LECTURE No. 1: SUSTAINABLE DEVELOPMENT GOALS AND MEDICINE. LIFE CYCLE ASSESSMENT AND CARBON FOOTPRINT

Duration: 2 academic hours (90 minutes)

INTRODUCTION: WHY SHOULD A PHYSICIAN THINK ABOUT ECOLOGY?

Dear students!

Let us begin our lecture with an unusual question. Imagine: you prescribe a course of antibiotics to a patient, perform surgery, or simply write a prescription. Do you think there is a connection between your professional decision and the melting of glaciers in the Arctic?

At first glance — no. But if you dig deeper, such a connection exists. Every medical product — from a surgical mask to an MRI machine — has its own environmental footprint. It is produced from raw materials that are extracted, processed, and transported. After use, it is disposed of. At each stage, greenhouse gases are emitted, waste is generated, and water and energy are consumed.

The World Health Organization calls climate change **the greatest threat to global health in the 21st century**. At the same time, the healthcare sector makes a significant contribution to this problem. Medical activity generates about **4-5% of global greenhouse gas emissions** — more than aviation or shipping.

But there is also good news: it is physicians who can become part of the solution. **The goal of today's lecture** is to lay the foundation for understanding how every medical worker can contribute to sustainable development in their workplace.

We will examine three key questions:

1. What are the UN Sustainable Development Goals and why are they important for a physician?
2. How to assess the environmental impact of a medical product throughout its life?
3. What is a carbon footprint and how is it calculated in healthcare?

1. GLOBAL CONTEXT: UN SUSTAINABLE DEVELOPMENT GOALS AND THEIR ADAPTATION TO HEALTHCARE

From the Millennium Goals to the Sustainable Development Goals

In 2015, the United Nations adopted the **17 Sustainable Development Goals (SDGs)**, which came into force on January 1, 2016. This document became the successor to the Millennium Development Goals and covers all three aspects of sustainability: **economic, social, and environmental**.

The key principle of the SDGs is **"no one should be left behind."** This means that progress must be equitable and reach the most vulnerable population groups.

Which SDGs are directly related to healthcare?

Almost all 17 goals are either directly related to health or indirectly contribute to its improvement. However, let us highlight the most relevant:

SDG	Name	Connection to healthcare
SDG 3	Good health and well-being	Ensuring a healthy lifestyle for all ages. Includes 13 targets — from fighting infections to non-communicable diseases and mental health
SDG 6	Clean water and sanitation	Access to safe water and proper sanitary conditions — the basis for infection prevention in healthcare facilities
SDG 7	Affordable and clean energy	Energy efficiency of medical equipment and transition to renewable energy sources
SDG 11	Sustainable cities and communities	Impact of air quality and the urban environment on public health
SDG 12	Responsible consumption and production	Medical waste management, sustainable procurement, life cycle assessment of products
SDG 13	Climate action	Adaptation of healthcare systems to climate change

Key idea: universal health coverage permeates all health-related goals and reflects the strong emphasis of the SDGs on equity and reaching the most disadvantaged people.

The "One Health" Concept

Human health is inextricably linked to animal health and the state of the environment. This concept has gained widespread recognition in response to such threats as:

- Zoonotic infections (COVID-19, Ebola, avian influenza)
- Antibiotic resistance (uncontrolled use of antibiotics in medicine and animal husbandry)
- Water and air pollution

For the physician, this means: it is impossible to treat a patient while ignoring the environment in which they live. The air they breathe, the water they drink, the food they eat — all of these are determinants of their health.

The Role of Healthcare in Achieving the SDGs

Healthcare systems are not only exposed to environmental problems but also create an environmental burden themselves. Therefore, the mandate of the healthcare sector includes tasks to **improve environmental efficiency and reduce environmental impact**.

Key categories of environmental consequences of healthcare system activities:

1. **Medical waste** — the healthcare sector is one of the largest sources of waste
2. **Wastewater** — hospitals produce significant volumes of wastewater
3. **Greenhouse gas emissions** — direct and indirect emissions from medical activity

2. ENVIRONMENTAL FOOTPRINT OF MEDICAL ACTIVITY

Main Sources of Impact

Before talking about assessment, let us understand what exactly in medical activity creates an environmental burden.

1. Medical waste

- The healthcare sector generates huge volumes of waste
- From 75% to 95% of waste is close in composition to ordinary household waste
- Hazardous medical waste requires special handling and can pose a serious risk to human health and the environment

2. Energy consumption

- Ventilation and air conditioning (HVAC systems)
- Sterilization of equipment
- Operation of diagnostic equipment (MRI, CT — the most energy-intensive)
- Lighting

3. Water consumption

- Laundry of linen and clothing
- Instrument processing
- Cooling systems

4. Greenhouse gas emissions

- Anesthetic gases (sevoflurane, desflurane — powerful greenhouse gases)
- Transport (ambulances, service vehicles)
- Procurement of goods and services (Scope 3 — up to 70% of all emissions)

The Vicious Circle

Pollution from the activities of healthcare organizations → Climate change → Increase in climate-sensitive diseases → Increased burden on healthcare.

This vicious circle is broken precisely through **sustainable development** and the **"green transition"** in medicine.

Categories of Actions to Improve Environmental Sustainability

Category	Examples of actions
Reduction and rational disposal of medical waste	Minimization of waste, personnel training, replacement of hazardous chemicals
Rational use of resources	Economical water use, energy saving, sustainable design
Sustainable procurement	Establishment of environmental criteria, life cycle analysis of goods

Reduction of emissions	Carbon footprint assessment, transition to low-carbon energy sources
Disease prevention	Intersectoral cooperation, promotion of healthy conditions
Innovative models of care	Telemedicine, digital healthcare

3. LIFE CYCLE ASSESSMENT (LCA) OF MEDICAL PRODUCTS

What is LCA and why is it needed?

Life Cycle Assessment (LCA) is a methodology for quantitative assessment of a wide range of environmental impacts, including global warming, throughout the entire life cycle of products, processes, and systems.

LCA allows making **informed environmental decisions** when comparing products that perform the same function.

Stages of the life cycle of a medical product

Imagine any medical product — a scalpel, a mask, a medication, an MRI machine. It goes through several stages:

Raw material extraction → Production → Packaging and transportation → Use → Disposal

1. Raw material extraction

- Metals for instruments (ore mining)
- Oil for plastic (for disposable products)
- Chemicals for medications

2. Production

- Energy costs at the factory
- Emissions during production
- Use of water and chemicals

3. Packaging and transportation

- Packaging materials (often plastic)
- Logistics, cooling (for vaccines)
- Global supply chains

4. Use

- Sterilization (energy, water, chemicals)
- Energy consumption during operation
- Consumables

5. Disposal

- Incineration
- Landfilling
- Recycling (where possible)

How is LCA conducted?

There are different approaches to conducting LCA:

Type of LCA	Description
Process-based LCA	"Bottom-up" — uses detailed, product-specific data. There are two types: • Attributional: assesses current impacts within a defined scope • Consequential: assesses how a decision may create larger-scale consequences
Economic input-output LCA (EIO-LCA)	"Top-down" — uses economic data at the sector level to assess large systems
Hybrid LCA	Combines both approaches to balance accuracy and completeness

Examples of LCA in medicine

Example 1: Disposable and reusable sensors in the operating room

A study compared two sensors for monitoring neuromuscular transmission in the operating room — disposable and reusable. Both performed the same clinical function with the same accuracy and safety.

Result: In terms of CO_2 emissions per single application per patient, the **disposable sensor turned out to be the more sustainable choice**.

This example shows: "disposable" does not always mean "bad." In some contexts, sterilization of a reusable product requires so much energy and water that the environmental footprint is higher.

Example 2: Hemodialysis

Studies show that in-hospital hemodialysis has the greatest impact on all environmental categories:

- Greenhouse gas emissions from in-hospital dialysis are 62.3% higher than from home hemodialysis
- Travel by patients and personnel contributes 40% of the total impact in in-hospital dialysis

Conclusion: LCA data help make decisions about where and how to provide care.

Features of LCA in healthcare

It is important to understand: **there are no universal LCA data**. Results depend on regional characteristics:

- Source of electricity (renewable or coal)
- Type of practices and protocols

- Distances for transporting patients and personnel

For example, in the Canadian province of British Columbia, the main energy source is hydropower (grid intensity 0.0113 kg CO_2/kWh), whereas in a coal region this figure can reach 0.47 kg CO_2/kWh — a difference of more than 40 times.

4. CARBON FOOTPRINT OF A HEALTHCARE ORGANIZATION

What is a carbon footprint (Carbon Footprint)?

A carbon footprint is the total amount of greenhouse gases (CO_2, CH_4, N_2O, and others), expressed in units of **CO_2 equivalent**, that is emitted by an organization as a result of its activities.

In essence, a carbon footprint is an **LCA focused only on the impact on climate change**.

Three categories of emissions: Scope 1, 2, 3

The system based on the **Greenhouse Gas Protocol** distinguishes three types of emissions:

Scope 1 — Direct emissions

Emissions from sources that the organization owns or directly manages:

- Fuel combustion in its own boiler houses
- Emissions of anesthetic gases (sevoflurane, desflurane, nitrous oxide)
- Vehicles on the balance sheet (ambulances, service transport)
- Refrigerants (leaks from air conditioning systems)

Scope 2 — Indirect emissions from purchased energy

- Electricity purchased from external suppliers
- Heat and steam

Scope 3 — Other indirect emissions

This category accounts for up to **70% of all emissions** of healthcare organizations. It includes:

- Procurement of goods and services (medications, medical products, consumables)
- Waste management
- Travel by personnel and patients
- Production, packaging, and transportation of medications
- Nutrition of patients and personnel
- Capital costs (buildings, equipment)

How to calculate a carbon footprint?

Basic formula:

Greenhouse gas emissions = Activity data × Emission factor

Activity data — how much of what was consumed:

- kWh of electricity
- liters of fuel
- kilometers of transport
- kilograms of waste
- tons of purchased materials

Emission factor shows how many greenhouse gases are emitted per unit of consumption.

Example of calculation for a typical department

Suppose we want to calculate the carbon footprint of a surgical department for a year:

1. **Data collection:**
    - Electricity consumption: 500,000 kWh
    - Gas consumption: 50,000 m^3
    - Number of operations: 1,000
    - Volume of waste: 20 tons
    - Amount of purchased consumables: 5,000,000 som
2. **Calculation (simplified):**
    - Scope 1 (gas): 50,000 m^3 × 0.2 t CO_2/1000 m^3 = 10 t CO_2
    - Scope 2 (electricity): 500,000 kWh × 0.4 kg CO_2/kWh = 200 t CO_2
    - Scope 3 (procurement): 5,000,000 som × 0.05 kg CO_2/som = 250 t CO_2
3. **Total:** ~460 t CO_2 per year

Tools for calculation

In Germany, a free tool **KliMeG-Rechner** has been developed based on the Greenhouse Gas Protocol, which allows clinics to calculate their emissions. The tool takes into account:

- Direct emissions from fuel combustion and anesthetic gases
- Indirect emissions from electricity
- Emissions throughout the supply chain (Scope 3)

Similar calculators are being developed in other countries, and this approach is gradually becoming a global standard.

Steps for managing a carbon footprint

1. **Data collection** — collect data from energy consumption, procurement, transport, and waste accounting systems
2. **Determining the baseline** — calculate current emissions as a reference point
3. **Setting a reduction target** — for example, a 50% reduction by 2030
4. **Developing a strategy** — identifying key sources and planning measures

5. **Monitoring progress** — regularly tracking changes
6. **Public reporting** — transparency for patients and society

5. THE ROLE OF THE PHYSICIAN AND NURSE IN ACHIEVING ENVIRONMENTAL SUSTAINABILITY

At the micro level: the workplace

Every medical worker can contribute to sustainable development:

1. Rational prescribing

- Fewer unnecessary tests and procedures = less waste and emissions
- Audit of prescriptions for redundancy

2. Environmentally conscious choice

- Preference for anesthetics with lower global warming potential
- Choice between disposable and reusable products based on LCA data
- Participation in "green procurement"

3. Resource conservation

- Turn off lights and equipment when not needed
- Careful use of water
- Proper waste sorting

4. Exemplary behavior

- Personal example — the basis for forming a culture of sustainability in the team

At the macro level: patients and society

The physician is an authoritative source of information for the population:

1. Climate-informed counseling

- Explaining the link between air pollution and diseases (COPD, bronchial asthma, cardiovascular diseases)
- Recommendations on behavior during periods of high air pollution or extreme heat

2. Promotion of a healthy lifestyle with an environmental emphasis

- Active transport (walking, cycling) is good for both health and the climate
- Rational nutrition — less food waste and emissions

3. Participation in the development of environmental culture in the healthcare organization

- Proposals for improving the waste management system
- Participation in energy-saving projects

CONCLUSION

Key conclusions of the lecture:

1. **Climate change is a medical problem.** WHO calls it the greatest threat to global health, and the healthcare sector itself is part of this problem.
2. **The Sustainable Development Goals (SDGs) set the direction.** The 17 SDGs adopted by the UN cover all aspects of sustainability — economic, social, and environmental. Healthcare is connected to almost all of them.
3. **Life Cycle Assessment (LCA) is a tool for comparison.** LCA allows quantitative assessment of the environmental impact of medical products at all stages — from raw material extraction to disposal.
4. **The carbon footprint is the part of LCA focused on climate.** The three categories of emissions (Scope 1, 2, 3) help systematize sources and develop reduction strategies.
5. **The physician's role is key.** Environmentally sustainable healthcare begins with every medical worker — at the workplace and in communication with patients.

Connection to project work

The knowledge of LCA and carbon footprint gained today will be directly needed for completing **group projects** (ISW). You will need to assess the environmental impact of a chosen medical unit and propose practical measures to improve its sustainability.

Questions for reflection

1. **Can a disposable product be more environmentally friendly than a reusable one? Give an example.** (Answer: Yes, as shown by the example with operating room sensors — if sterilization of the reusable one requires a huge amount of energy and water).
2. **Which of the three Scopes is the most difficult to measure and reduce, and why?** (Scope 3 — due to the complexity of collecting data across the entire supply chain).
3. **What simple actions at your workplace could reduce the carbon footprint?** (Turning off equipment, proper waste sorting, using reusable products where it is safe).

RECOMMENDED LITERATURE

1. WHO. "Health in 2015: from MDGs to SDGs"
2. Nunziato JD, et al. "Environmental Life Cycle Assessment in Medical Practice: A User's Guide"
3. Guide to calculating the carbon footprint of clinics (KliMeG-Projekt)
4. National Academy of Medicine USA. "Carbon Accounting 101"