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## 9.1 Infections

Infection is the adherence of pathogens and their multiplication in a host as well as the associated triggering of reactions of the host organism.

The pathogens of an infection may be bacteria, viruses, fungi, worms, protozoa or ectoparasites. The clinical picture of an infection is expressed on the basis of specific or unspecific symptoms:

- Systemic infection (sepsis): fever, chills, low blood pressure, “shock”
- Local: redness, swelling, heat, impaired function
- Organ specific: e.g. cough, headache

Laboratory test suggestive of infection:

- Increased granulocytes
- C-reactive protein
- Microbiology results

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By definition, fever is a body temperature above 38.2 °C. The causes may be inflammation (infection, disease of the rheumatoid type) or malignant tumours, but also postoperative and traumatic events can cause fever.

Infectious diseases can be classified in several ways:

- Pathogen-related
- Organ-related (pneumonia, urinary tract, etc.)
- Systemic located
- Transmitter-related (vector)
- Behaviour-related (travel diseases, venereal diseases)
- History-related (acute, subacute, chronic, recurrent, etc.)
- Immunosuppression
- Community-acquired (“outside” the hospital) vs. hospital infections (healthcare-associated infections, HAI)

Regardless of the classification of infection, the general target of infection is a rapid diagnosis including rapid pathogen identification and the initiation of targeted therapy for treatment.

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## 9.2 Diagnostics

An indispensable diagnostic measure is the collection of a detailed medical history and clinical examination (including blood pressure, pulse and temperature measurement) to determine the status of the patient. As further standard diagnostic possibilities, laboratory chemical examinations can be requested (blood count, inflammatory parameters) and blood cultures taken (each two blood culture vials), and urine culture and lung X-ray can be carried out. Specific, mostly symptom-related diagnosis includes stool culture, wound swab, lumbar puncture, etc.

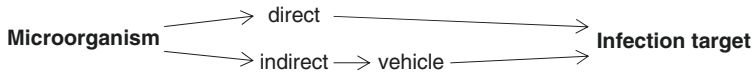
The microbiological diagnostics include:

- Direct: visualization natively (e.g. stool for worms) and microscopic (malaria, *Treponema*, Gram colour for bacteria).
- Culture.
- Tissue section (histology, special stains) with direct visual detection and/or staining.
- PCR (polymerase chain reaction). PCR is a molecular technique that allows for the rapid detection and characterization of microorganisms, including those difficult to culture; PCR methods are used in a broad range of medical diagnostic fields, including bacteriology, virology, mycology and parasitology.
- Indirect: serological tests.

If no pathogen is detected, so-called “empirical” therapy is initiated to prevent an uncontrolled progression of the infection.

### 9.3 Transmission of Infections

The basic model for the *transmission* of infections is as follows:



By direct transmission is meant direct contact with the agent, e.g. by aerosol formation when eating or coughing. Indirect contact infection occurs between a noninfected person and their environment. This can, e.g. be a contaminated object. The pathogens enter, e.g. about open wounds or the mucous membranes in the host. One form of indirect contact infection is the smear infection. It takes place faecally via the excretions of infected persons. So-called living sources of infection can be patients, visitors or hospital staff. Inanimate objects such as aqueous solutions, foods or instruments may also be a medium for pathogenic microorganisms.

The most important vehicle for indirect transmission is the *hands*. Hands are our most common working tool and are therefore most likely to be at risk of contamination. Further vehicles for the indirect transmission path are professional clothing (stomach region, sleeves), catheters, instruments, rinsing fluids, body bowl, stethoscope, dust and air (rather rare). In practice, the pathogens often find the source of infection via several vehicles: bandage → hand → instrument → patient.

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### 9.4 Healthcare-Associated Infections (HAI)

A nosocomial infection (NI) is any infection that is causally related to treatment in the hospital (or other healthcare facilities). The word nosocomial derives from the Greek “nosos” (disease) and “komein” (care). NI is the most common complication of medical care and affects all healthcare facilities (long-term care facilities, rehab centres). NI is worldwide referred to as “healthcare-associated infections” (HCAI, HAI). Nosocomial pathogens are thus pathogens of hospital infections.

By definition, an HAI is any infection that occurs in the hospital after 48 h and on entering the hospital not yet incubated. The reasons for HAI are multifactorial:

- *Patient factors* (severe underlying disease, treatment-specific factors)
- *Microbiological factors* (pathogenicity, virulence, infectivity)
- *Environmental factors* (proximity of patients to each other, lack of dispenser)
- *Technical factors* (medical devices)
- *Hygiene factors* (contamination, cleaning defects, poor hand hygiene)

Certain factors influence the transmission of a healthcare-associated infection. Reduced immune response or breaches of natural barriers (skin defects, wounds) facilitate the colonization by pathogenic or facultative pathogenic microorganisms.

<p><i>Risk factors for healthcare-associated infections</i></p> <ul style="list-style-type: none"> <li>• Age (new-born, old people)</li> <li>• Invasive measures (surgery, catheter, etc.)</li> <li>• Metabolic disorder (diabetes, etc.)</li> <li>• Cardio-circulatory diseases</li> <li>• Neurological (paralysis, etc.)</li> <li>• Oxygen deficiency in the tissue</li> <li>• Immunosuppression</li> <li>• Antibiotics</li> <li>• Most complicated examination and surgical instruments (flexiscopes)</li> <li>• Blood vessel catheter</li> <li>• High immunosuppression (stem cell transplantation)</li> <li>• Organ transplantation</li> <li>• Etc. (see table on the right)</li> </ul>	<p><i>Health status</i></p> <p>Advanced age</p> <p>Malnutrition</p> <p>Alcoholism</p> <p>Smoke</p> <p>Chronic respiratory diseases</p> <p>Diabetes</p> <p><i>Acute factors</i></p> <p>Operational intervention</p> <p>Trauma</p> <p>Combustion</p> <p><i>Invasive procedures</i></p> <p>Endotracheal or nasal intubation</p> <p>Mechanical ventilation</p> <p>Central venous catheterization</p> <p>Extracorporeal renal replacement therapy</p> <p>Lying drains</p> <p>Feeding tube</p> <p>Tracheostomy</p> <p>Urinary catheter</p> <p><i>Associated treatment</i></p> <p>Blood transfusions</p> <p>Recent antimicrobial therapy</p> <p>Immunosuppressive therapy, e.g. cortisone, etc.</p> <p>Stress ulcer prophylaxis</p> <p>“Lying position”</p> <p>Parenteral nutrition</p>
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## 9.5 Epidemiology

According to the European Centre for Disease Prevention and Control (ECDC), around 80,000 patients in Europe suffer daily from HAI. The prevalence of HAI in Europe is currently about 6%; the incidence is 7 HAI/100 hospital admissions.

The most common HAI are:

- *Urinary tract infections*: up to 35%
- *Surgical site infections*: up to 25%
- *Pneumonia*: up to 20%
- *Septicaemia*: up to 7%

Around 8% of these infections are ultimately the direct cause of death of those affected.

The consequences of an HAI have great individual as well as socioeconomic significance. Not only is the hospital stay extended by the infection (on average 7 days), but the treatment takes longer and becomes more expensive (rehabilitation). For working patients, this leads to a loss of earnings or production, and elderly

people often end up in disability or retirement. Eight out of 100 patients die as a result of NI.

Hospital infections rarely occur epidemically (only about 5%); there is rarely an outbreak of HAI. The vast majority (95%) of NI is sporadic (endemic) and must be sought to fully capture them.

### 9.5.1 Surgical Site Infection (SSI)

Surgical site infections (SSIs) are the most common type of nosocomial infections in low- and middle-income countries (from 1.2% to 23.6%) and affect up to one third of patients who have undergone a surgical procedure. Although SSI incidence is much lower in high-income countries, it remains the second most frequent type of HAI in the USA and the most common type in some European countries. According to 2015 European Centre for Disease Prevention and Control (ECDC) surveillance report, colon surgery has the highest prevalence in Europe with 9.6 episodes per 100 operations, followed by 2.9 for coronary artery bypass graft, 1.7 for caesarean section, 1.4 for cholecystectomy, 1.1 for hip prosthesis, 0.8 for laminectomy and 0.6 for knee prosthesis. The distribution of microorganisms that cause SSIs varies by type of surgical procedure. Gram-positive cocci are the most commonly reported for coronary artery bypass graft, hip and knee prosthesis, laminectomy and caesarean section. For gallbladder and colon operations, the majority of the responsible microorganisms are *Enterobacteriaceae*. SSI may cause poor wound healing, further antibiotic treatment, additional surgical procedures, organ failure, longer postoperative hospital stays, higher mortality and higher healthcare costs. It can occur in the incision skin area (superficial SSI), beneath the incision area in the muscle and the tissues surrounding the muscles (deep SSI) or in a body organ or a space between organs (organ SSI). SSI typically occurs within 30 days after surgery, and the proportion of SSI diagnosed in-hospital varied from 17% in caesarean sections to 67% in colon operations.

### 9.5.2 SSI Post Caesarean Section

Surgical site infection (SSI) is one of the most common complications following caesarean section and has an incidence varying worldwide from 3% to 15%.

Most wound infections do not become clinically apparent until postoperative days 4–7, when most women have already been discharged from the hospital. Since early treatment has an important role in preventing severe consequences, it is essential to instruct these women on signs and symptoms requiring further evaluation.

Risk factors can be divided into three categories:

1. Host-related factors (age, morbidity, pregestational diabetes mellitus and previous caesarean delivery)

2. Pregnancy and intrapartum-related factors (hypertensive disorder, gestational diabetes mellitus, twin pregnancy, preterm rupture of membranes, greater number of vaginal examinations)
3. Procedure-related factors (emergency delivery, caesarean hysterectomy, surgery duration of more than 60 min).

The infections after caesarean section are usually caused by Gram-positive cocci, although a polymicrobial infection consisting of both aerobic and anaerobic organisms is not rare.

Besides daily inspection of the caesarean incision, evidence-based interventions may significantly reduce post-caesarean delivery wound complications:

1. Appropriate timing of perioperative prophylaxis (before the skin slit)
2. Alcohol-based antiseptic solutions based on chlorhexidine for surgical site skin preparation

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## 9.6 Antimicrobial Resistance and Healthcare-Associated Infections

The abusive administration of broad-spectrum antibiotics led to the development of resistance to standard antibiotics. Today, the development of new antibiotics does no longer keep in pace with the development of resistance of the microorganisms. This can lead to expensive, elaborate therapies. Increasingly, there are untreatable infections.

The WHO published a list of multiresistant bacteria for which new antibiotics are urgently needed, the WHO priority pathogens list for research and development of new antibiotics (see Chapter 11, multidrug-resistant microorganisms).

The complications of NI can range from localized wound infection to fulminant sepsis.

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## 9.7 Prevention of Healthcare-Associated Infections

As the effects of antibiotics are decreasing, the focus is on prevention through basic hygiene measures:

- Hand hygiene.
- Spatial separation between infectious and non-infectious patients.
- Adequate cleaning and reprocessing of medical devices and objects with which patients come in contact.
- In the prevention of HAI, two important approaches are antisepsis and asepsis:

- Asepsis: measures to prevent contamination, e.g. through barriers (gloves, tweezers)
- Antisepsis: control of microorganisms by disinfection, sterilization and conditional cleaning

For details on hygiene measures in hospitals, see also chapter “Multidrug-Resistant Pathogens and Hygiene”. For hand hygiene, see chapter “Hand Hygiene”.

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## 9.8 Surveillance of HAI

There are several tools available to detect and monitor HAI. *Prevalence* studies (1 day, 1 week), *incidence* studies (continuous monitoring of all incidences for extended periods, surveillance) or *outbreak* investigations with case-control or cohort studies are used as appropriate to describe HAI and to recognize HAI (see chapter “Epidemiology”).

*Surveillance* is the systematic, continuous collection, analysis and interpretation of relevant data on healthcare-associated infections. This data collection can be used to provide feedback to the medical and nursing staff, thus reducing the frequency of HAI. Surveillance is also a form of internal quality assurance. The informative value and effectiveness is increased if one’s own data on infection frequencies are compared with those of others (clinics, departments, etc.). Only in the context of the data of other departments, the measure of their own infection frequency is assessable. In order not to draw wrong conclusions, a comparison is only possible if identical methods are used to collect the data.

*HAI-Net* (Healthcare-Associated Infections Surveillance Network) is a network that has been providing anonymized data on healthcare-associated infections in European hospitals since the beginning of the 2000s. The network is now coordinated as a permanent agenda of ECDC, which publishes Austrian data at regular intervals compared to data from other European countries (<http://ecdc.europa.eu/>).

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## Further Reading

European Centre for Disease Prevention and Control. Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals. Stockholm: ECDC; 2013. ISBN 978-92-9193-485-0. <https://doi.org/10.2900/86011>.

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WHO Report on the burden of endemic health care-associated infection worldwide. A systematic review of the literature. Geneva: World Health Organization; 2011.