

Module 02 - lecture 01

Microbiological hazards

Microorganisms are very small



YOGHURT

World population is
5.5 BILLION
i.e. 5 500 000 000

1 cup
of yoghurt contains
22 X this number!
i.e. **120 000 000 000**
separate living
organisms.

Microorganisms classified by their significance

- ◆ **Pathogenic organisms**
- ◆ **Spoilage organisms**
- ◆ **Useful organisms**

Dangerous microorganisms

Foodborne diseases

- ◆ **Bacteria**
- ◆ **Moulds**
- ◆ **Viruses**
- ◆ **Parasites**

Major bacteria causing foodborne disease

Aeromonas spp.

Bacillus cereus

Brucella spp.

Campylobacter jejuni

Clostridium botulinum

Clostridium perfringens

Escherichia coli

Listeria monocytogenes

Mycobacterium bovis

Salmonella spp.

Shigella spp.

Staphylococcus aureus

Vibrio cholerae

Vibrio parahaemolyticus

Vibrio vulnificus

Yersinia enterocolitica

Spoilage microorganisms

- **Bacteria**
- **Yeasts**
- **Moulds**

Food products made with useful microorganisms

- ◆ **Fermented meats**
- ◆ **Yoghurt**
- ◆ **Cheese**
- ◆ **Beer**
- ◆ **Leavened bread**
- ◆ **Soy sauce**
- ◆ **Fermented soybean (tofu)**

Useful microorganisms

Lactic acid bacteria (LAB)

These ferment carbohydrates into organic acids which inhibit

- ◆ ***Salmonella***
- ◆ ***Staphylococcus***
- ◆ ***Listeria***
- ◆ ***Clostridium***
- ◆ ***E. coli***

LAB are found in

- ◆ **Plants**
- ◆ **Soil**
- ◆ **Animals**
- ◆ **Human gut**

Major viruses causing foodborne disease

- ◆ **Hepatitis A and E viruses**
- ◆ **Small round structured viruses
(e.g. Norwalk agent)**
- ◆ **Rotavirus**
- ◆ **Polio virus**

Some toxigenic moulds causing foodborne disease

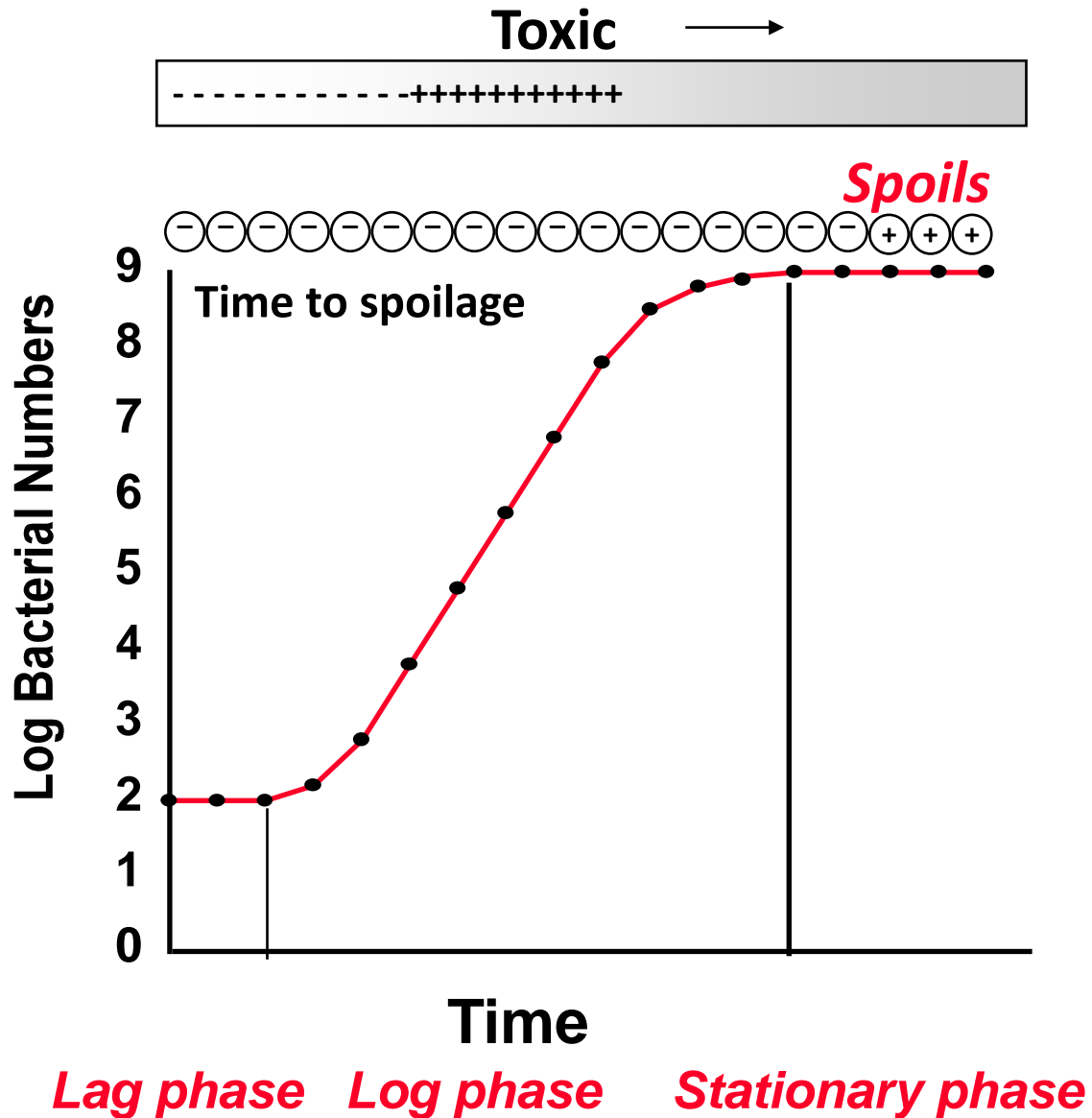
- *Aspergillus* spp.
- *Fusarium* spp.
- *Penicillium* spp.

(*Main sources - fruits, nuts and grains*)

Major parasites causing foodborne disease

- ◆ *Anisakis*
- ◆ *Ascaris*
- ◆ *Clonorchis sinensis*
- ◆ *Cryptosporidium*
- ◆ *Cyclospora cayetanensis*
- ◆ *Diphyllobothrium*
- ◆ *Echinococcus*
- ◆ *Entamoeba histolytica*
- ◆ *Fasciola hepatica*
- ◆ *Giardia*
- ◆ *Opisthorchis felinus*
- ◆ *Opisthorchis viverrini*
- ◆ *Sarcosporidium*
- ◆ *Taenia*
- ◆ *Toxoplasma*
- ◆ *Trichinella*

Bacterial growth curve



Infectious foodborne bacteria

INFECTION

**Invasion of and multiplication
within the body by**

Salmonella

Campylobacter

***E. coli* (certain strains)**

V. parahaemolyticus

V. cholerae

Y. enterocolitica

A. hydrophila

L. monocytogenes

Salmonellosis

➤ *Main symptoms*

- Diarrhoea
- Fever
- Abdominal cramps
- Vomiting

➤ *Persons at high risk*

- Young
- Old
- Pregnant women
- Immunocompromised
- Underlying disease states

➤ *Fatality rate*

- < 1%

➤ *Incubation period*

- usually 12 - 36 hours

Salmonella

2200 different serotypes

200 of which cause foodborne disease in Europe in any one year

70% cases caused by *S. enteritidis* and *S. typhimurium*

Serotypes split into subtypes called *phage-types* (PT)

Raw food materials likely to be contaminated by *Salmonella*

- ◆ Poultry
- ◆ Meat
- ◆ Milk
- ◆ Eggs
- ◆ Vegetables
- ◆ Shellfish
- ◆ Spices and herbs
- ◆ Untreated water

Thermal resistance of *Salmonella* in food

Salmonella is heat - sensitive

Pasteurization is sufficient to kill

Salmonella in high - moisture foods

Heating at 70°C for 2 min can achieve
a 6 *log* reduction in numbers

Campylobacteriosis

➤ *Main symptoms*

- Mild to severe diarrhoea
- Fever
- Nausea
- Abdominal cramps

➤ *Persons at risk*

- Babies and young people
- Debilitated people

➤ *Incubation usually 2-5 days*

Survival of *Campylobacter*

A very fragile organism, it does not survive well in food processing environments

- ◆ **Heat - sensitive**
- ◆ **Sensitive to drying**
- ◆ **Survives freezing (several months in frozen meat and poultry)**
- ◆ **Survives better at chilled conditions rather than at ambient temperatures**

Pathogenic *E. coli*

Enteropathogenic *E. coli* (EPEC)

Enteroinvasive *E. coli* (EIEC)

Enterotoxigenic *E. coli* (ETEC)

Enterohaemorrhagic *E. coli* (EHEC)

Pathogenic *E. coli*

EPEC Acute watery diarrhoea - young children particularly susceptible

EIEC Dysentery - like syndrome

ETEC Acute watery diarrhoea - often in travellers

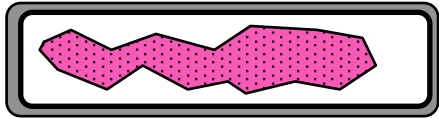
EHEC Bloody diarrhoea syndrome

Incubation 8 - 44 hours depending on type

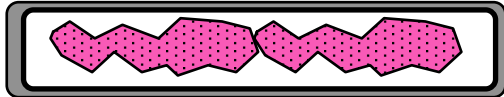
Pathogenic *E. coli* associated with foodborne disease

Type of <i>E. coli</i>	Reservoir	Source of food contamination	Cause of FBD outbreaks
<i>EPEC</i>	Man	Food handlers - sewage - environment	Rare
<i>EIEC</i>	Man	Food handlers - sewage	Soft cheese - water
<i>ETEC</i>	Man	Food handlers - sewage	Soft cheese - water
<i>EHEC</i>	Cattle	Cattle faeces - meat handling facilities Dairies	Under-cooked ground beef (hamburgers etc.) Unpast. milk

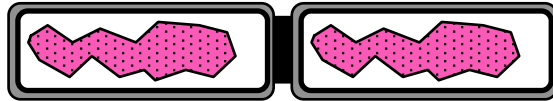
Bacterial division



1



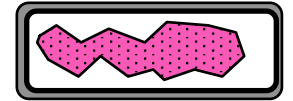
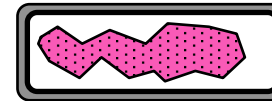
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3



4



5

Infective dose

Host

- ◆ **Age**
- ◆ **Immune status**
- ◆ **Gastric acidity - time of day**
- ◆ **Immuno - competence**
- ◆ **Nature of gut flora - carrier state**
- ◆ **Pregnancy**

Infective dose

Organism

Virulence of the strain

Vegetative cells or spores

Infective dose

Food

- ◆ **Presence of fat**
- ◆ **Acidity**

Host factors

Consequences of previous foodborne infections:

Lasting immunity

Hepatitis A

Short-term immunity

Campylobacter

V. cholerae

No immunity

Salmonella (unless a carrier)

Minimum infective dose

- ◆ EPEC 10^6
- ◆ ETEC 10^6
- ◆ *Shigella*, EIEC 10 - 100
- ◆ EHEC 10
- ◆ *L. monocytogenes* high, but probably in risk groups
c. 100/g of food
- ◆ *Salmonella* (excluding *typhi*) 10^6 (lower nos (i.e. 10-1000) may
cause infection in fatty foods
such as chocolate & cheese)
- ◆ *Campylobacter* ca. 500
- ◆ *Salmonella typhi* 10 - 100
- ◆ *V. cholerae* 10^6

Toxigenic foodborne bacteria

Intoxication due to

Toxin produced in the food

- ◆ *Bacillus cereus*
- ◆ *Clostridium botulinum*
- ◆ *Escherichia coli* (ETEC)
- ◆ *Staphylococcus aureus*

What is a toxin ?

A poison found in some animals and plants and microorganisms

**Botulinum toxin is formed when
C. botulinum grows - it is a PROTEIN**

***Approximately 500g is enough to kill
the human race !***

Characteristics of FBD due to *C. botulinum*

<i>Characteristic</i>	<i>Proteolytic type</i>	<i>Non-proteolytic type</i>
Onset	2h - 8 days	SAME
Duration	Days to several months	
Symptoms	Nausea Vomiting Visual disturbances, vertigo	
Toxic dose	0.005 - 0.1 μg	0.1 - 0.5 μg

Characteristics of FBD due to *S. aureus*

Incubation period 1 - 6h

Main symptoms at 6 - 24h

Nausea

Vomiting

Diarrhoea

Abdominal pain

***NO* Fever**

Collapse and dehydration in severe cases

Characteristics of FBD due to *Bacillus cereus*

<i>Characteristic</i>	<i>Diarrhoeal Syndrome</i>	<i>Emetic Syndrome</i>
Onset of symptoms	4 - 16 hours	1 - 14 hours
Duration of symptoms	12 - 24 hours	6 - 36 hours
Symptoms	Abdominal pain, watery diarrhoea	Nausea and vomiting
Number of bacteria in incriminated food	10^8 / g	10^8 / g

Minimum toxic doses of bacterial toxins

Minimum toxic dose (cells / g)

S. aureus

10^6

C. botulinum

$10^4 - 10^5$

C. perfringens

B. cereus

$10^7 - 10^8$

Factors affecting growth of bacteria in food

- ◆ **Temperature**
- ◆ **Time**
- ◆ **pH**
- ◆ **Water activity (a_w)**
- ◆ **Oxygen tension**
- ◆ **Preservatives**
- ◆ **Microbial interactions**

Temperature range for growth of pathogenic bacteria

Temperature °C

	<i>Min.</i>	<i>Opt.</i>	<i>Max.</i>
<i>Salmonella</i>	5	35 - 37	47
<i>Campylobacter</i>	30	42	47
<i>E. coli</i>	10	37	48
<i>S. aureus</i>	6.5	37 - 40	48
<i>C. botulinum (proteolytic)</i>	10		50
<i>C. botulinum (non-proteolytic)</i>	3.3		25 - 37
<i>B. cereus</i>	4	30 - 35	48 - 50 ¹ 43 ²

¹ = Mesophilic

² = Psychrotrophic

Temperature range for growth of toxigenic mould species

	<i>Min.</i>	<i>Opt.</i>	<i>Max.</i>
	°C	°C	°C
<i>Penicillium verrucosum</i>	0	20	31
<i>Aspergillus ochraceus</i>	8	28	37
<i>Aspergillus flavus</i>	10	32	42
(aflatoxin formation)	12	25	37
<i>Fusarium moniliforme</i>	3	25	37

Prevention of foodborne disease

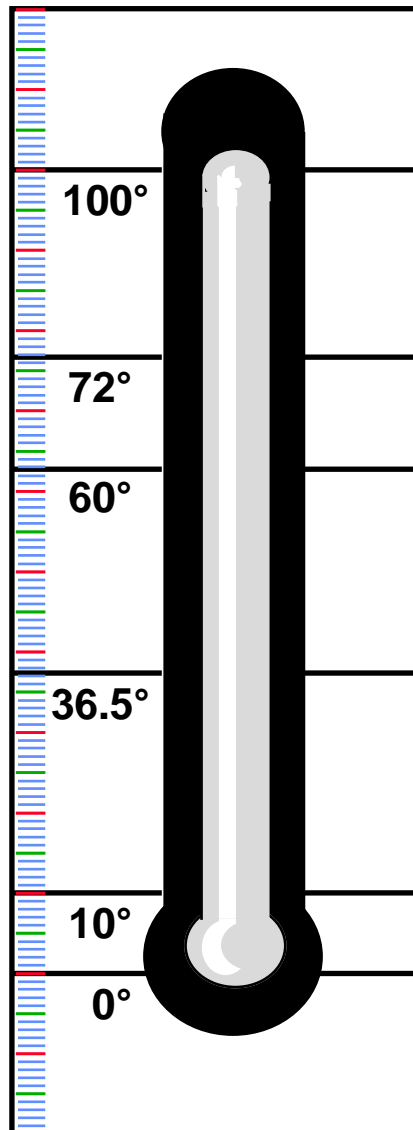
Boiling point

Pasteurizing temperature

Body temperature

Fridge

Freezer

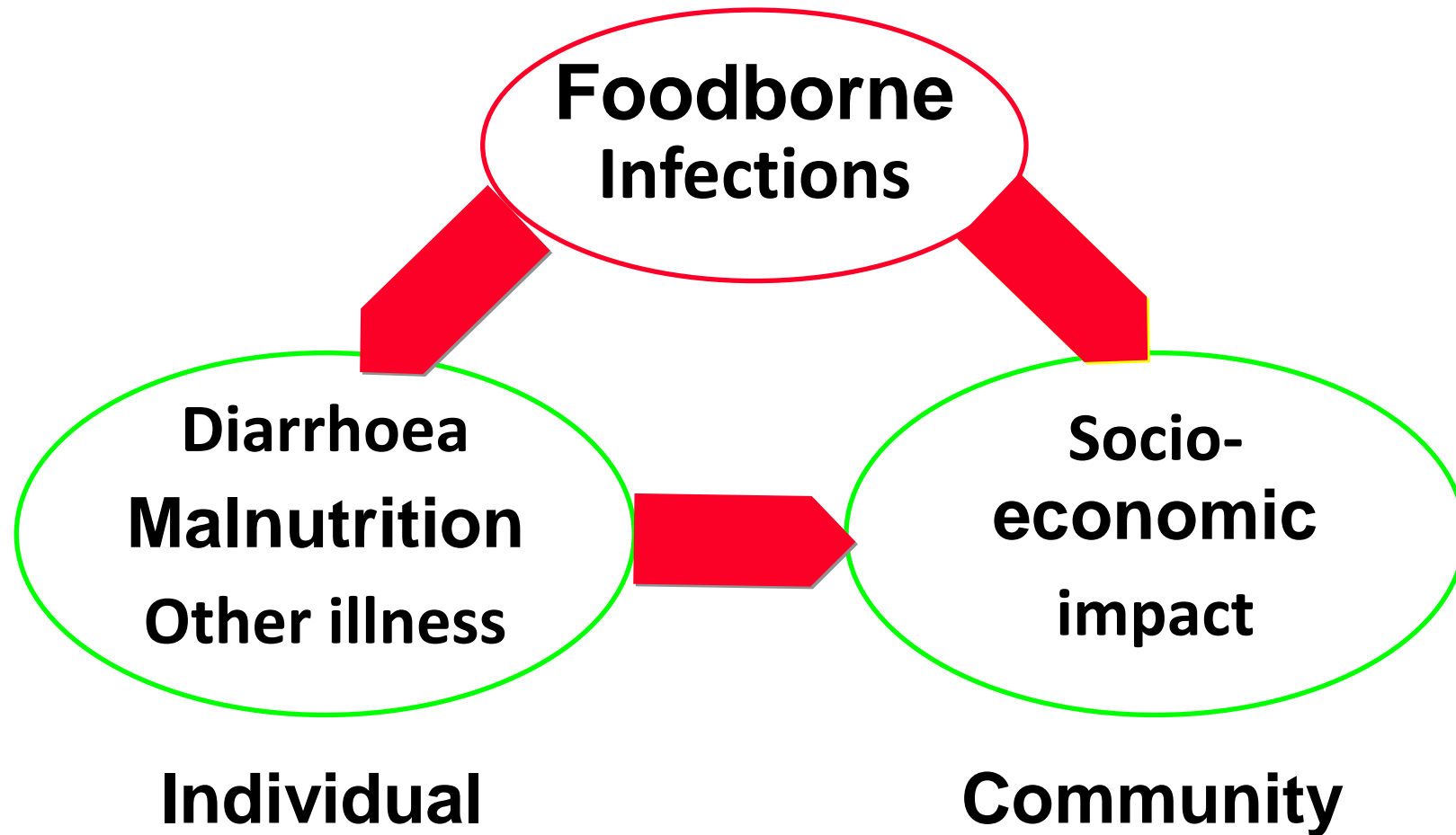


SAFETY

DANGER

SAFETY

Consequences of foodborne infections



Annual morbidity and mortality from diarrhoea

Estimates for global morbidity

2.6 episodes / child / year	1980 - 1990	Bern et al (1992)
2.2 episodes / child / year	————→ 1982	Snyder and Merson (1982)

Estimates for global mortality

3.3 million	1990	Bern et al. (1992)
4.6 million	1982	Snyder and Merson (1982)

Places where food in outbreaks was mishandled

	<i>% Outbreaks</i>	
	<i>USA</i>	<i>Canada</i>
Food service	34.0	32.6
Homes	14.7	14.6
Food processing	2.8	5.5
Retail food	-	4.1
Farms	-	0.2
Other	-	1.2
Unknown	48.5	41.8

Food handling faults in food service establishments in the USA

% Outbreaks

Inadequate cooling	64
Prepared too far in advance	39
Infected persons	34
Inadequate reheating	24
Inadequate hot storage	21
Inadequate cleaning	10
Cross-contamination	10

Major factors contributing to foodborne illness

Contamination

Cross - contamination
Unclean equipment
Unsound / unwholesome food
Chemical contamination
Insects / rodents
Infected handlers

Survival

Inadequate cooking / reheating

Growth

Insufficient cooling / hot holding

Nature of bacteria, moulds, viruses and parasites - key messages

- **Bacteria may be harmful or useful.**
- **Bacteria, yeasts and moulds can be used to preserve foods.**
- **Foodborne diseases are caused by bacteria, moulds, viruses, and parasites.**
- **Bacteria and moulds multiply on foods and may produce toxins.**
- **Viruses and parasites do not grow in food.**
- **Understanding the factors controlling growth of microorganisms allows us to control them in food.**

Infectious pathogens - key messages

- **Most FBD are caused by infectious rather than toxigenic pathogens**
- **Globally most important are**
 - *Salmonella*
 - *Campylobacter*
 - *Shigella*
 - *E. coli*
- ***Infectious dose varies widely and depends on***
 - **Host**
 - **Organism**
 - **Food**
- ***Lasting immunity is rare***
 - **Preventive measures therefore essential**
 - **Vaccine available only for hepatitis A**