Foodborne Infections:

Know thy self, know thy enemy.

Agung Dwi Wahyu Widodo

Departemen Mikrobiologi dan Parasitologi Kedokteran,

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Subyek

- Pendahuluan
- Foodborne Disease
- Foodborne Pathogen
- Food Microbiology

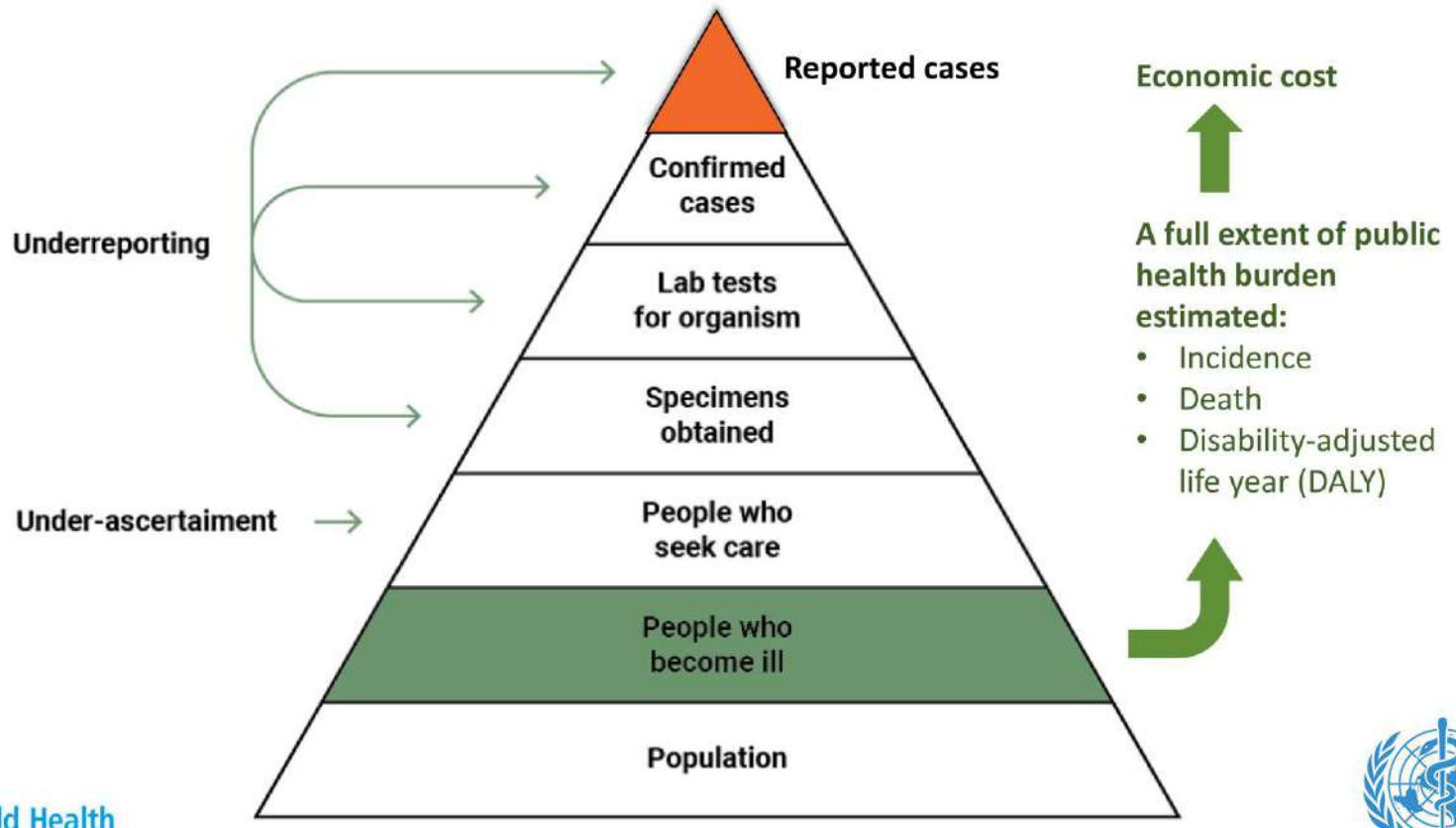
Foodborne Disease WHO 2025

WHO Estimates of the Global Burden of Foodborne Diseases 2025 edition

29 November 2024 | CAC47 Side Event
Yuki Minato, on behalf of WHO secretariat
Monitoring and Surveillance Nutrition and Food Safety (MNF) Unit
Department of Nutrition and Food Safety

World Health Organization

Ice-berg Phenomena



World Health Organization

World Health Organization

WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

Foodborne diseases in the WHO Region of the Americas

Every year

77 million people fall **ill** } **>9 000** **die**

including

31 million children <5 fall **ill** } **>2 000** **die**

Diarrhoeal diseases are responsible for 95% of foodborne illnesses in the Region

Key causes of diarrhoeal diseases:

- Norovirus
- *E. coli*
- *Campylobacter*
- Non-typhoidal *Salmonella*

FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.

For more information: **www.who.int/foodsafety**

#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

Foodborne diseases in the WHO European Region

Every year

23 million people fall **ill**

5 000 people **die**

Diarrhoeal diseases are responsible for most foodborne illnesses

Norovirus infection = almost 15 million cases

***Campylobacter* = nearly 5 million cases**

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For more information: **www.who.int/foodsafety**

#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

Foodborne diseases in the WHO Eastern Mediterranean Region

Every year

>100 million people fall **ill**

37 000 **die**

including

32 million children <5 fall **ill**

Diarrhoeal diseases are responsible for **70% of the burden of foodborne diseases**

E. coli Norovirus *Campylobacter* Non-typhoidal *Salmonella*

FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.

For more information: **www.who.int/foodsafety**

#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

Foodborne diseases in the WHO South-East Asia Region

Every year

>150 million people fall **ill** } **>175 000 die**

including

60 million children <5 fall **ill** } **50 000 die**

Diarrhoeal diseases are responsible for majority of deaths. Key causes:

- Norovirus
- Non-typhoidal *Salmonella*
- Pathogenic *E. coli*

Region has

>1/2 the people

globally who are infected and die from **typhoid fever or hepatitis A**

FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.

For more information: **www.who.int/foodsafety**

#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

Foodborne diseases in the WHO Western Pacific Region

Every year

125 million people fall **ill** } **>50 000** **die**

including

40 million children <5 fall **ill** } **7 000** **die**

Aflatoxin (caused by mould on grain) is main cause of foodborne disease deaths with **70% of all cases worldwide in this Region**

As a result **>10 000** people develop liver cancer each year

Region has highest death rate from foodborne **parasites**

FOODBORNE DISEASES ARE PREVENTABLE. EVERYONE HAS A ROLE TO PLAY.

For more information: **www.who.int/foodsafety**

#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

Foodborne diseases in the WHO African Region

Every year

>91 million people fall **ill**

137 000 people **die**

representing **1/3** of the global **death** toll for foodborne diseases

Diarrhoeal diseases are **responsible for 70%** of the burden of foodborne diseases

- Non-typhoidal *Salmonella*
- Foodborne cholera
- *E. coli*

Chemical hazards (cyanide and aflatoxin) **cause more than 3000 deaths annually**

Paralysis (Konzo) caused by cyanide in cassava, is unique to the African Region, resulting in death in **1 in 5** people affected

FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.

For more information: **www.who.int/foodsafety**

#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

Foodborne Disease

World Health Organization

- **Over 200 diseases are caused by eating food contaminated with bacteria, viruses, parasites or chemical substances such as heavy metals**. This growing public health problem causes considerable **socioeconomic impact** though strains on health-care systems lost productivity, and harming tourism and trade. These diseases contribute significantly to **the global burden of disease and mortality**.
- **Foodborne diseases are caused by contamination of food and occur at any stage of the food production, delivery and consumption chain.** They can result from several forms of environmental contamination including pollution in **water, soil or air, as well as unsafe food storage and processing**.
- **Foodborne diseases encompass a wide range of illnesses from diarrhoea to cancers**. Most present as gastrointestinal issues, though they can also produce neurological, gynaecological and immunological symptoms.
- **Diseases causing diarrhoea** are a major problem in all countries of the world, though the burden is carried disproportionately by low- and middle-income countries and by children under 5 years of age.

WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

Diarrhoeal diseases are the most common illnesses resulting from unsafe food

Diarrhoeal diseases are responsible for:

1/2
global burden of foodborne diseases caused by 31 hazards

Key global causes of diarrhoeal diseases:

- Norovirus
- *E. coli*
- *Campylobacter*
- Non-typhoidal *Salmonella*

550m
people falling **ill**
230 000
deaths

including
220m
children <5 falling **ill**
96 000
of whom **die**

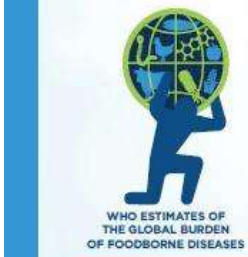
FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.

For more information: **www.who.int/foodsafety**

#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization



The burden of foodborne diseases is substantial

Every year foodborne diseases cause:

almost **in 10** people to fall ill

33 million healthy life years lost

Foodborne diseases can be deadly, especially in children <5

420 000 deaths

Children account for **1/3** of deaths from foodborne diseases

FOODBORNE DISEASES ARE PREVENTABLE. EVERYONE HAS A ROLE TO PLAY.

For more information: **www.who.int/foodsafety**

#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

Foodborne diseases are a major global public health concern

Foodborne diseases are caused by types of:

Bacteria | Viruses | Parasites | Toxins | Chemicals

Some of these are a public health concern across all regions
Others are much more common in middle- and low-income countries

But in a **globalized world** they can **spread quickly** along the food chain and **across borders**

FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.

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#SafeFood

Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

WHO ESTIMATES OF THE GLOBAL BURDEN OF FOODBORNE DISEASES

Key foodborne diseases and hazards

Bacteria:

- ***Listeria*** can result in blood poisoning and meningitis, and is usually spread by consuming contaminated raw vegetables, ready-to-eat meals, processed meats, smoked fish or soft cheeses.
- ***Brucella***, commonly from unpasteurized milk or cheese of infected goats or sheep, can cause fever, muscle pain or more severe arthritis, chronic fatigue, neurologic symptoms and depression.
- **Cholera** can be caused by consuming food contaminated with *Vibrio cholerae*. It causes watery diarrhoea that can be fatal within hours if left untreated.

Virus:

- **Hepatitis A** is a liver disease caused by the hepatitis A virus, transmitted through food contaminated by the faeces of an infected person. It causes jaundice, nausea, anorexia, fever, malaise and abdominal pain.

Parasites:

- **Toxoplasmosis**, caused by *Toxoplasma gondii*, spread through undercooked or raw meat and fresh produce, can result in impaired vision and neurological conditions.
- **Pork tapeworm** (*Taenia solium*) can cause cysts to develop in the brain (cysticercosis), which is the most frequent preventable cause of epilepsy worldwide.
- ***Echinococcus* tapeworms** can infect humans through food contaminated with dog or fox faeces. They can cause tumours to form in the liver, lungs and brain.
- **Chinese liver fluke** (*Clonorchis sinensis*) commonly contracted through raw and incorrectly processed or cooked fish, can cause bile duct inflammation and cancer.

Chemicals and toxins:

- **Aflatoxin** is a toxin produced by mould that grows on grain that has been stored inappropriately, and can cause liver cancer, one of the most deadly forms of cancer.
- **Cyanide** poisoning occurs when inappropriately processed cassava is consumed.

FOODBORNE DISEASES ARE PREVENTABLE.
EVERYONE HAS A ROLE TO PLAY.

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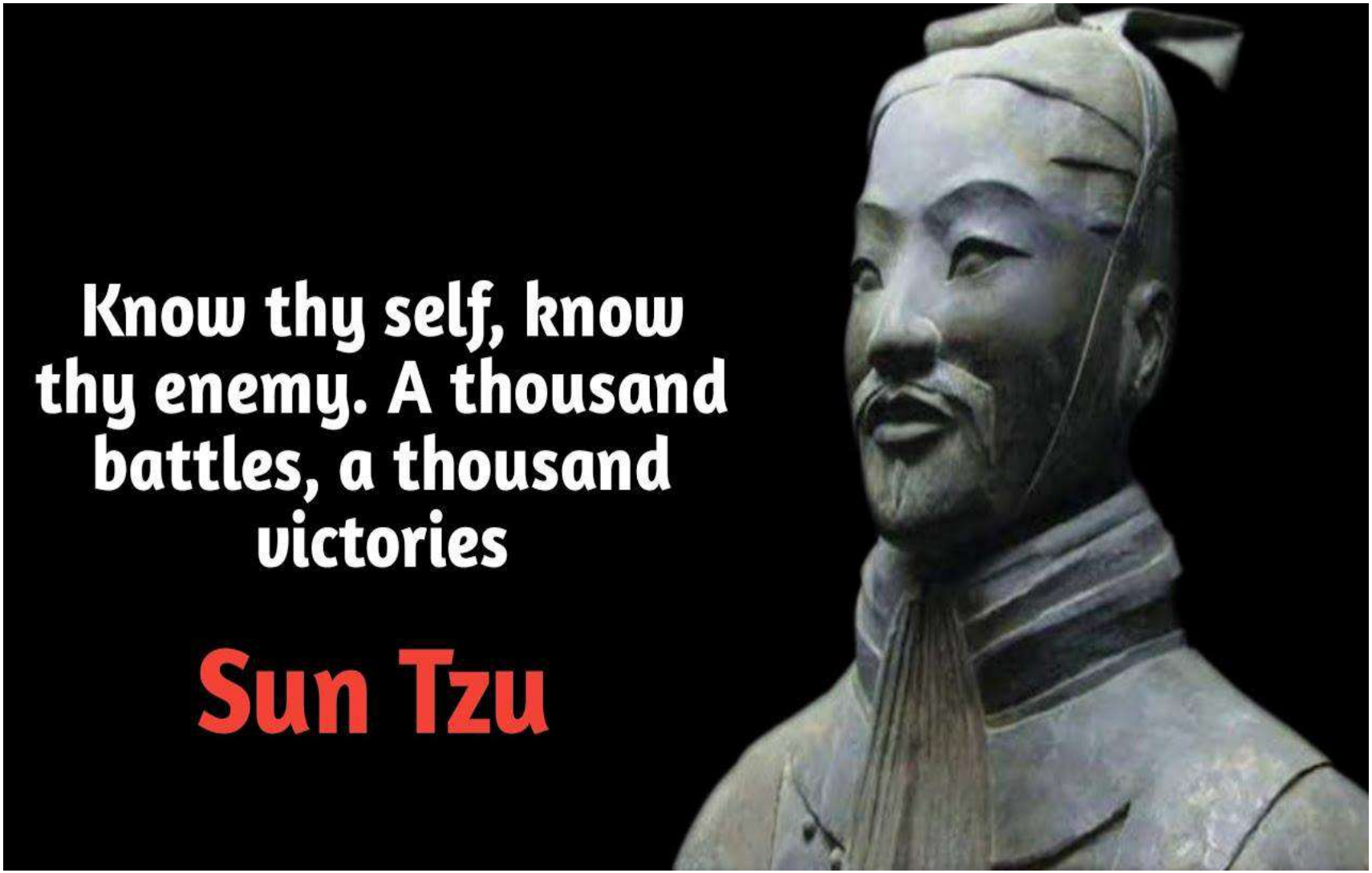
#SafeFood

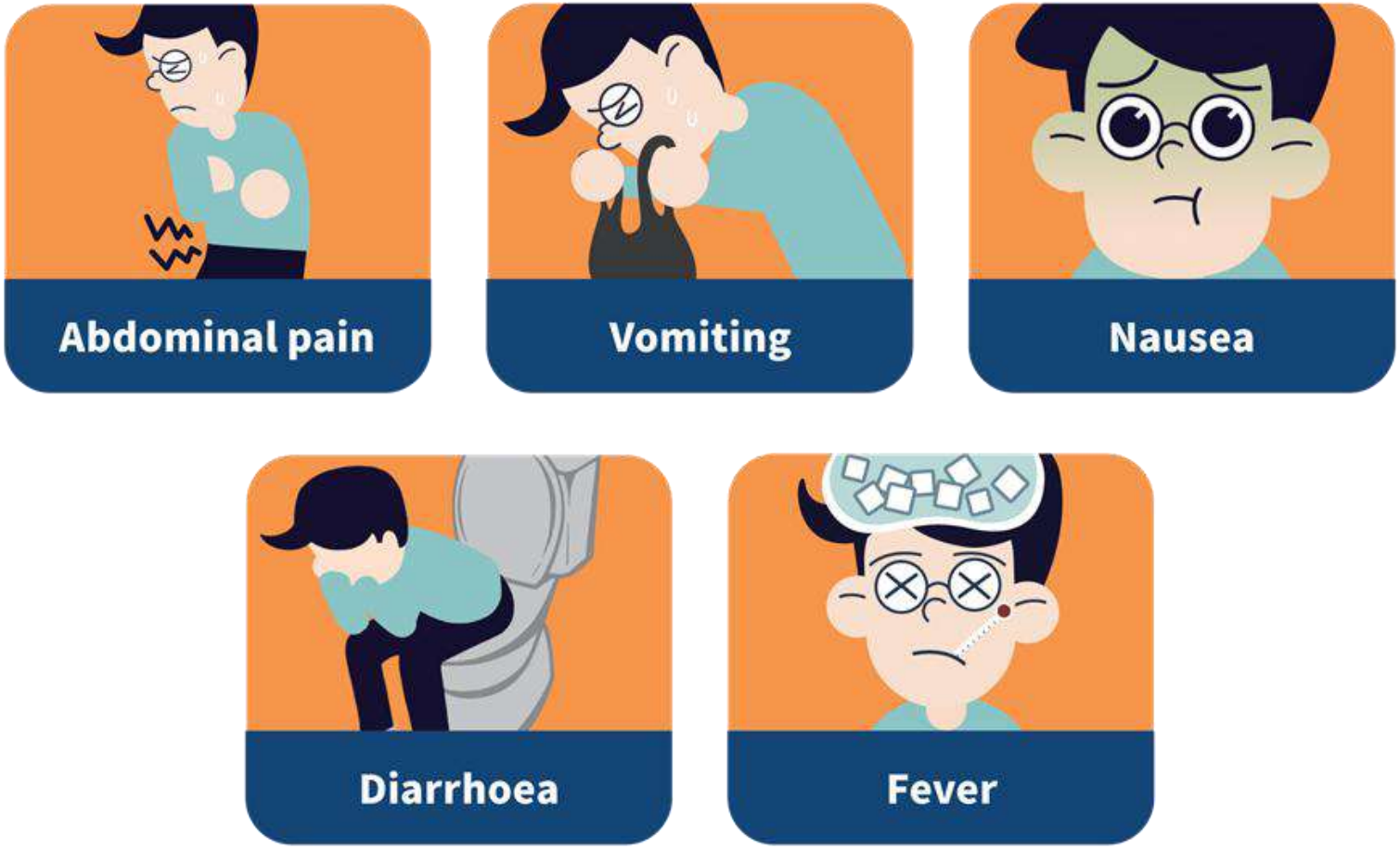
Source: WHO Estimates of the Global Burden of Foodborne Diseases. 2015.

World Health Organization

Strategi Perang Sun Tzu



Foodborne Infections



Diarrhoeal disease

- **Diarrhoeal disease** is the third leading cause of death in children 1–59 months of age. It is both **preventable** and **treatable**.
- **Each year diarrhoea kills around 443 832 children under 5** and an additional **50 851 children aged 5 to 9 years**.
- A significant proportion of diarrhoeal disease can be **prevented** through **safe drinking-water and adequate sanitation and hygiene.**
- Globally, there are nearly **1.7 billion cases of childhood diarrhoeal disease every year**.
- Diarrhoea is a leading cause of **malnutrition in children under 5 years old**.

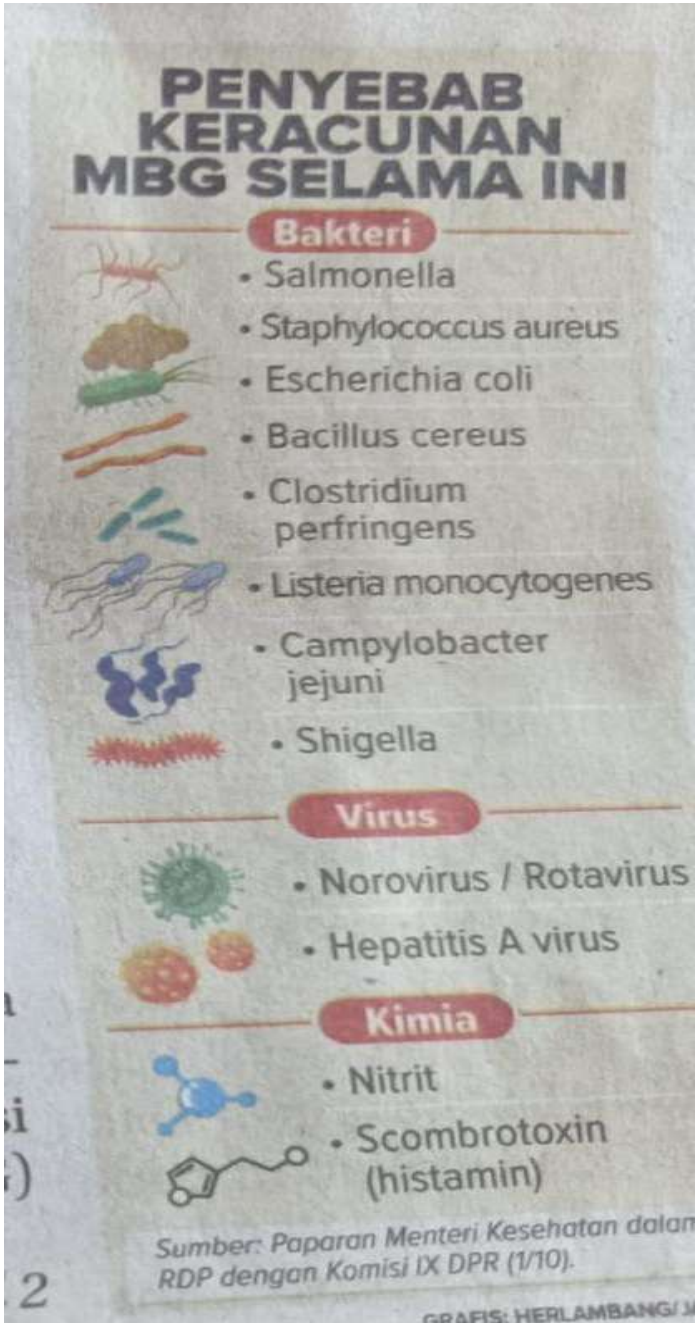
World Health Organization

Pathogens

Penyebab terbanyak kasus keracunan makanan MBG yang ditemukan adalah

- *Escherichia coli (45%)*
- *Bacillus cereus (23%)*
- *Salmonella sp (18%)*
- *Staphylococcus aereus (18%)*
- *Coliform (14%)*

**Pada beberapa kejadian keracunan pangan dapat ditemukan lebih dari 1 patogen*



sciencenotes.org

Types of Food Poisoning

Food poisoning comes from many sources, including bacteria, viruses, and fungi.

Listeria
fresh milk, unwashed produce

E. coli
fecal contamination

Campylobacter
undercooking, unhygienic kitchen

Salmonella
undercooking, poor hygiene

Staphylococcus
unrefrigerated food

Ciguatera
coral algae toxin

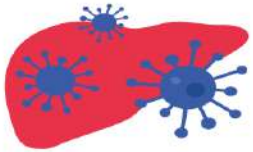
Shigella
human waste contamination

Botulism
damaged cans

Big 6 Foodborne Illnesses

Norovirus

- Direct contact with the infected
- Contact with fecal matter
- Bodily fluids transfer to food
- Contaminated water

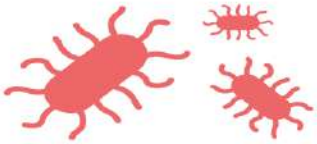


Hepatitis A

- Contaminated food and water
- Contact with fecal matter
- Cross-contamination

E.coli

- Contact with fecal matter
- Contaminated food and water
- Undercooked meat
- Raw milk



Non-typhoidal

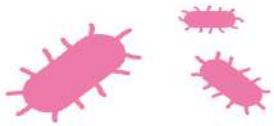
Salmonella

- Food of animal origin
  (e.g., poultry, eggs and other meat)
- Contaminated fruits and vegetables
- Processed foods
  (e.g., peanut butter and frozen pies)
- Contaminated water

Typhoidal

Salmonella

- Undercooked meat
  (e.g., poultry, beef, and pork)
- Contaminated raw fruits and vegetables
- Raw/undercooked eggs and egg products
- Raw milk



Shigella

- Contaminated food and water
- Sick food handler
- Contact with fecal matter
- Cross-contamination

Foodborne Disease WHO 2025

Hazards for which burden of foodborne disease estimates are being considered for 2025 Edition

Diarrhoeal disease agents (14)	Invasive disease agents (10)	Parasitic hazards (10)	Chemical and toxin hazards (9)
Viruses	Viruses	Cestodes	Organic pollutants
1. Norovirus	1. *Hepatitis A* virus	1. *Echinococcus granulosus*	1. Dioxin
2. Rotavirus	Bacteria	2. *Echinococcus multilocularis*	Toxins and alergens
Bacteria	2. *Brucella* spp.	3. *Taenia solium*	2. Aflatoxin B1
3. *Campylobacter* spp.	3. *Listeria monocytogenes*	Nematodes	3. Aflatoxin M1
4. Enteroaggregative *E.coli* (EAEC)	4. *Mycobacterium bovis/caprae/orygis*	4. *Ascaris* spp.	4. Cassava cyanide
5. Enteropathogenic *E.coli* (EPEC)	5. *Salmonella* enterica non-typhoidal*	5. *Trichinella* spp.	5. Peanut allergens
6. Enterotoxigenic *E.coli* (ETEC)	6. *Salmonella enterica Paratyphi*	Trematodes	Metals
7. Shiga toxin-producing *E.coli* (STEC)	7. *Salmonella enterica Typhi*	6. *Clonorchis sinensis*	6. Inorganic Arsenic
8. *Salmonella enterica* non-typhoidal	Protozoa	7. *Fasciola* spp.	7. Cadmium
9. *Shigella* spp.	8. *Toxoplasma gondii*	8. Intestinal flukes	8. Lead
10. *Vibrio cholerae*	9. *Trypanosoma cruzi*	9. *Opisthorchis* spp.	9. Methylmercury
Protozoa	Enteric intoxication	10. *Paragonimus* spp.	
11. *Cryptosporidium* spp.	10. *Clostridium botulinum*		
12. *Cyclospora cayetanensis*			
13. *Entamoeba histolytica*			
14. *Giardia duodenalis*			

*This hazard is under two categories

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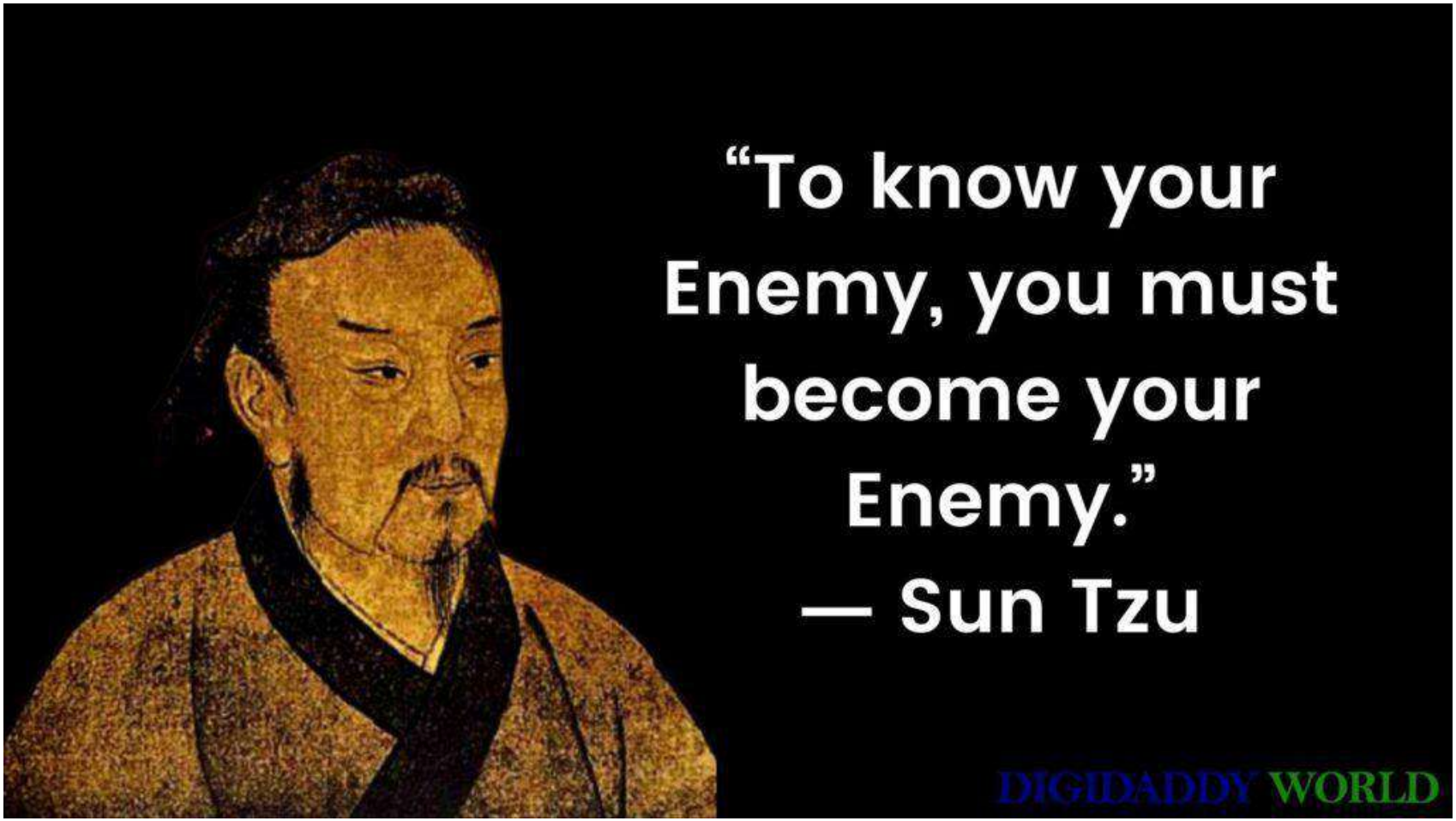
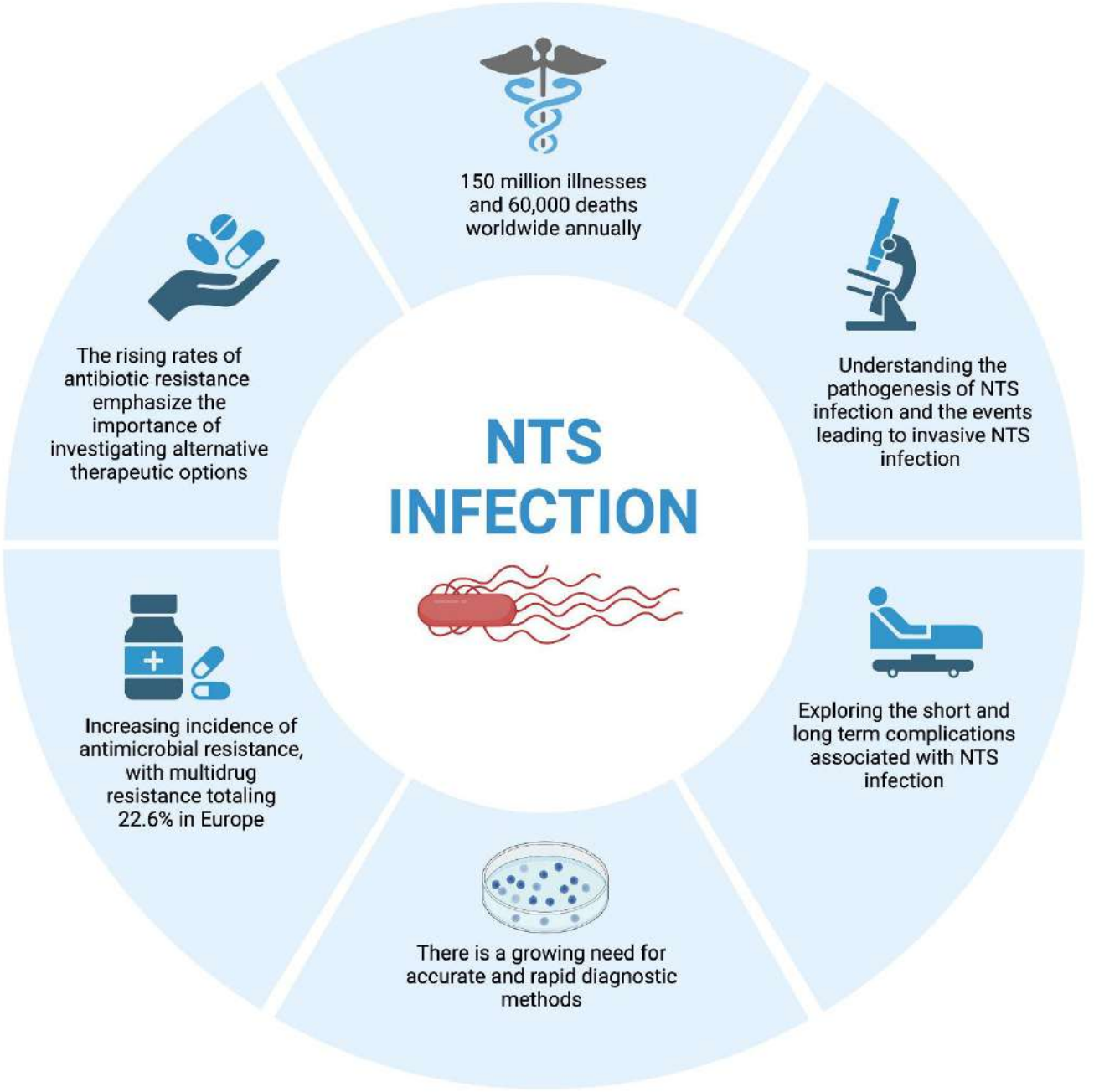


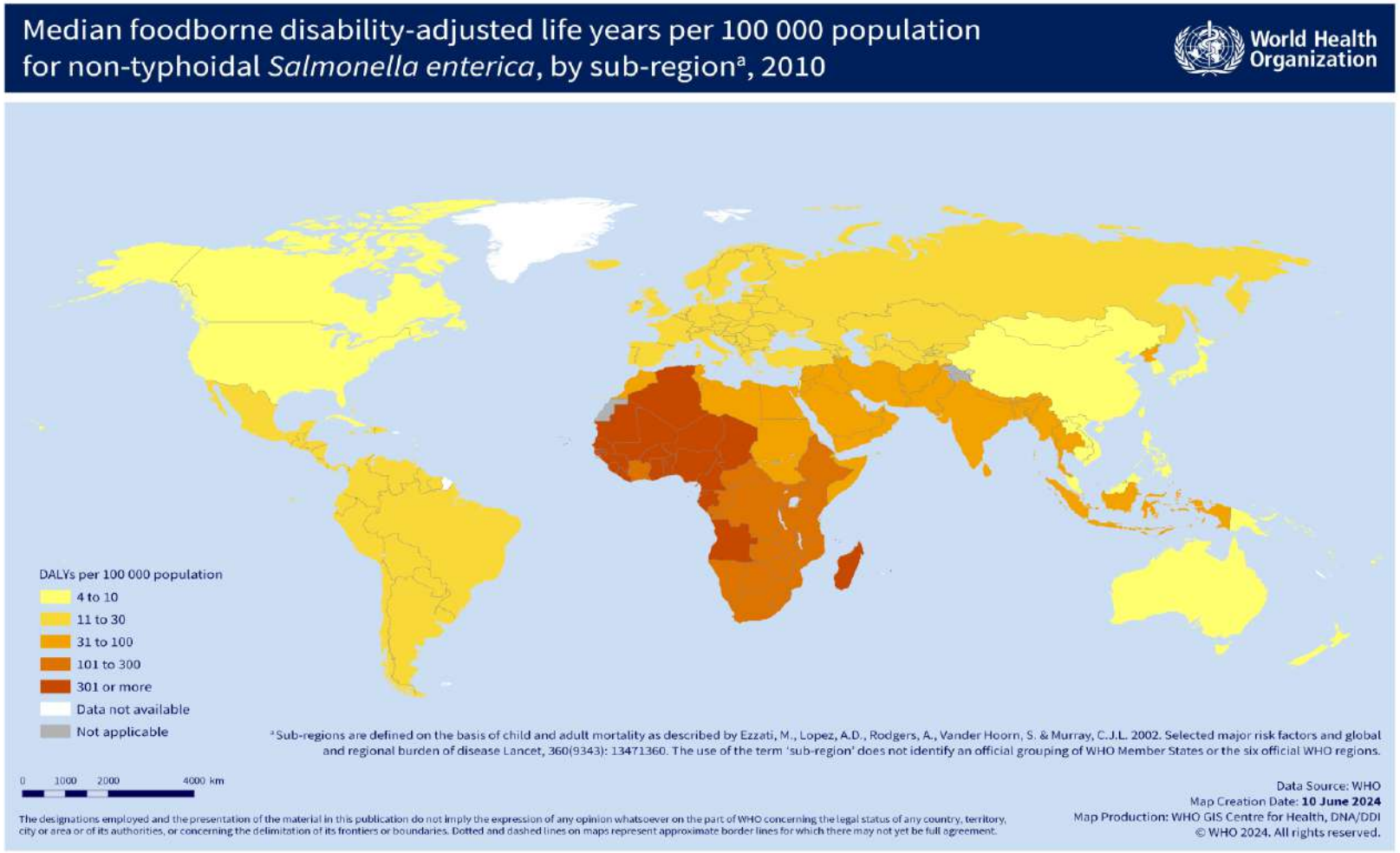
Salmonella (non-typhoidal)

- Salmonella is **1 of 4 key global** causes of **diarrhoeal diseases**.
- Most cases of **salmonellosis are mild**; however, sometimes it can be life-threatening. The severity of the disease depends on **host factors** and **the serotype of Salmonella**.
- **Antimicrobial resistance** is a global public health concern and Salmonella is one of the microorganisms in which some resistant serotypes have emerged, affecting the food chain.
- **Basic food hygiene practices**, such as "cook thoroughly", are recommended as a **preventive measure against salmonellosis**.

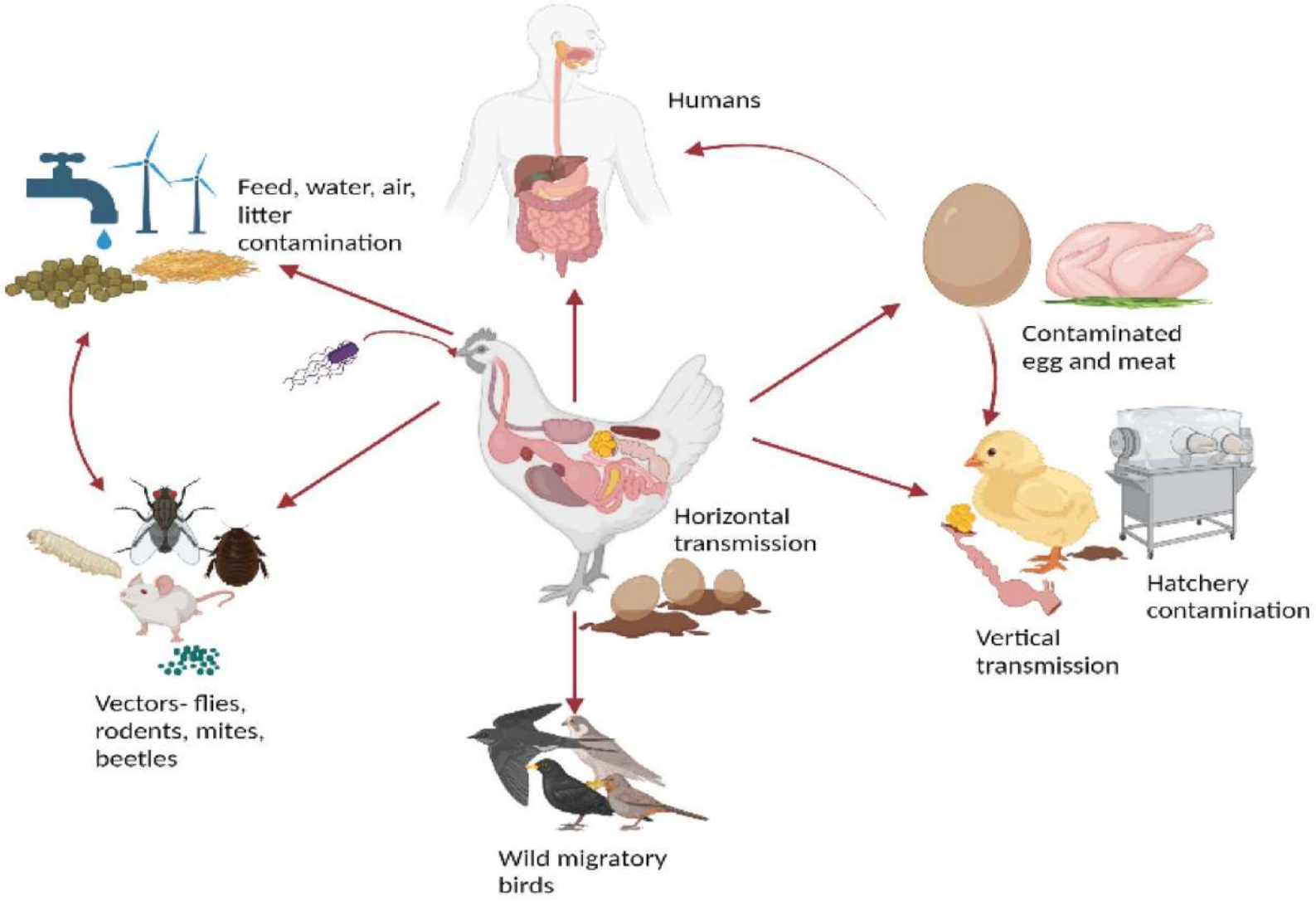
World Health Organization


150 million illnesses and 60,000 deaths worldwide annually
Understanding the pathogenesis of NTS infection and the events leading to invasive NTS infection
Exploring the short and long term complications associated with NTS infection
There is a growing need for accurate and rapid diagnostic methods
Increasing incidence of antimicrobial resistance, with multidrug resistance totaling 22.6% in Europe
The rising rates of antibiotic resistance emphasize the importance of investigating alternative therapeutic options
NTS INFECTION

Non-Typhoidal Salmonella



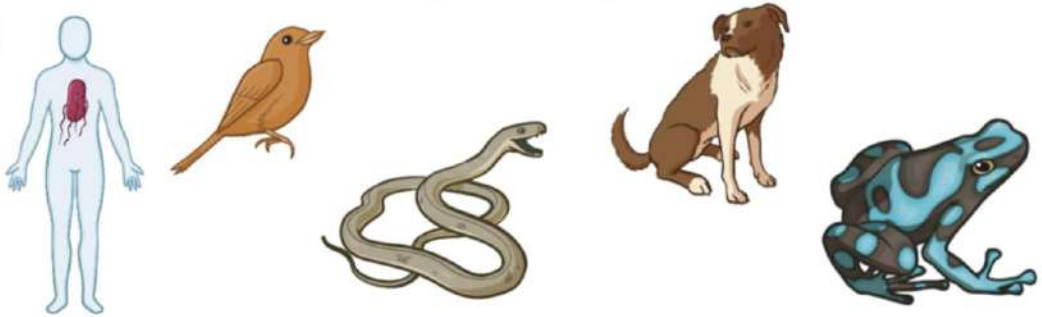
Routes Transmission of Salmonella



Salmonella

RESERVOIRS for NON-TYPHOIDAL SALMONELLA

* INFECTED HUMANS
* ANIMALS
  - BIRDS
  - REPTILES
  - MAMMALS
  - AMPHIBIANS



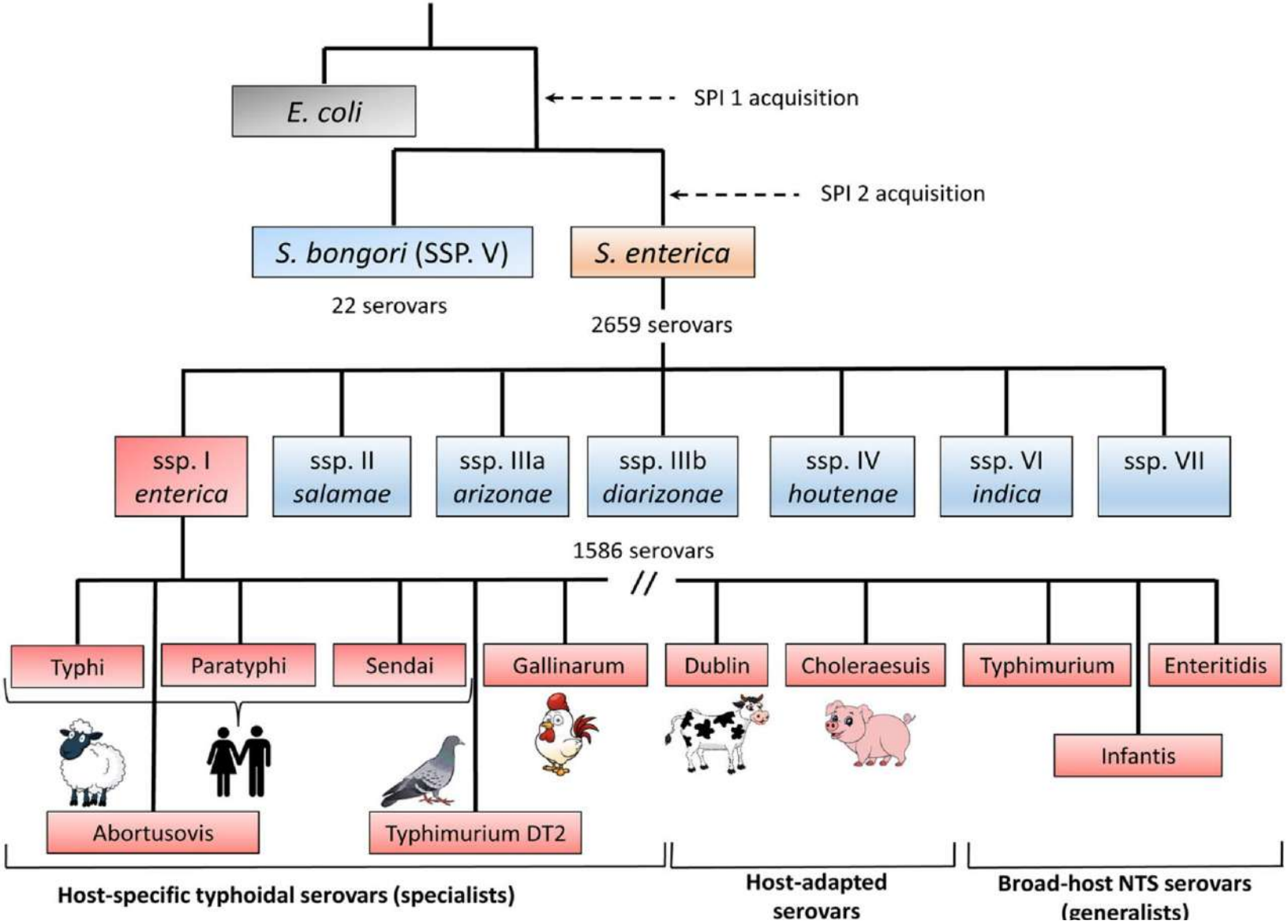
TRANSMISSION

* FECAL to ORAL
* FOODBORNE
  CONSUMPTION of CONTAMINATED RAW/UNDERCOOKED ANIMAL PRODUCTS
  - POULTRY
  - MEAT
  - EGGS
  - UNPASTEURIZED MILK (or MILK PRODUCTS)

* CONTAMINATED CONSUMABLES
  - WATER
  - FRUITS/VEGETABLES
  - PEANUT BUTTER

* DIRECT CONTACT with INFECTED ANIMALS
  - CONTAMINATED HANDS REACH THE MOUTH

OSMOSIS.org


E. coli
SPI 1 acquisition
SPI 2 acquisition
S. bongori (SSP. V)
22 serovars
S. enterica
2659 serovars
ssp. I enterica
ssp. II salamae
ssp. IIIa arizonae
ssp. IIIb diarizonae
ssp. IV houtenae
ssp. VI indica
ssp. VII
1586 serovars
Typhi
Paratyphi
Sendai
Gallinarum
Dublin
Choleraesuis
Typhimurium
Enteritidis
Infantis
Abortusovis
Typhimurium DT2
Host-specific typhoidal serovars (specialists)
Host-adapted serovars
Broad-host NTS serovars (generalists)

E. coli

World Health Organization

- **Escherichia coli (E. coli)** is a bacteria that is commonly found in the lower intestine of warm-blooded organisms. Most E.coli strains are harmless, but some can cause serious food poisoning.
- **Shiga toxin-producing E. coli (STEC)** is a bacterium that can cause severe foodborne disease.
- **Primary sources of STEC outbreaks** are raw or undercooked ground meat products, raw milk, and faecal contamination of vegetables.
- In most cases, the illness is self-limiting, but it may lead to a life-threatening disease including **haemolytic uraemic syndrome (HUS),** especially in **young children and the elderly**.
- STEC is heat-sensitive. In preparing food at home, be sure to follow basic food hygiene practices such as "cook thoroughly".
- Following the WHO “Five keys to safer food” is a key measure to **prevent infections with foodborne pathogens such as STEC**.

Listeriosis

World Health Organization

- **Listeriosis** is a serious, but preventable and treatable disease.
- **Pregnant women, the elderly or individuals with a weakened immune system**, such as people with immuno-compromised status due to HIV, leukaemia, cancer, kidney transplant and steroid therapy, are at greatest risk of severe listeriosis and should avoid high risk foods.
- **High risk foods** include deli meat and ready-to-eat meat products (such as cooked, cured and/or fermented meats and sausages), soft cheeses and cold smoked fishery products.
- **Listeria monocytogenes** are widely distributed in nature. They can be found in soil, water, vegetation and the faeces of some animals and can contaminate foods.
- **Listeriosis** is an infectious disease caused by the bacterium Listeria monocytogenes.

Campylobacter

World Health Organization

- **Campylobacter** is 1 of 4 key global causes of diarrhoeal diseases. It is considered to be the most common bacterial cause of human gastroenteritis in the world.
- **Campylobacter infections** are generally mild, but can be fatal among **very young children, elderly, and immunosuppressed individuals**.
- Campylobacter species can be killed by heat and thoroughly cooking food.
- To prevent Campylobacter infections, make sure to follow **basic food hygiene practices** when preparing food.

Natural toxins in food

World Health Organization

- Some **natural toxins** can be formed in food as defense mechanisms of plants, through their infestation with toxin-producing mould, or through ingestion by animals of toxin-producing microorganisms.
- **Natural toxins** can cause a variety of adverse health effects and pose a serious health threat to both humans and livestock. Some of these toxins are **extremely potent**.
- Adverse health effects can be **acute poisoning** ranging from **allergic reactions** to **severe stomachache** and **diarrhoea**, and **even death**.
- **Long-term health** consequences include effects on **the immune, reproductive or nervous systems,** and also **cancer.**

Botulism

World Health Organization

- **Clostridium botulinum** is a bacterium that produces dangerous toxins (botulinum toxins) under low-oxygen conditions.
- **Botulinum toxins** are one of the most lethal substances known.
- Botulinum toxins block nerve functions and can lead to respiratory and muscular paralysis.
- **Human botulism** may refer to foodborne botulism, infant botulism, wound botulism, and inhalation botulism or other types of intoxication.
- **Foodborne botulism**, caused by consumption of improperly processed food, is a rare but potentially fatal disease if not diagnosed rapidly and treated with antitoxin.
- Homemade canned, preserved or fermented foodstuffs are a common source of foodborne botulism and their preparation requires extra caution.

Hepatitis A

- **Hepatitis A** is an inflammation of the liver that can cause mild to severe illness.
- **The hepatitis A virus (HAV)** is transmitted through ingestion of contaminated food and water or through direct contact with an infectious person.
- Almost everyone recovers fully from hepatitis A with **a lifelong immunity.** However, a very small proportion of people infected with hepatitis A could **die from fulminant hepatitis**.
- The risk of hepatitis A infection is associated with a **lack of safe water and poor sanitation and hygiene** (such as contaminated and dirty hands).
- A **safe** and **effective vaccine** is available to prevent hepatitis A.

World Health Organization

Bacillus cereus

Fig. 1: *Bacillus cereus* on gram stain (100X)

Fig. 2: *Bacillus cereus* on blood agar

Fig. 3: *Bacillus cereus* on MYPA agar

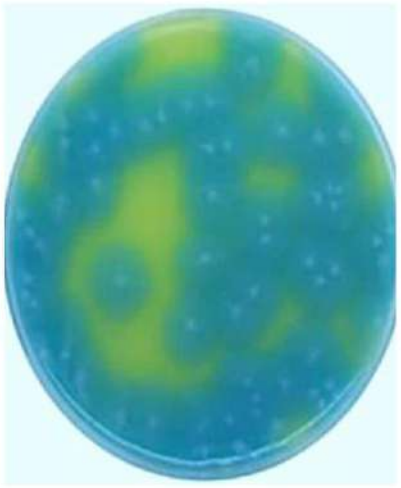
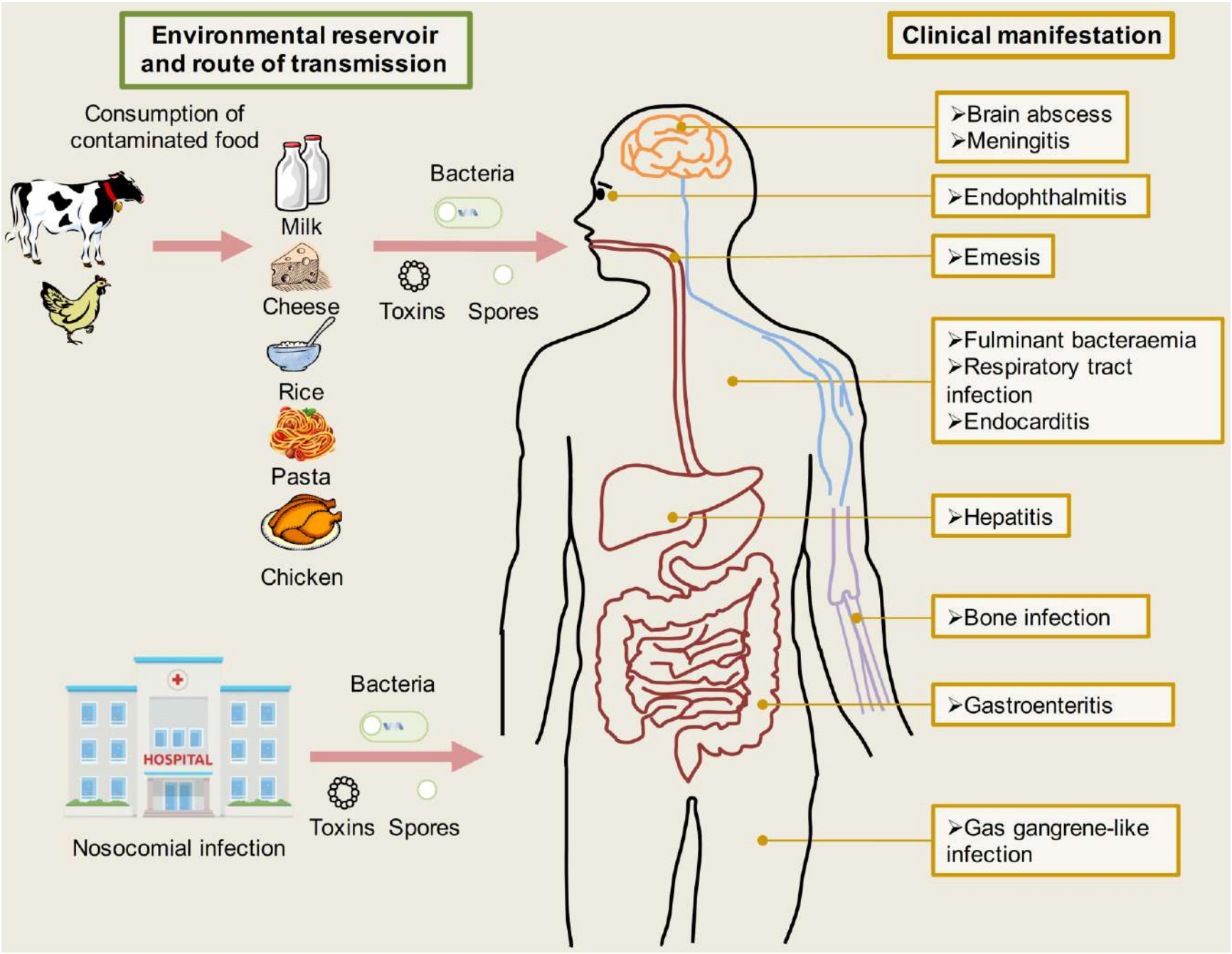
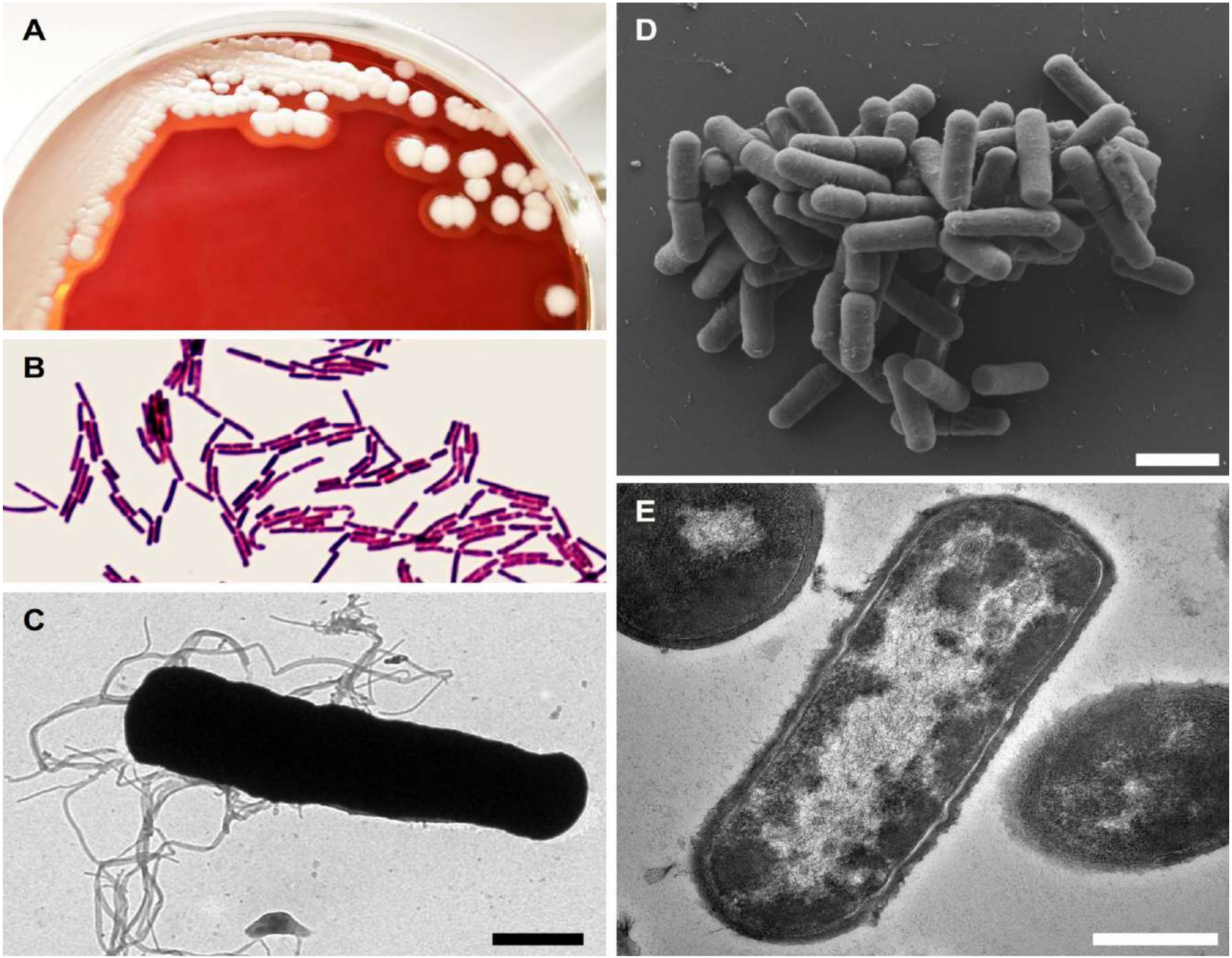
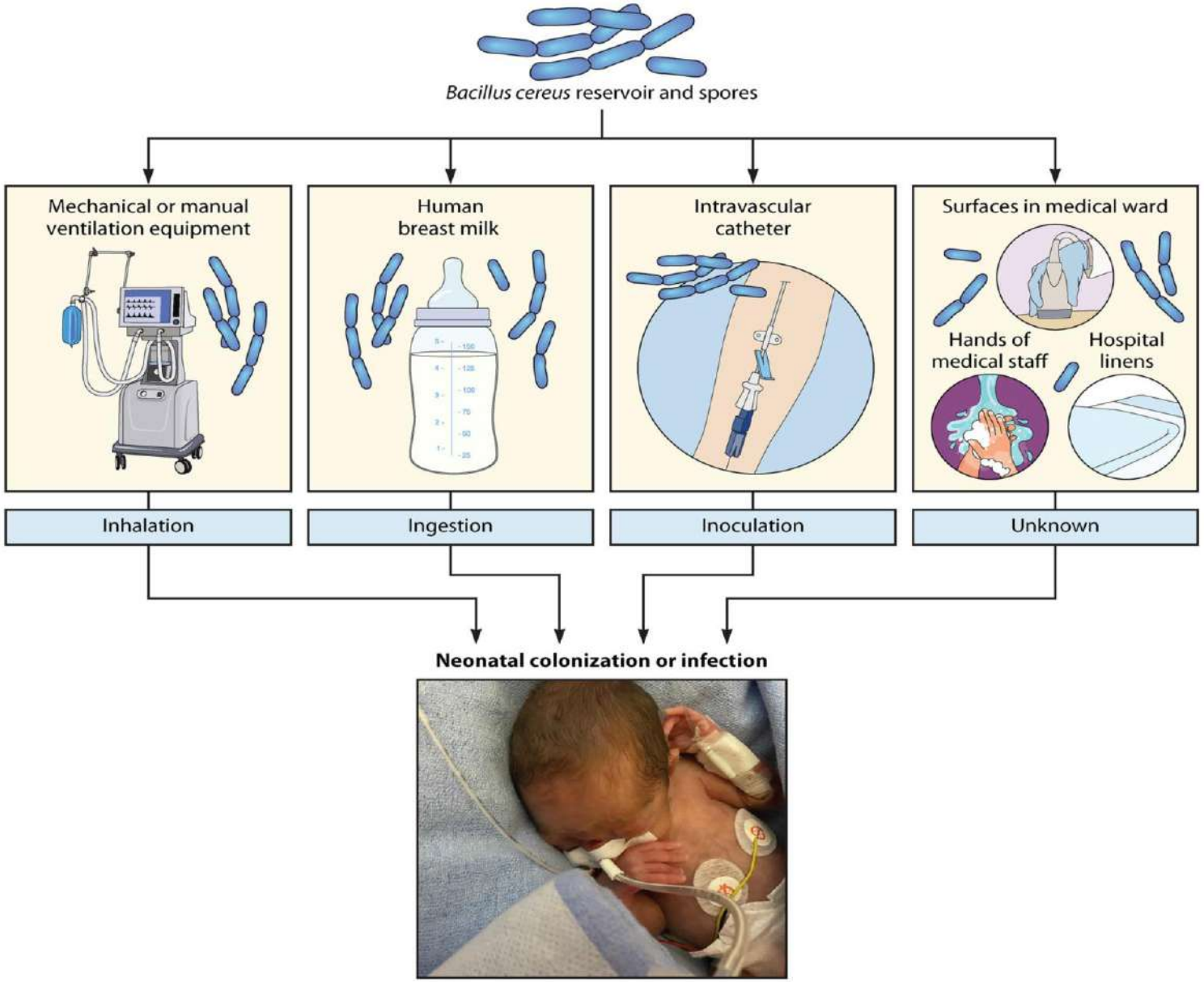


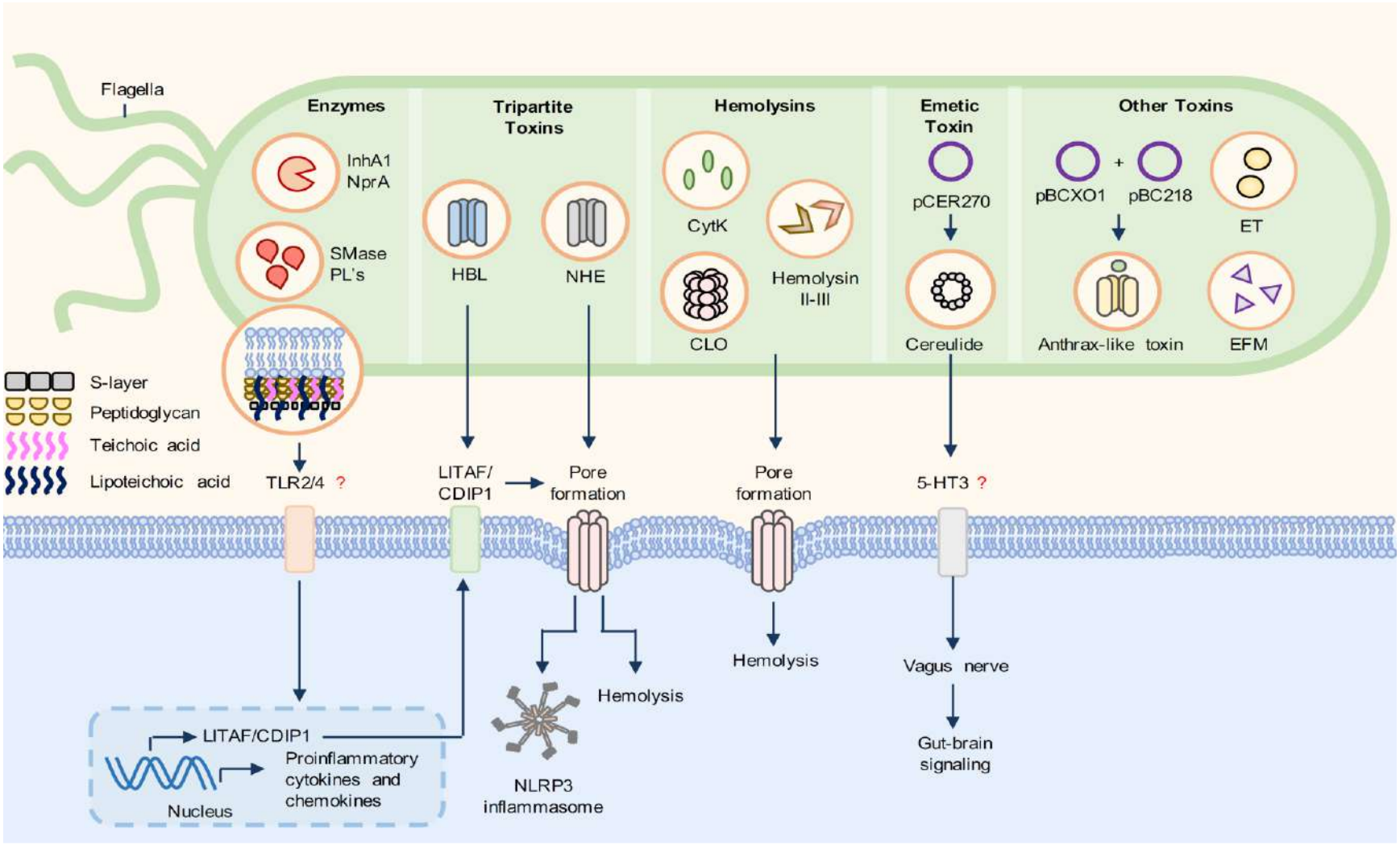
Fig. 4: *Bacillus cereus* on PEMBA agar

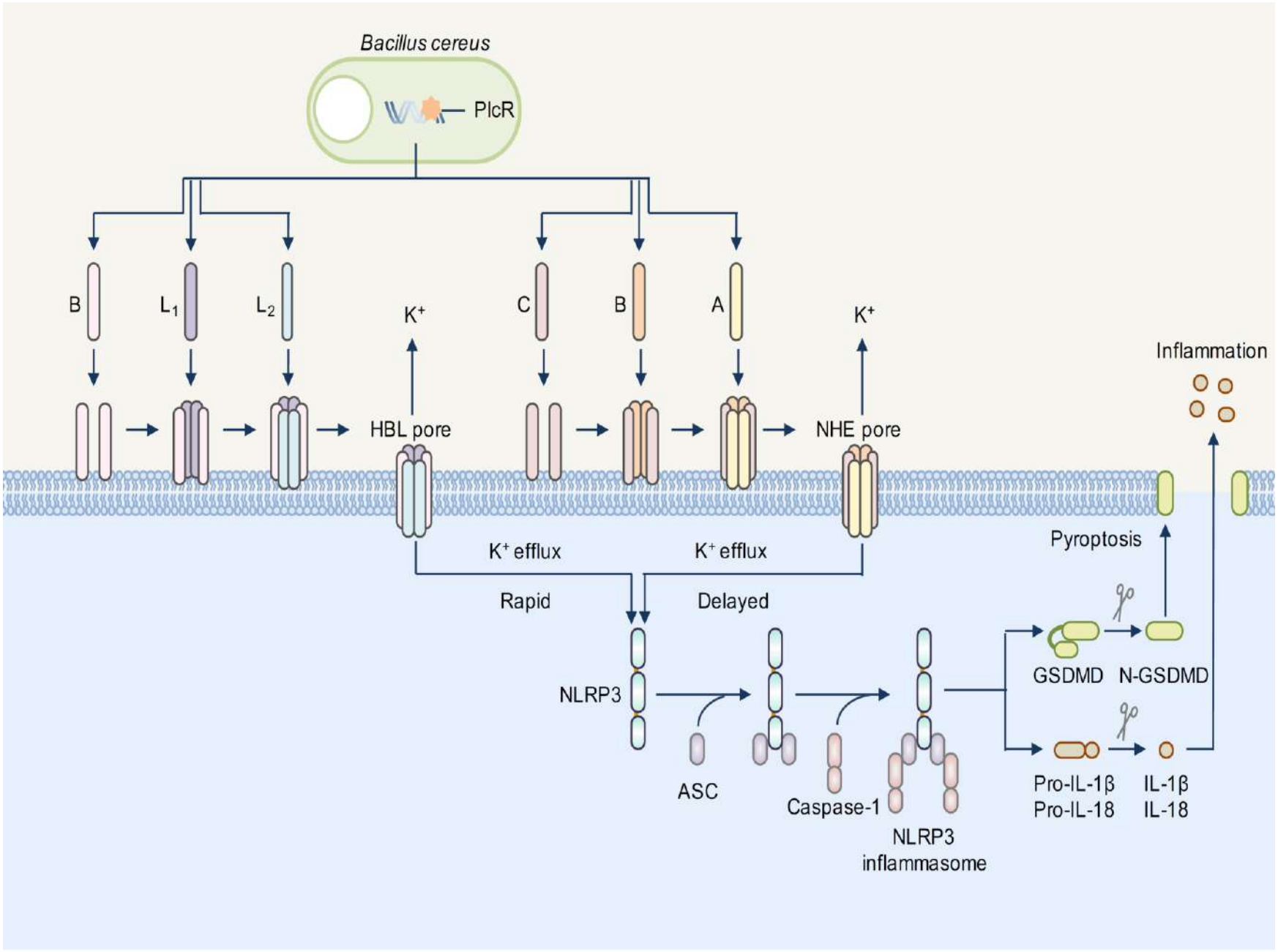

Environmental reservoir and route of transmission
Clinical manifestation
Consumption of contaminated food
Milk
Cheese
Rice
Pasta
Chicken
Bacteria
Toxins
Spores
HOSPITAL
Nosocomial infection
Bacteria
Toxins
Spores
➢Brain abscess
➢Meningitis
➢Endophthalmitis
➢Emesis
➢Fulminant bacteraemia
➢Respiratory tract infection
➢Endocarditis
➢Hepatitis
➢Bone infection
➢Gastroenteritis
➢Gas gangrene-like infection

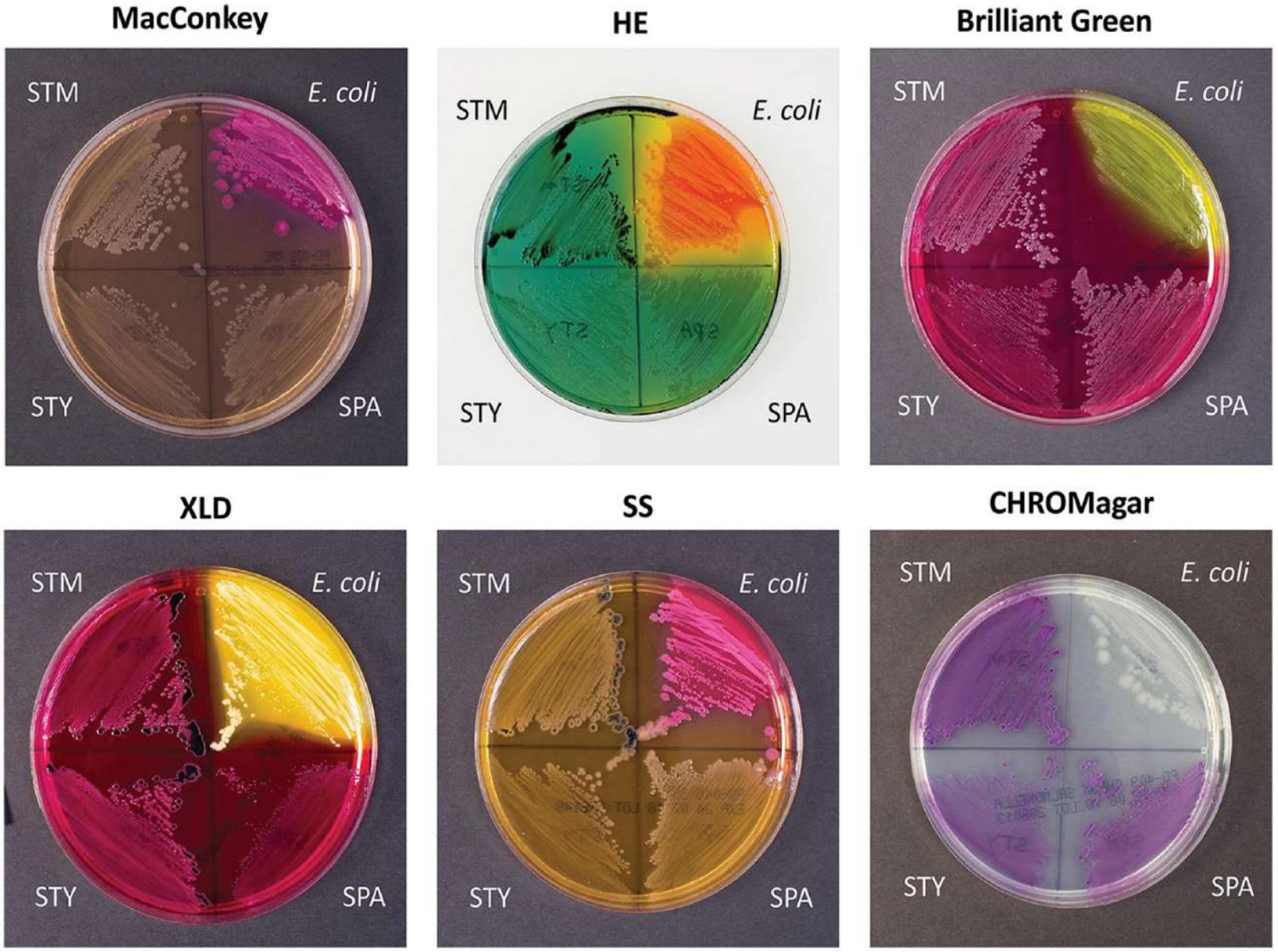

A
B
C
D
E


Bacillus cereus reservoir and spores
Mechanical or manual ventilation equipment
Human breast milk
Intravascular catheter
Surfaces in medical ward
Hands of medical staff
Hospital linens
Inhalation
Ingestion
Inoculation
Unknown
Neonatal colonization or infection

Bacillus cereus Toxins




Bacillus cereus
PlcR
B
L1
L2
K+
C
B
A
K+
Inflammation
HBL pore
NHE pore
Pyroptosis
K+ efflux
K+ efflux
Rapid
Delayed
NLRP3
GSDMD
N-GSDMD
ASC
Caspase-1
Pro-IL-1β
Pro-IL-18
IL-1β
IL-18
NLRP3
inflammasome


MacConkey
STM
E. coli
STY
SPA
HE
STM
E. coli
STY
SPA
Brilliant Green
STM
E. coli
STY
SPA
XLD
STM
E. coli
STY
SPA
SS
STM
E. coli
STY
SPA
CHROMagar
STM
E. coli
STY
SPA

Pathogenic of diarrhoeagenic E. coli.

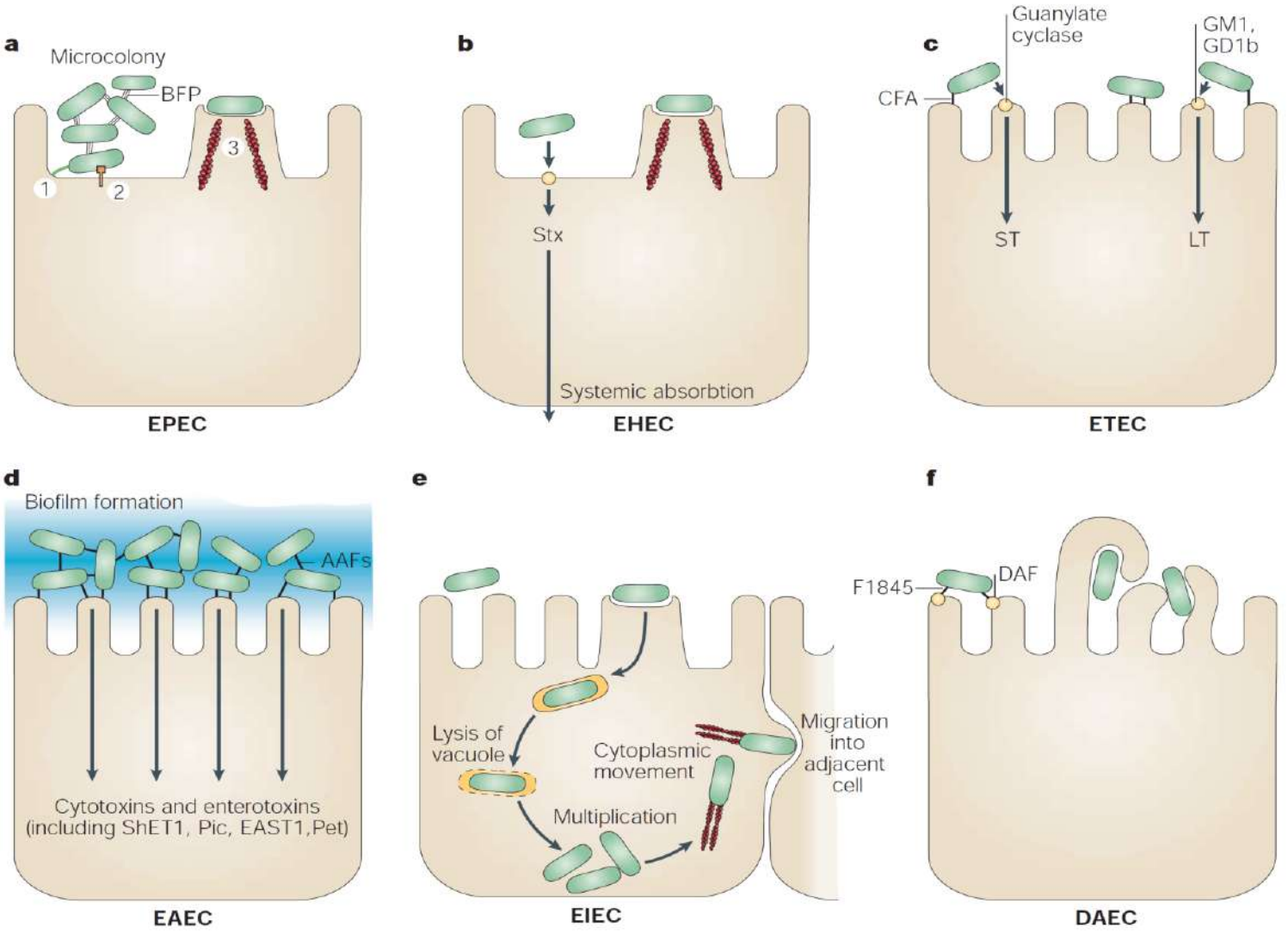
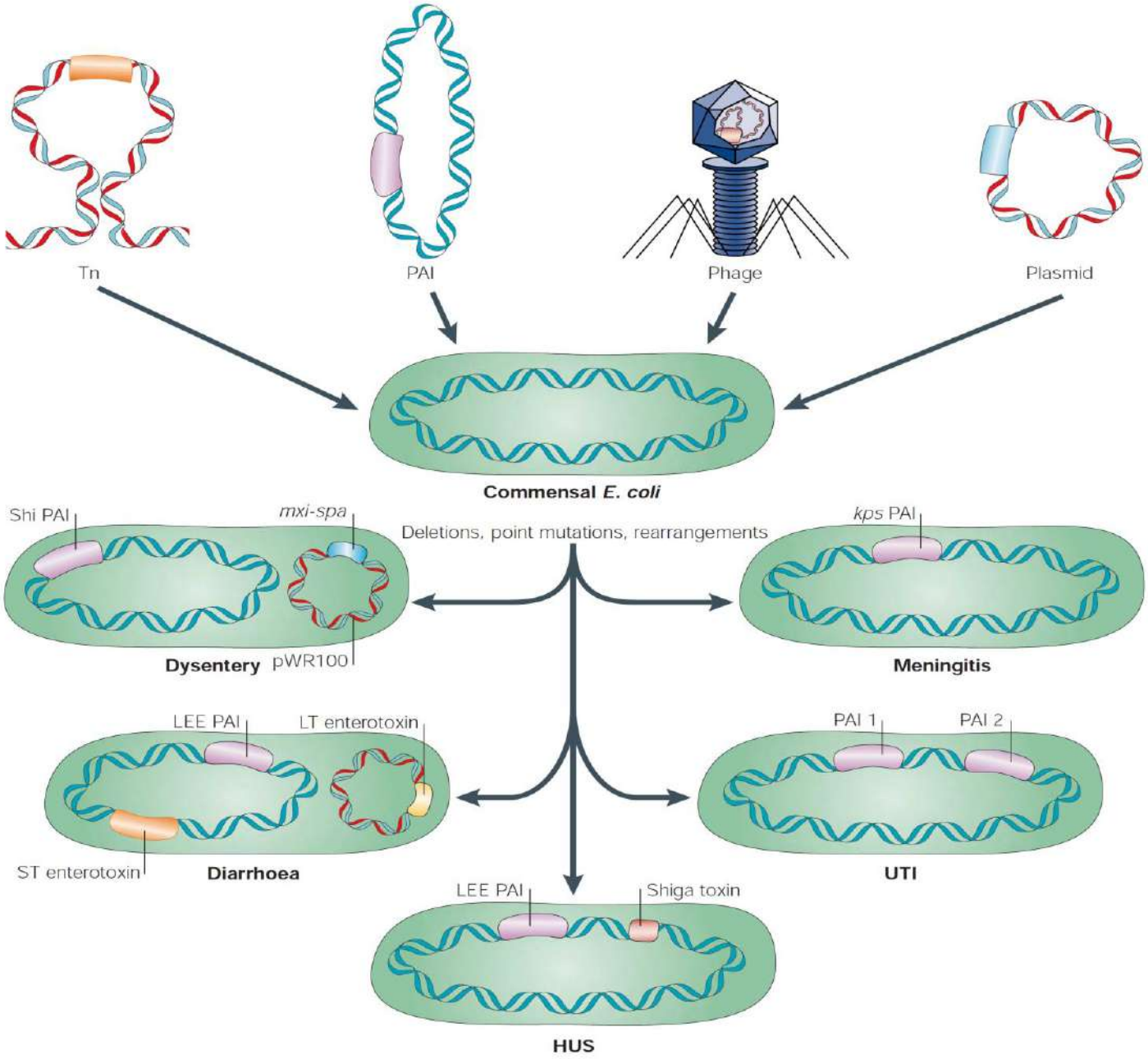
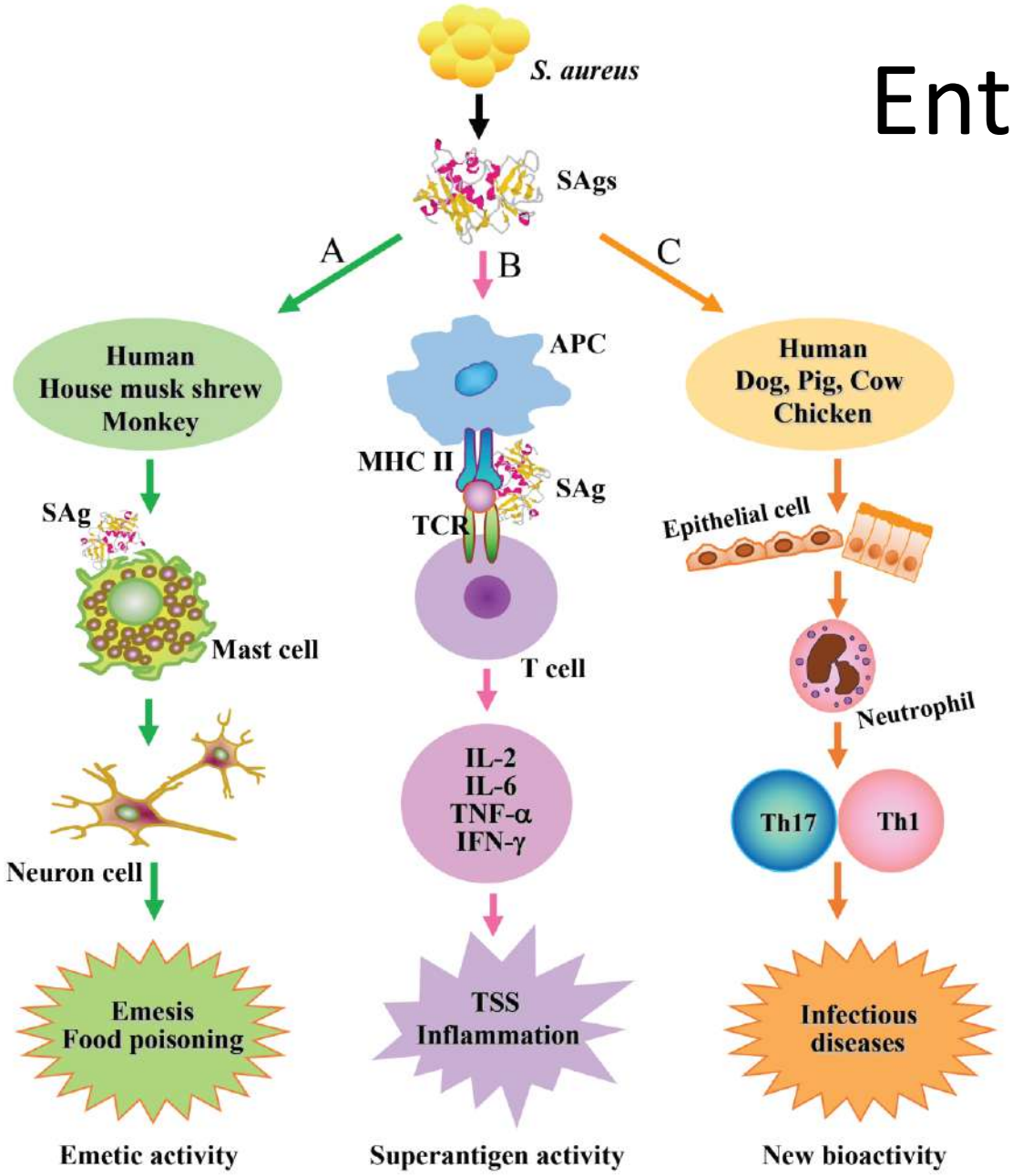


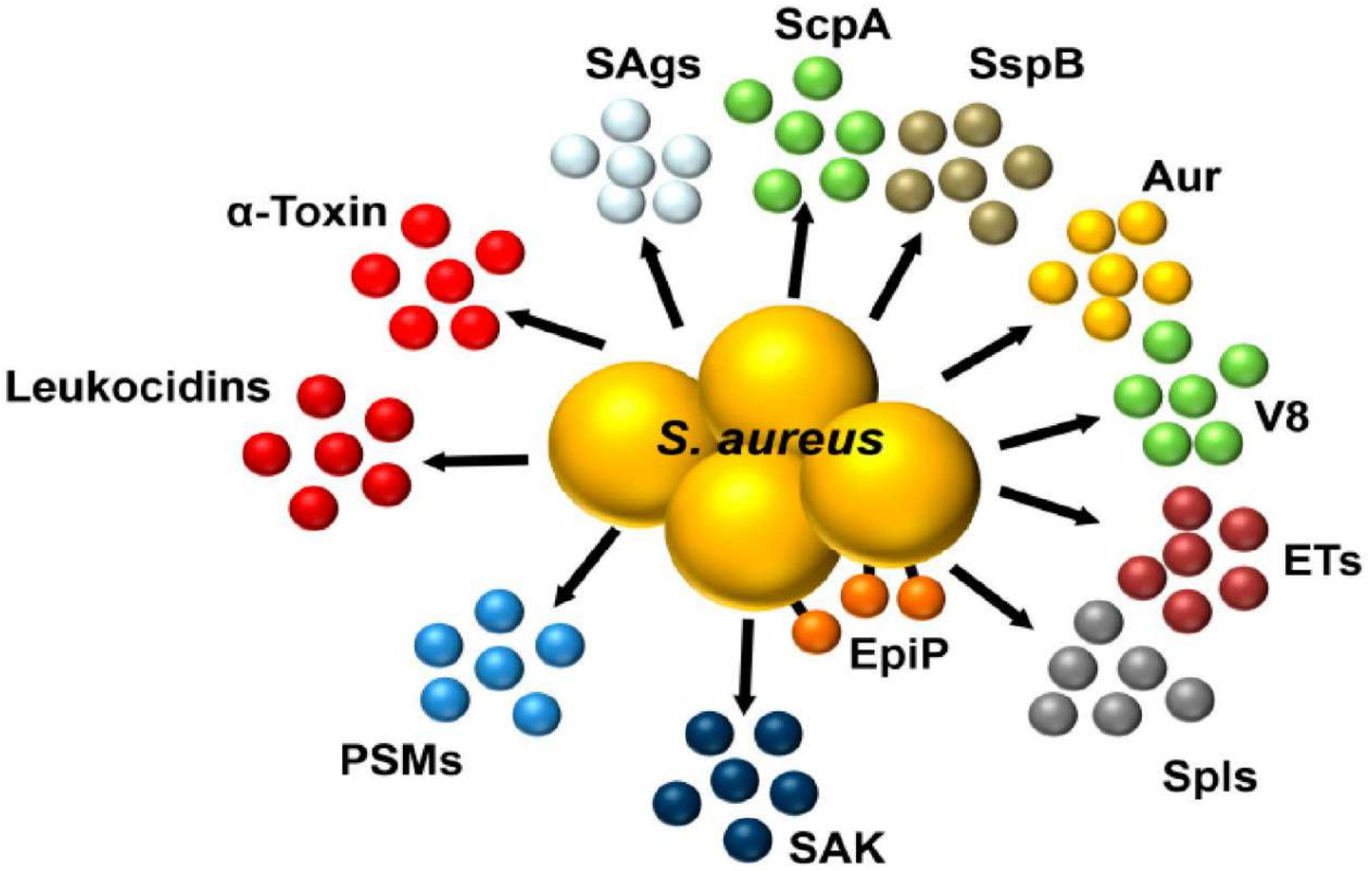
Figure 3 | **Attaching and effacing histopathology caused by EPEC and EHEC.** The attaching and effacing histopathology results in pedestal-like structures, which rise up from the epithelial cell on which the bacteria perch. Image courtesy of J. Girón.


Tn
PAI
Phage
Plasmid
Commensal E. coli
Deletions, point mutations, rearrangements
Shi PAI
mxi-spa
Dysentery
pWR100
kps PAI
Meningitis
LEE PAI
LT enterotoxin
ST enterotoxin
Diarrhoea
PAI 1
PAI 2
UTI
LEE PAI
Shiga toxin
HUS

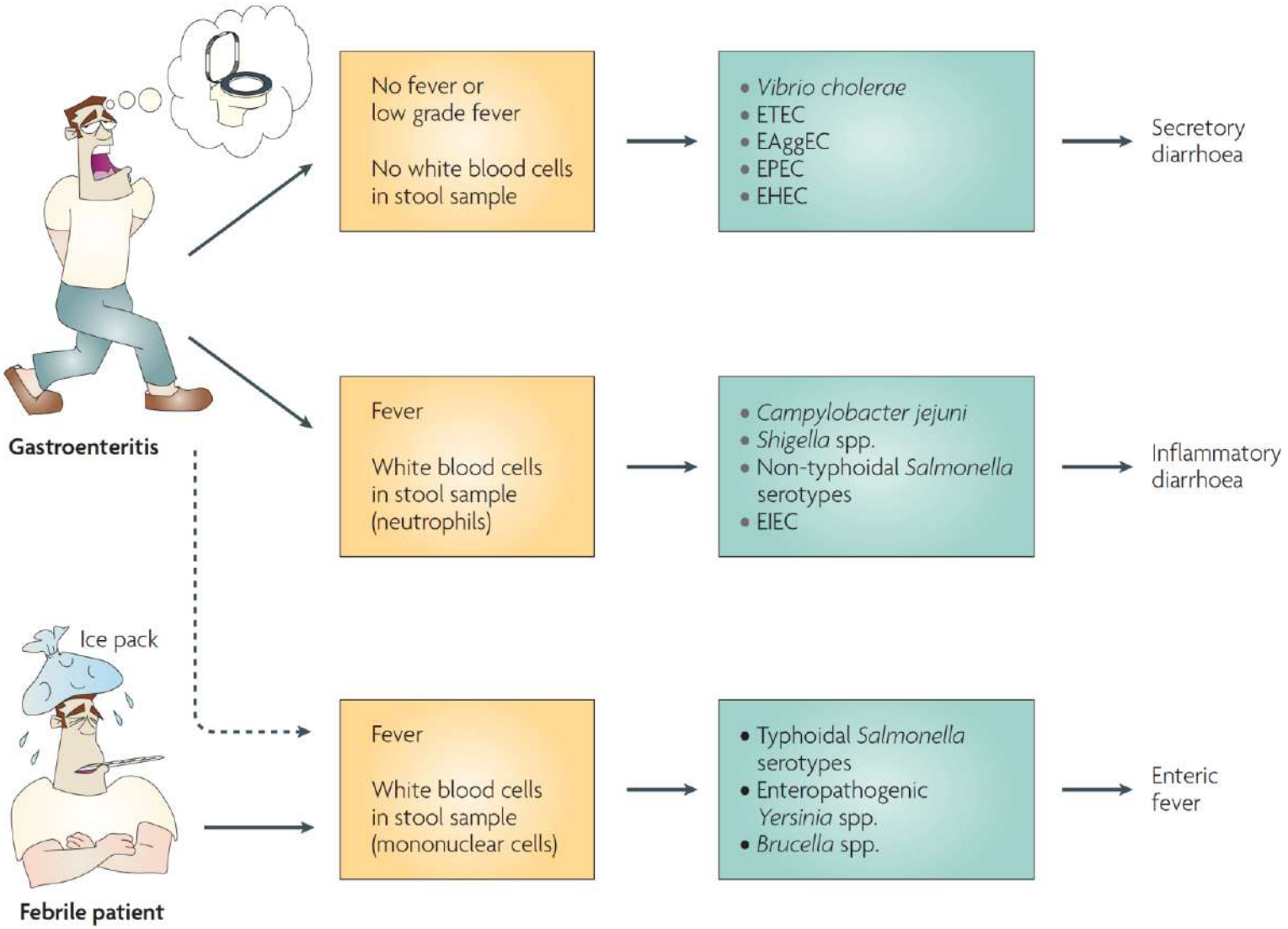
Enterotoxin Sa



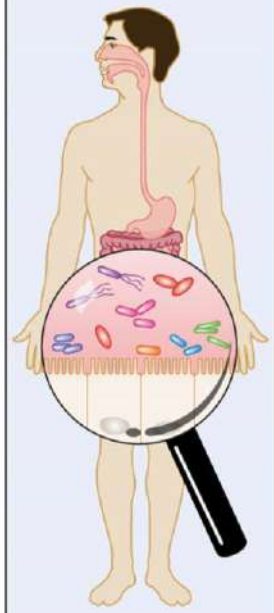
Staphylococcus Virulence Factors



Major syndromes of enteric infection



Diagnosis tools



COLLECTION	PHENOTYPIC & MOLECULAR DETECTION	TYPING	DETECTION & TYPING FUTURE PROSPECTS
• Fresh stool specimen • Rectal swab • Surgical resection* • Transport media 1. Buffered Glycerol saline (BGS) medium 2. Cary-Blair transport medium	*Phenotypic* • Stool examination • Selective media • Biochemical assays • Infection of cultured cells 1. Adherence pattern / invasiveness 2. Fluorescent actin stain 3. Cytotoxicity assays *Molecular* • PCR (single, multiplex, quantitative) Microarrays • Enzyme immunoassays	• O, H antigen based typing 1. Agglutination assays 2. PCR 3. Dipsticks 4. Restriction fragment length polymorphism (RFLP) 5. Microarrays 6. Microbead-suspension assays • Multilocus sequence typing (MLST) • Pulsed field gel electrophoresis (PFGE) • Ribotyping • Multiple locus variable number tandem repeat analysis (MLVA)	• Matrix-assisted laser desorption/ionization – time of flight (MALDI-TOF) mass spectrometry • Sequencing 1. High throughput 2. Whole genome • Single nucleotide polymorphism (SNP) and MLST analysis of whole genome sequences

*Refers to resection of Crohn's patients lesions for AIEC isolation only

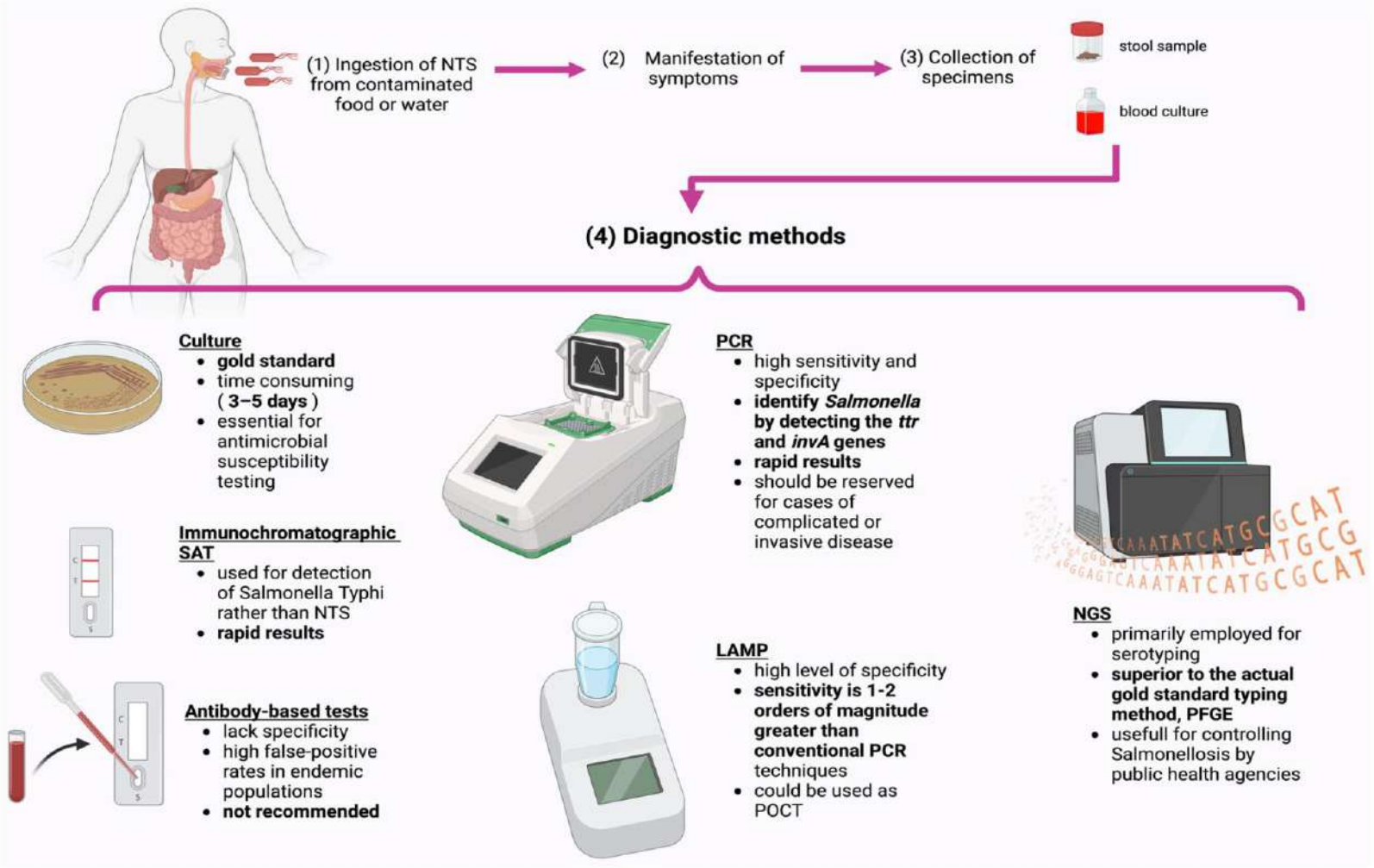
Key points for the laboratory diagnosis of gastrointestinal infections

- **The specimen of choice to diagnose diarrheal illness is the diarrheal stool**, not a **formed stool** or a **swab**, with a notable exception in pediatrics where a swab is acceptable when feces is noted on the swab.
- **Fecal testing for causes of infectious gastroenteritis using culture or culture independent methods** is indicated for patients with moderate to severe, bloody, febrile, dysenteric, nosocomial, or **persistent diarrheal illnesses** or immunocompromised patients.
- Culture independent **multiplex molecular tests** are reported to be more sensitive than culture, result in higher rates of detection, and often **cost more than culture methods**.
- Toxin or nucleic acid amplification testing for C. difficile should only be done on diarrheal stool.

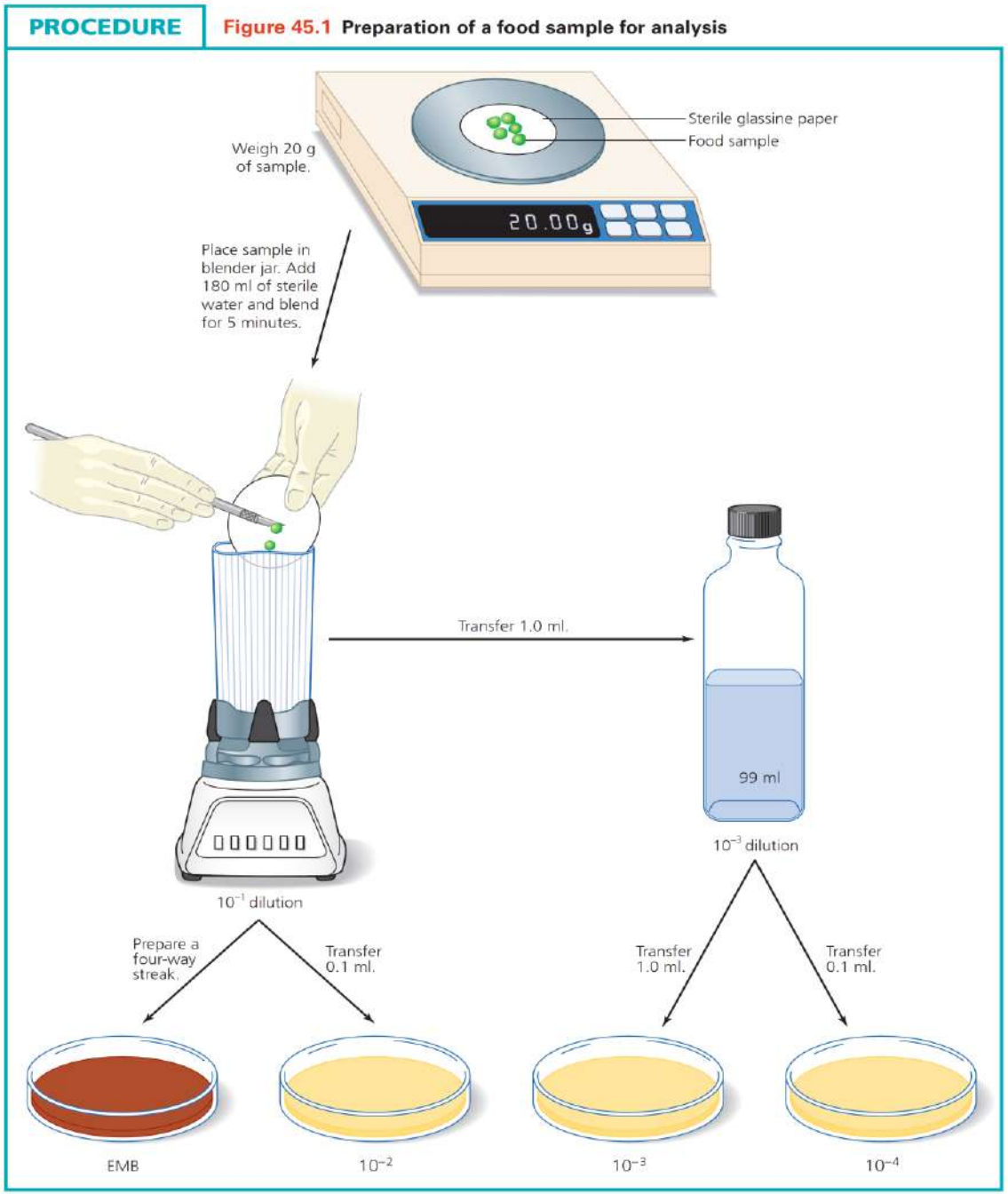
Table 34. Laboratory Diagnosis of Gastroenteritis, Infectious and Toxin-Induced Diarrhea

Etiologic Agents	Diagnostic Procedures	Optimum Specimens	Transport Issues
Bacteria			
Clostridioides difficile	GDH antigen and NAAT or toxin A/B performed as part of an algorithm	Unformed Stool	Closed container, RT, 2 h
	NAAT and toxin A/B	Unformed Stool	Closed container, RT, 2 h
	NAAT	Unformed Stool	Closed container, RT, 2 h
Salmonella spp. *Shigella* spp. *Campylobacter* spp.	NAAT	Unformed Stool	Closed container, RT, 2 h[a] Cary-Blair or manufactured specified transport medium, RT, 24 h
	Routine stool enteric pathogen culture[b]	Unformed Stool	Closed container, RT, 2 h[a] Cary-Blair transport medium, RT, 24 h
Enterohemorrhagic *E. coli* (including *E. coli* O157:H7 and other Shiga-toxin-producing *E. coli*)	NAAT for Shiga toxin genes	Unformed Stool	Closed container, RT, 2 h[a] Cary-Blair or manufactured specified transport medium, RT, 24 h
	Shiga-toxin immunoassay	Unformed Stool	Closed container, RT, 2 h[a] Cary-Blair transport medium, RT, 24 h
	Culture for *E. coli* O157:H7[c]	Unformed Stool	Closed container, RT, 2 h[a] Cary-Blair transport medium, RT, 24 h
Yersinia enterocolitica *Vibrio* spp. *Plesiomonas shigelloides* *E. coli* Enterotoxigenic Enteroinvasive[d] Enteropathogenic[d] Enteroaggregative[d]	NAAT[e]	Unformed Stool	Closed container, RT, 2 h[a]
Yersinia enterocolitica *Vibrio* spp. *Aeromonas* spp. *Plesiomonas shigelloides* *Edwardsiella tarda*	Specialized stool cultures[f]	Unformed Stool	Closed container, RT, 2 h[a] Cary-Blair transport medium, RT, 24 h
Bacillus cereus *Clostridium perfringens*, *Staphylococcus aureus*	Specialized procedure for toxin detection[g]	Stool	Closed container, RT, 2 h
Clostridium botulinum	Mouse lethality assay, specialized culture, and toxin detection[h] (Usually performed at the State Public Health Laboratory)	Stool, enema (infant botulism), gastric contents, vomitus[i]	Closed container Store and transport specimens at 4°C. Do not freeze

Diagnostic Method of Foodborne Infections



Microbiological Analysis of Food Products: Bacterial Count



Isolation of Salmonella from Raw Meat

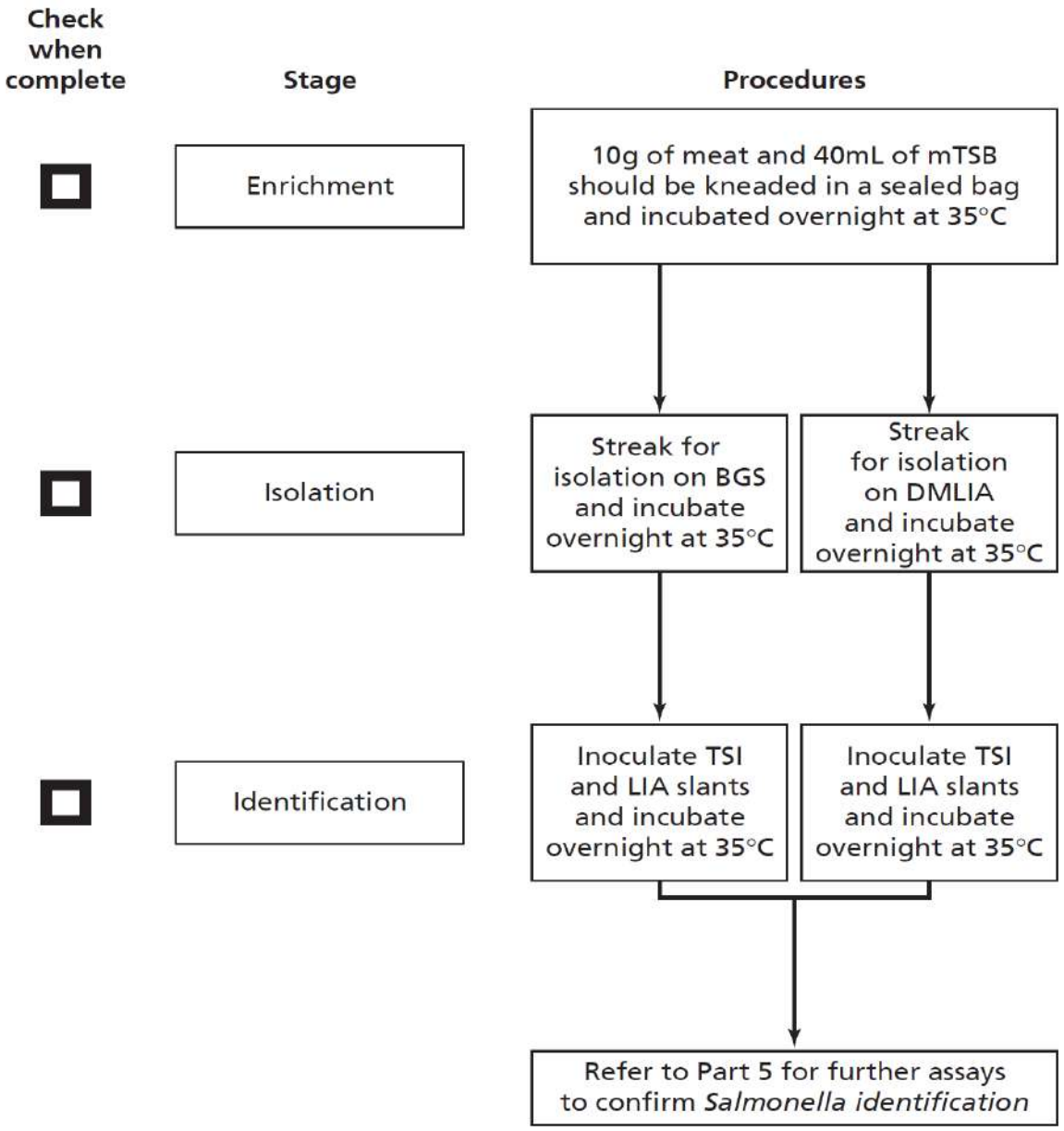
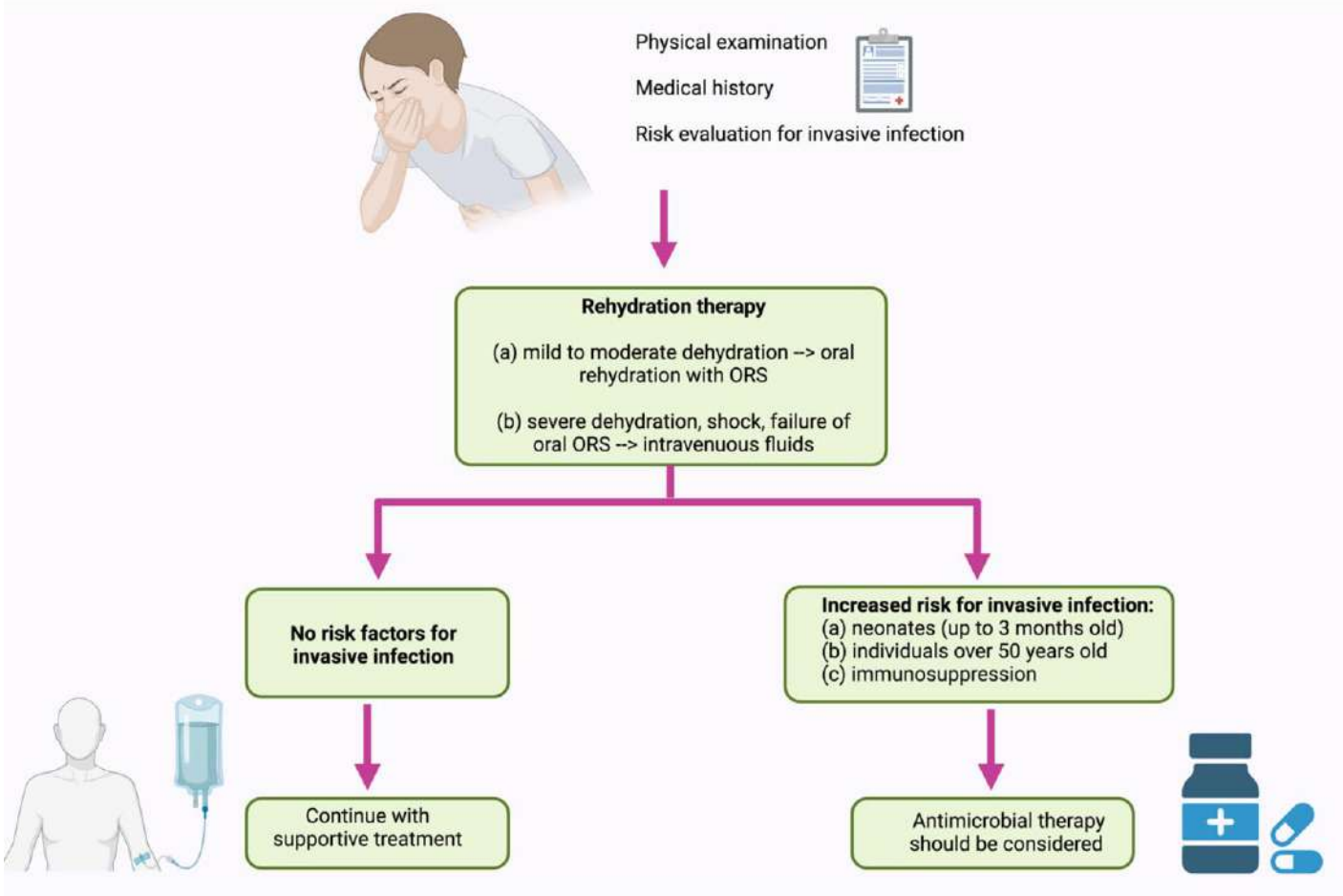
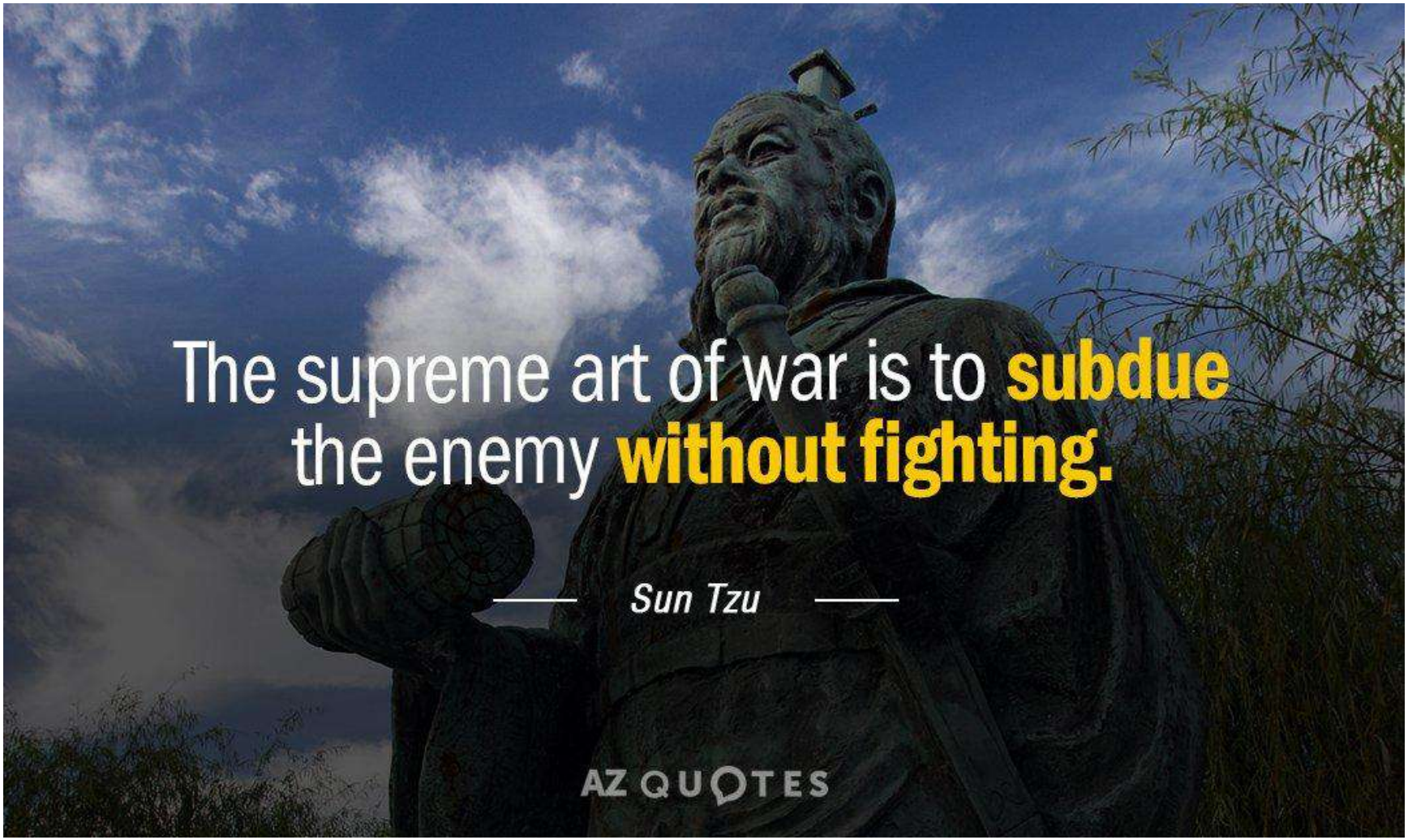


Figure 46.1 Preparation of a food sample for analysis

Management of Foodborne Infections



Strategi Perang Sun Tzu

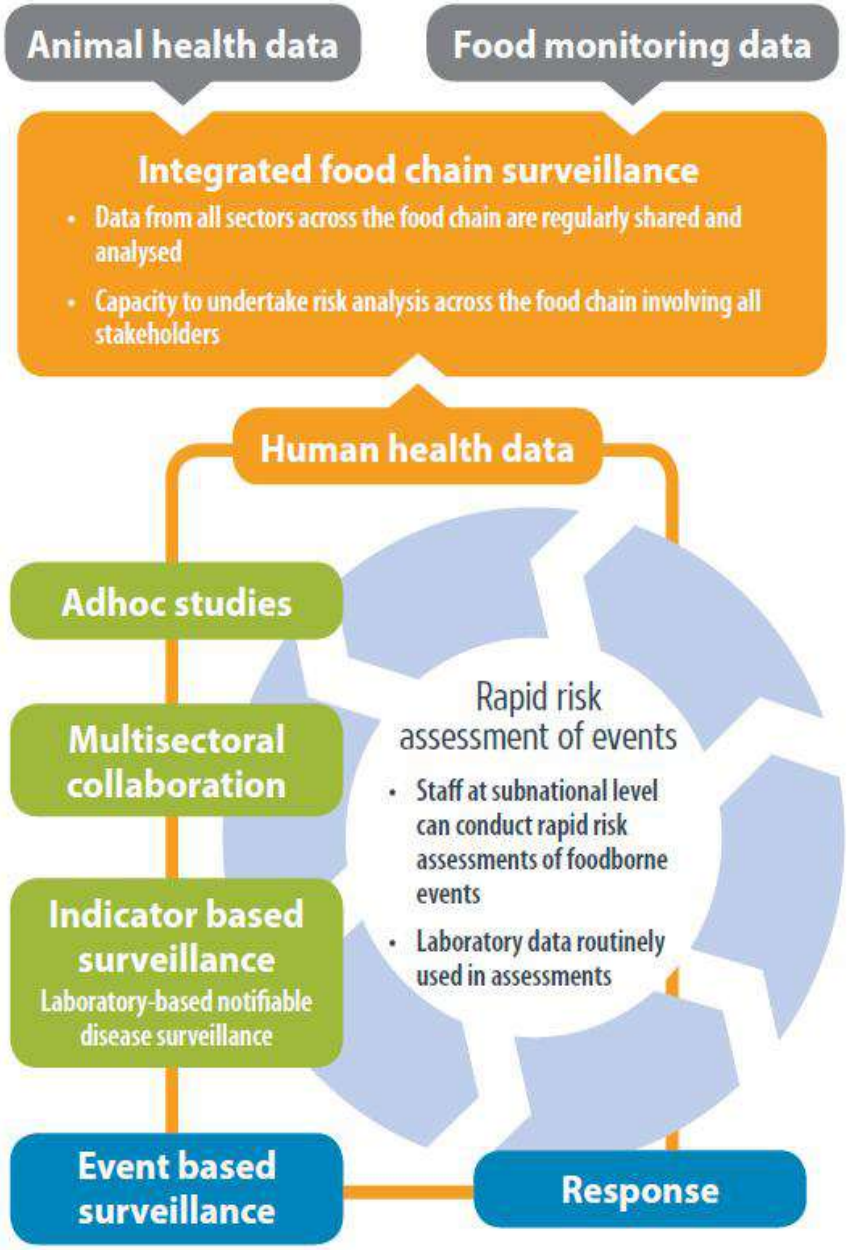


Food safety

World Health Organization

- **Food safety, nutrition** and **food security** are inextricably linked.
- An estimated **600 million** – almost **1 in 10 people** in the world – fall ill after eating contaminated food and **420 000 die every year**.
- **US$ 110 billion** is lost each year in productivity and medical expenses resulting from unsafe food in low- and middle-income countries.
- **Children under 5 years** of age carry **40% of the foodborne disease** burden, with **125 000 deaths every year**.
- **Foodborne diseases** impede socioeconomic development by straining health care systems and harming national economies, tourism, and trade.
- **Food safety** is a shared responsibility among different national authorities and requires a multisectoral, one health approach.

Surveillance



World Health Organization

Five keys to safer food

Keep clean

- Wash your hands before handling food and often during food preparation
- Wash your hands after going to the toilet
- Wash and sanitize all surfaces and equipment used for food preparation
- Protect kitchen areas and food from insects, pests and other animals

Why?

While most microorganisms do not cause disease, dangerous microorganisms are widely found in soil, water, animals and people. These microorganisms are carried on hands, wiping cloths and utensils, especially cutting boards and the slightest contact can transfer them to food and cause foodborne diseases.

Separate raw and cooked

- Separate raw meat, poultry and seafood from other foods
- Use separate equipment and utensils such as knives and cutting boards for handling raw foods
- Store food in containers to avoid contact between raw and prepared foods

Why?

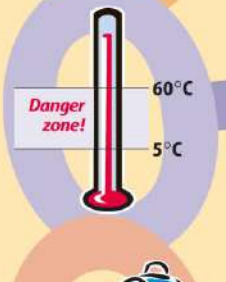
Raw food, especially meat, poultry and seafood, and their juices, can contain dangerous microorganisms which may be transferred onto other foods during food preparation and storage.

Cook thoroughly

- Cook food thoroughly, especially meat, poultry, eggs and seafood
- Bring foods like soups and stews to boiling to make sure that they have reached 70°C. For meat and poultry, make sure that juices are clear, not pink. Ideally, use a thermometer
- Reheat cooked food thoroughly

Why?

Proper cooking kills almost all dangerous microorganisms. Studies have shown that cooking food to a temperature of 70°C can help ensure it is safe for consumption. Foods that require special attention include minced meats, rolled roasts, large joints of meat and whole poultry.



Keep food at safe temperatures

- Do not leave cooked food at room temperature for more than 2 hours
- Refrigerate promptly all cooked and perishable food (preferably below 5°C)
- Keep cooked food piping hot (more than 60°C) prior to serving
- Do not store food too long even in the refrigerator
- Do not thaw frozen food at room temperature

Why?

Microorganisms can multiply very quickly if food is stored at room temperature. By holding at temperatures below 5°C or above 60°C, the growth of microorganisms is slowed down or stopped. Some dangerous microorganisms still grow below 5°C.

Use safe water and raw materials

- Use safe water or treat it to make it safe
- Select fresh and wholesome foods
- Choose foods processed for safety, such as pasteurized milk
- Wash fruits and vegetables, especially if eaten raw
- Do not use food beyond its expiry date

Why?

Raw materials, including water and ice, may be contaminated with dangerous microorganisms and chemicals. Toxic chemicals may be formed in damaged and mouldy foods. Care in selection of raw materials and simple measures such as washing and peeling may reduce the risk.

Food Safety
World Health Organization

Knowledge = Prevention

WHO/SDE/PHE/FOS/05.1
Distribution: General
Original: English

World Health Organization

Arigatou
Gozaimasu