

N.O. VYNOGRAD

GENERAL EPIDEMIOLOGY

2nd edition, corrected

RECOMMENDED

by the Ministry of Education and Science
of Ukraine as a study guide for students
of higher medical education institutions
of the 3rd—4th levels of accreditation

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The study guide was prepared according to the typical syllabus for Epidemiology with due account of the qualification description and standards of training on the basis of regulatory and binding documents of the Ministry of Health of Ukraine. The book sets out in concise detail the fundamentals of general epidemiology and approaches to prevention of epidemiological complications, protection of the population and territory from the spread of infectious diseases.

The study guide is intended for students and internship doctors of higher medical education institutions of the 3rd—4th levels of accreditation.

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Preface

Introduction of the new generalized epidemiology programs into the educational process of higher medical education establishments of Ukraine of the 3rd–4th levels of accreditation is related to synchronization of the Ukrainian system of medical education with the standards of the European Higher Education Area in the context of the Bologna process.

Students have an opportunity to use this manual during preparation for practical classes and to master basic theoretical knowledge, which will allow them to practice skills during classes. The knowledge of epidemiology fundamentals concerning preventive measures in the society and on a certain territory are represented step by step: basic methods of blocking the sources of infectious agents (Topics 1 and 2), disruption of the mechanisms of infectious agent transmission (Topic 2), specific protection of population by vaccination, estimation of the efficiency of scheduled immunization and features of urgent vaccination (Topics 3 and 4). Considerable attention is paid to the mastering of modern evidential methods of population phenomena study, including distribution of causative agents of infectious diseases among people, planning and implementation of preventive measures and countermeasures on a certain territory (Topic 5). In Topic 6 the basic elements of analytical and experimental research, which enable students to write an independent work (Chapter 7 of the general *Epidemiology* program, Ukraine, ratified by MoPH on 22.12.2008), are laid out. Each topic ends with control questions, case study, and tests with answers to them; this gives a possibility to self-control one's knowledge.

The change of the legislative framework of the service activity has stipulated the necessity of introducing additional information into the study guide (Topics 3 and 4, Appendixes 4 and 6), which was done in the third edition.

The Appendixes provide basic information materials needed for performance of practical tasks, a list of recommended literature and normative legal documents, which regulate realization of measures of influence on the development of the epidemic process.

THE DOCTRINE OF THE EPIDEMIC PROCESS. COUNTERMEASURES IN THE FOCI OF INFECTIOUS DISEASES. ANTI-EPIDEMIC WORK OF A DISTRICT (FAMILY) PHYSICIAN AND AN INFECTIOUS DISEASE SPECIALIST

THE DOCTRINE OF THE EPIDEMIC PROCESS

The epidemic process (EP) doctrine is the basic theory of epidemiology of infectious diseases.

Epidemiology is an independent branch of medical science that studies objective laws of occurrence, distribution, and cessation of infectious diseases in a human society, and is aimed at prevention, control, and final eradication of these diseases.

The subject of epidemiology is EP.

Epidemic process is a complex social-biological phenomenon, which arises owing to interaction of micro- and macroorganisms at the population level resulting in specific infectious conditions of people (disease or carrier state) and provides preservation of an agent in the nature as a biological species. EP can be described as a chain of interconnected infectious conditions in a human society. It arises and is supported only in the presence and interaction of three elements – a source of an agent of infection (SAI), a mechanism of transmission of an agent of infection (MTAI), and a susceptible organism, with all of them consistently recreating (Fig. 1). Above specified three links of EP are the **primary driving forces**. The natural and social phenomena, which predetermine quantitative and qualitative changes of EP by means of influence on its primary driving forces, are referred to as **secondary driving forces**.

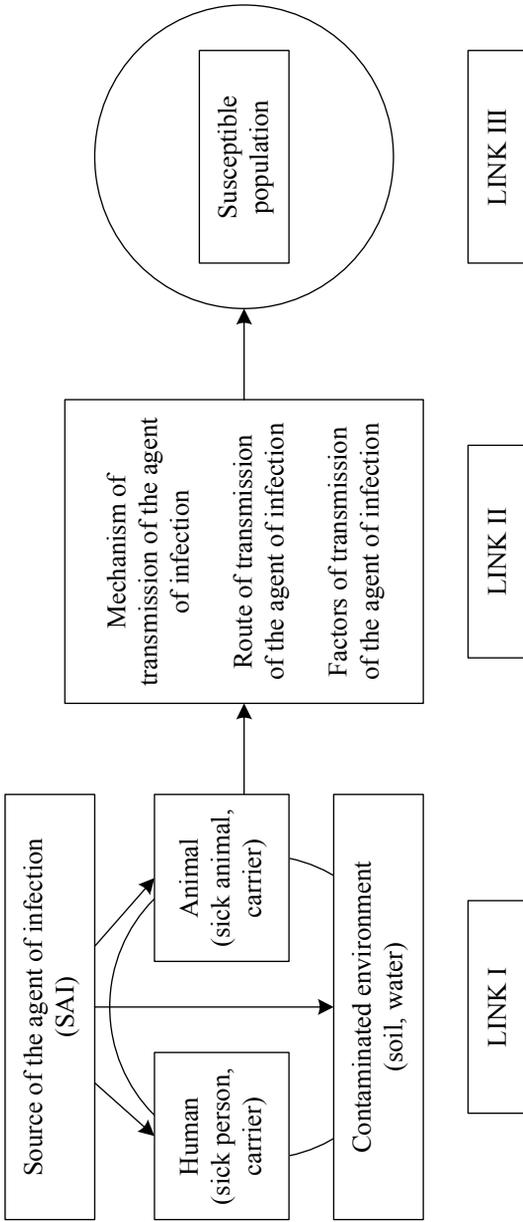


Fig. 1. Structure of the epidemic process

The object of epidemiology is infectious condition (diseases and carrier states).

The source of an infectious agent is an object that is a site of natural habitation, multiplication (replication), accumulation of pathogenic microorganisms and from which the agent gets to the environment. Three groups of SAI are distinguished: basic, additional, and casual.

Basic SAI is the infected organism of a human or an animal, or the environment, all of which are the natural place of agent habitation. All the basic SAI are called the **reservoir** of infection. The reservoir of infection is that biological species (human, animal, or environment), which provides the existence of the agent in the nature as a biological species.

Additional SAI is the infected organism of a human or an animal, which under certain conditions serves as a temporary place of multiplication of the agent and can be a potential SAI for the surrounding people. Additional SAI cannot provide the existence of the agent as a biological species.

The causal SAI is an object, into which an agent penetrates and where it is accumulating, but from which the agent can extremely seldom get out, therefore it has no practical epidemiological importance.

Infectious diseases, for which the reservoir of an agent is the biological species *Homo sapiens*, are called **anthroponoses** (typhus fever, poliomyelitis, diphtheria, measles, etc.). If the reservoirs of agents of infectious diseases are animals, such infectious diseases are referred to as **zoonoses** (brucellosis, leptospirosis, Q fever, plague, anthrax, etc.). An important role in the emergence of human infectious diseases is played by domestic **animals and birds**, which under certain conditions are SAI. To assess their epidemiological significance one should take into account their spatial distribution, conditions of their management, and the contacts with human, especially the biological cycles of development. According to the degree and type of contacts with people animals and birds are divided into: farm (domestic), guarding, decorative; synanthropic, semi-synanthropic, exanthropic (wild).

Some pathogenic for a human microorganisms can persist and even accumulate for an indefinite period of time (preserving themselves as a biological species) in objects of the environment: soil, water, which in these cases are reservoirs of infection. These infectious diseases are referred to as **sapronoses**.

Two types of SAI are distinguished: patients and carriers.

A **carrier** is a human or an animal, in which the presence of pathogenic microorganisms is not accompanied by clinical manifestation of a disease.

Duration of a disease differs among **acute** and **chronic** infectious diseases. The greatest epidemic danger is created by infectious patients with

an acute course of a disease. These patients constantly excrete infectious agents into the environment in a significant amount. In chronic diseases agents are excreted for a long period of time, but in smaller quantities. The greatest epidemic significance is ascribed to the periods of disease aggravation, when agent excretion increases, or the period of disease relapse, when agent excretion renews after a period of remission.

The clinical picture of an infectious disease can be **typical** or **atypical** and of different severity. The most massive excretion of infectious agents is observed in severe and moderate disease, but epidemic significance of these patients is less than that of persons with mild disease, because the first two categories of patients are necessarily hospitalized. People with a mild, atypical form of a disease are of great epidemic danger because of the difficulty of their identification and diagnostics.

The course of an infectious disease has the following **periods**:

1. Incubation (latent) – from the moment of infection until the first clinical manifestations of disease.

2. Prodromal – the first days of disease from the incubatory period up to typical clinical manifestations.

3. The period of typical clinical manifestations. It is the peak of disease (the process or the greatest expression of clinical symptoms).

4. Convalescence (recovery).

Essential epidemic significance is ascribed to such disease periods:

1. Incubation period, if in its second half or in the end there begins excretion of infectious agents (because of the absence of symptoms in this period the person continues to stay among his/her coworkers and thus spreads the agents of the disease).

2. Prodromal (premonitory) period – the period when there are still no typical manifestations of a diseases, but plenty of agents are being excreted. In this period clinical diagnostics, duly isolation, hospitalization, and treatment of the patient are not yet possible.

3. During the period of typical clinical manifestations in certain infectious diseases plenty of agents are excreted by the patient, but if the infected person is isolated and hospitalized during this period, the epidemic significance of this one is less than in the two previous cases.

4. The period of convalescence is characterized by gradual disappearance of clinical symptoms, but recovery is not always accompanied by clearing of the patient's organism from infectious agents. Thus, a convalescent carrier state can be formed.

In some infectious diseases, EP is basically supported due to the existence of carriers (typhoid fever, poliomyelitis, diphtheria, etc.). Epidemic danger of carriers is determined by conditions of their work and life. It is

possible to detect a carrier only by laboratory study (testing). The majority of carriers is not detected and not registered.

Primary (healthy) carrier is a person, who has never had this infectious disease and has not been vaccinated against it. Primary carriage is mainly short-term and not intensive. It can be: 1) transited – the agent does not stay in the organism of the person, and shortly leaves it, the duration is shorter than that of the disease (shigellosis, cholera, hepatitis A viral (HAV) infection, meningococcal infection, scarlet fever), and 2) asymptomatic (unapparent) – the duration of agent excretion is mainly the same as in the infectious disease (shigellosis, amoebic dysentery, cholera, poliomyelitis, meningococcal infection, scarlet fever).

Secondary carriage develops after infectious disease or immunization when an infectious agent gets into the organism.

Secondary carriage that is formed after a disease can be: a) acute convalescent – not more than 3 months after a disease (shigellosis, amoebic dysentery, cholera, poliomyelitis, hepatitis B viral (HBV) infection, hepatitis C viral (HCV) infection, typhoid fever, paratyphoid fever, salmonellosis, diphtheria, meningococcal infection, scarlet fever) and b) chronic – last for more than 3 months after a disease (typhoid fever, paratyphoid fever, salmonellosis, HCV infection, malaria).

Persons in whom immunity developed after a disease or immunization belong to the category of immune carriers. These persons excrete the agent for a short period of time of 1–3 weeks (diphtheria, poliomyelitis).

The epidemiological danger of a patient or a carrier is estimated by the degree of their danger to surrounding people as a SAI.

In anthroponotic infections the epidemic danger of a person as a SAI depends on:

- 1) the form of infection manifestation (whether it is a disease or carriage state), its course and type;
- 2) the period of infectious disease and duration of its contagious period;
- 3) the degree of contagiousness of an infectious disease;
- 4) occupation of a person;
- 5) the level of the sanitary culture of the person.

To determine the epidemic danger of a SAI it is necessary to take into account contagiousness of the patient (carrier). Contagiousness is excretion of an infectious agent from the carrier's organism with its subsequent distribution through the environment and penetration into a susceptible organism. Contagiousness is determined by localization of the agent in the organism of the source (Appendix 1).

Localization of agents in the organism of a person can be primary and secondary.

Primary localization is a place (an organ or a system of organs), into which agents penetrate after infection, multiply and in most infectious diseases are excreted into the environment.

Secondary localization is an organ or a system of organs, into which agents penetrate from the places of their primary localization. The agents are excreted from the places of their secondary localization only if they are localized in the excretory organs. The place of agent localization can be changed due to the tropism of the agent to different tissues and organs of the body.

In epidemiology, there is also a concept of specific localization of agents. **Specific localization** of agents is that basic localization, which was formed during evolution and which provides the entry of the agent into the environment.

Infectious diseases, whose causative agents affect different tissues and organs in the human body agents, are of greater epidemic danger. For these diseases, their specific localization will be both primary and secondary localization of the agents (typhoid fever, paratyphoid fever, salmonellosis, measles, rubella, etc.), which can change the MTAI. The epidemic danger of the SAI, in which only one site (organ) in the human body is affected, is much less because the agents do not penetrate beyond the organs of their primary localization and are excreted into the environment only from those organs.

Comparing the epidemic danger of patients and carriers it is necessary to consider the following criteria:

1. The patient-to-carrier ratio.
2. SAI activity (hospitalization of the patient, sanitation of the carrier, isolation in domestic conditions, behavior of the patient or carrier).
3. Intensity of agent excretion.
4. Duration of the infectious period (Appendix 2).
5. Difficulties of finding a SAI (unlike patients, carriers do not have any symptoms of a disease, that is why carriers do not appeal for medical care and are detected only by laboratory study).

After excretion from the organism of a SAI infectious agents get on objects of the environment and together with them are transmitted to susceptible organisms.

The process of agent transference from a SAI to a susceptible organism, which was formed in the process of evolution, is referred to as the **mechanism of transmission** of the agents of infection (MTAI). Mechanisms of horizontal transmission of agents: fecal-oral, airborne (aerogenic), transmissible, contact (direct and indirect). Besides, there is also vertical transmission (through the placenta, intrauterine) that provides transmission of agents from the mother to her fetus.

Mechanisms of horizontal transmission consist of three phases:

- 1) exit of agents from a SAI;
- 2) persistence (movement) of the agents in the environment (is absent in case of direct contact MTAI);
- 3) penetration of agents into a susceptible organism.

Objects of the environment, by means of which agents are transmitted from a source to a susceptible organism, are referred to as **factors of transmission**. Water, food, household articles, clothes, tools, etc. are inanimate factors of transmission. Animate factors of transmission (living vectors of agents) are representatives of arthropods.

Realization of the MTAI under certain conditions of place and time is referred to as **route of agent transmission**. The route of agent transmission is called by the final factor of transmission, with which agents get into a susceptible organism. For the fecal-oral MTAI typical routes are via water, food, household articles, for airborne – air and dust.

The determining factor for the development of EP is **susceptible population** – the number of persons among certain populations in certain areas that may be affected by specific infectious agents. This in turn is determined by the number of non-immune people, population density, age, and social structure, race, behavior, and their ethnic characteristics, migration, hygiene, etc.).

COUNTERMEASURES IN THE FOCI OF INFECTIOUS DISEASES

Infectious Disease Focus

In case of an infectious disease there forms a focus of infectious disease as an area, within which the infectious agent is transferred from the SAI to the susceptible organism. The duration of an epidemic focus is determined by the duration of SAI existence, effect and duration of MTAI, the number of susceptible organisms that could potentially be involved into the EP. The borders of an anthroponotic infection focus depend on several factors: contagiousness of the infection, MTAI activity; sanitary culture of the population, the level of the sanitary conditions of the area. An epidemic focus will exist until there is a SAI and until the MTAI is terminated. The term of existence of a focus is determined by the maximum incubation period from the date of the last patient identification. The focus of infection is detected by passive (appealing of patients for medical assistance to health care settings (HCS)) or active (door-to-door visits, preventive examinations) ways.

Active detection of patients takes place in the course of routine inspection of certain groups of population, in the foci of infectious diseases, during selling of land (apartment), rounds in populated areas. Passive detection of patients occurs in a polyclinic or at home – when a patient himself appeals to health care settings. In the latter case, in connection with late appealing of the patient to health care settings, isolation and hospitalization of the patient can be delayed.

The carriers are revealed during scheduled examination according to epidemic indications or during examination of certain contingents of population.

Countermeasures concerning contagious patients and carriers are differentiated (Appendix 3).

Investigation of an Infectious Disease Focus

The purpose of infectious disease focus investigation is detection of SAI, identification of the route of pathogen transmission, carry out of focus measures. Investigation of a focus includes studying of medical documentation, carrying out of epidemiological investigation, certain laboratory investigations with observation, and making conclusions after focus elimination (Fig. 2). All information is entered into special forms.

Actual epidemiological investigation is conducted to determine the causes of diseases and conditions that contribute to pathogen dissemination by interviewing, sanitary inspection, and sampling for laboratory tests (bacteriological, virological, serological, parasitological, entomological, biological, allergological, chemical, etc.). Investigation should find the answer to the question: **who, where** and **when** is involved in EP, made a plan and conducted primary preventive measures in the focus.

Epidemiological observation continues until complete elimination of the focus and includes: medical survey of persons who present in the focus for early detection of disease; veterinary observation (with a similar aim in the focus of zoonanthropnotic disease), repeated laboratory tests of people, animals, and objects of the environment.

Conclusion: final conclusion about the SAI, routes of transmission (according to the date of laboratory investigation and assessment of the circumstances of epidemiological history: communication with a potential SAI with regard to the duration of the incubation period, etc.), and all the conditions that contributed to the emergence and elimination of the focus, assessment of the efficiency of preventive measures is made after focus elimination.

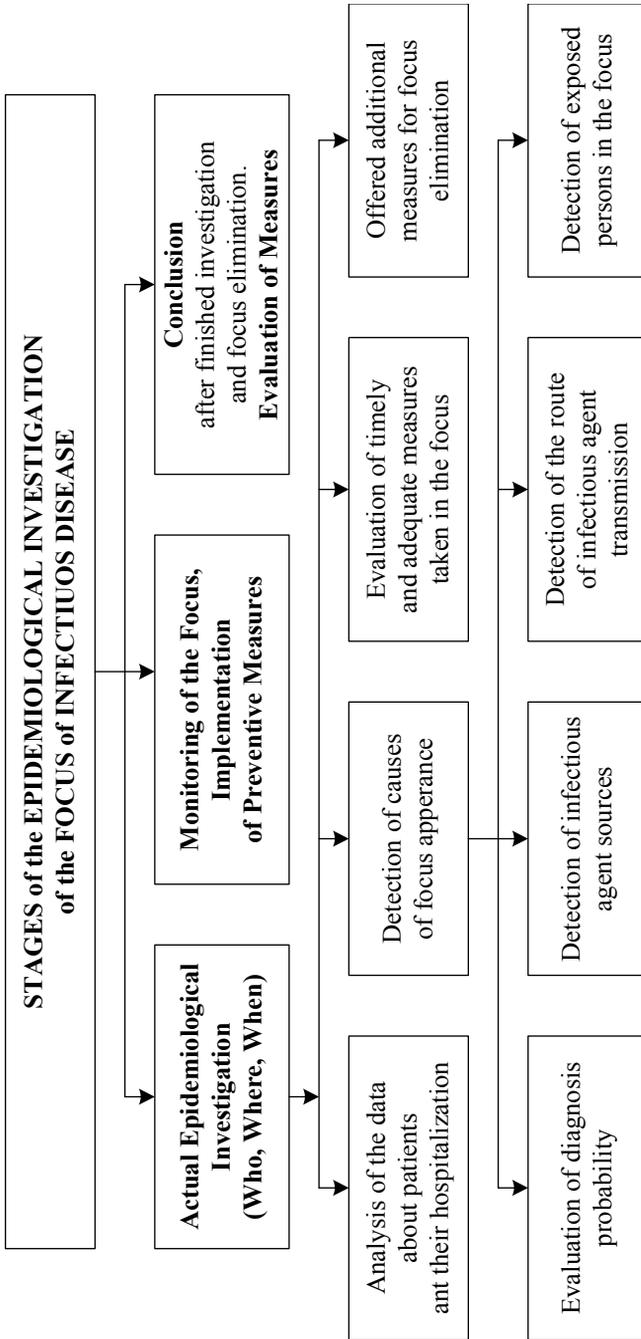


Fig. 2. Stages of epidemiological investigation of the infectious disease focus

MEASURES OF LOCALIZATION AND ELIMINATION OF INFECTIOUS DISEASES

The fight against infectious diseases is carried out by means of organization of preventive measures (Appendix 4) and countermeasures (Appendix 5). Preventive and counterwork is based on two principles:

1. Integrated approach to provide simultaneous influence on all three links of EP.

2. Influence on the main (conducting) part of EP. The conducting part is one of the components of primary driving forces of EP, for the blocking of which at the given stage there exist the most rational approaches.

Different measures in the focus of infectious diseases are applied: 1) measures concerning the SAI, 2) measures to block and destroy the MTAI (destroy pathogens on/in transmission factors), 3) measures aimed at persons potentially exposed to the risk of infection.

To determine a complex of necessary preventive and countermeasures it is important to estimate correctly the epidemic danger of the patient. The measures directed at reduction of epidemic danger of a patient belonging to a SAI include early detection of the patient by means of disease diagnostics (clinical, epidemiological, laboratory), isolation, treatment, laboratory control during treatment and at discharge, postinfection clinical supervision. Quarantine and treatment can be provided in hospital or at home.

Counter measures concerning the carriers includes: identification of carriers, their isolation (in particular cases) and treatment, restrict from work or other activities where they are epidemiological danger, laboratory examination, post infection supervision (Appendix 5).

In some infectious diseases (typhoid fever, typhus, and Brill disease, diphtheria, plague, cholera, anthrax, rabies, tetanus, etc.) hospitalization is obligatory, while in others it depends on clinical or epidemic indications. *Hospitalization according to clinical indications* is carried out taking into account the severity of the disease (severe or moderate), complications, and patient's age. *Hospitalization according to epidemic indications* is necessary in the absence of appropriate conditions for the isolation of the patient (accommodation without adequate sanitary conveniences, hostel, boarding school, preschool establishments, etc.) or if the patient belongs to specific occupational groups.

Home isolation can be organized for patients with infectious diseases that have a relatively mild course (measles, rubella, influenza, whooping cough, chickenpox, mumps, shigellosis, hepatitis A); requirements: satisfactory living conditions, there are people who can look after patients and

are not affected by this disease, there are no children, and the level of sanitary culture of the population is high.

Patients should be transported to the hospital by means of special-purpose vehicles (e.g. an ambulance car). At night, transportation of patients may be carried out with the help of special ambulances. When cars are used, their disinfection is conducted after transportation.

Upon arrival at the infectious hospital a patient is sanitized in the admission department. Then the question of their isolation in the hospital should be decided. There are such forms of infectious patients isolation in hospital: general wards, isolation wards, open wards divided by partitions that do not reach the ceiling, closed boxes (wards divided by solid walls), separate wards with a hallway and a bathroom with access to the common corridor, boxes with stranded extra-insulated external entrance (for both getting in and out), vestibule, sanitation delousing and bath; negative pressure ward.

After isolation of the patient preventive measures are aimed at: I) supervision of persons who communicate with the patient, II) separation of these persons, III) organization of special and emergency-prevention policy among those who were at risk of infection (active and/or passive immunization, chemotherapy, bacteriophages, interferon), IV) organization of disinfection and deratization in the focus of infection, and V) education.

ANTI-EPIDEMIC WORK OF A DISTRICT (FAMILY) DOCTOR AND AN INFECTIOUS DISEASE SPECIALIST

Doctors (district and family physicians, pediatricians, infectious disease specialists, etc.) spend considerable time providing anti-epidemic measures among population, which includes participation in organization and implementation of immunization, both active and passive detection of infectious patients, clinical supervision of patients after infectious diseases, deworming of population, health education, counter measures in infectious disease foci.

A district (family) doctor identifies and examines infectious disease foci, conducts initial examination, and compiles case history indicating possible causes of the disease, circumstances of infection (contacts with a possible SAI (people, animals, environment), possible modes of transmission determined by the number of persons who were under the risk of exposure, and indications for hospitalization. Doctors are obliged to determine the scale of infection and initial steps in the focus of infection (hospitalization or isolation of the patient, treatment, organization of disinfection, etc.), timely provide information (in a city – during up to 12 hours, in rural areas – up to 24 hours) to the epidemiological service to