium chlorides* and *didecyl dimethyl ammonium chloride*.
- ! Chlorine-based cleaners are **corrosive**, so any metal fixtures should be rinsed thoroughly after cleaning.



The typical pink or orange discolouration of damp surfaces caused by the growth of *S. marcescens*

The same shower cicle after cleaning with a thick bleach household cleaner.

THE BOTTOM LINE… [1,2,3,5,7,8,9,11]

- Patients hospitalised for extended periods, usually in an ICU, treated with invasive devices such as catheters, ventilators, and broad-spectrum antibiotics, are at the highest risk of acquiring a serious healthcare-associated infection.
- Apply alcohol-based hand rub frequently during tasks when hands are not visibly soiled, and after touching a patient, their environment, or possessions.
- Wash hands promptly after contact with infective material, and always after glove removal.
- Avoid the use of invasive devices where possible, and practice strict aseptic technique for their insertion and aftercare.
- The **'topping up'** of liquid soap dispensers (non-medicated as well as antimicrobial agents) is a dangerous practice - polymicrobial contamination of the soap solution has been implicated in many outbreaks of infection.
- **Poor cleaning, disinfection and drying** of everyday items of equipment such as wash basins, bedpans, measuring flasks, nebuliser chambers, laryngoscopes, and enteral feeding sets are common reservoirs for the growth of *S. marcescens* and similar moisture-loving pathogens (*e.g., Pseudomonas and Proteus species*).
- In the hospital and long-term care settings, clean and disinfect environmental surfaces with **a sodium hypochlorite-based detergent cleaner, using colour coded cloths and cleaning** equipment to designate different clinical areas. Frequently touched surfaces (e.g., cot sides, lockers, monitors, and light switches etc.) should be cleaned and disinfected at least once a day.
- If indwelling vascular and urinary catheters are suspected as the source of an infection, they should be removed.
- If *S. marcescens* is isolated from a non-sterile site (e.g., sputum or a wound), the interpretation of this result may be difficult, since it may be due to harmless colonisation of the site.
- A Clinical Microbiologist should always be consulted regarding appropriate antibiotic therapy for multi-drug resistant isolates and for advice in the event of an outbreak.

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