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TUTORIAL

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EDUCATIONAL AND METHODOLOGICAL TEXTBOOK FOR PRACTICAL CLASSES ON HYGIENE

Министерство науки и высшего образования РФ

Рекомендовано Координационным советом по области образования «Здравоохранение и медицинские науки» в качестве учебного пособия для использования в образовательных учреждениях, реализующих основные профессиональные образовательные программы высшего образования уровня специалитета по направлениям подготовки 31.05.01 «Лечебное дело», 33.05.01 «Фармация», 31.05.03 «Стоматология»

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MODULE 3. HYGIENE OF HEALTH CARE FACILITIES

Hygiene of medical institutions is a section of hygiene that studies the problems of preserving the health of medical personnel and more fully restoring the health of patients.

The tasks of hospital hygiene:

1. Development of hygienic standards for the effective placement, construction and operation of health facilities for sanitary and epidemiological well-being of patients and medical personnel.
2. Hygienic regulation of staff working conditions.
3. Prevention of nosocomial diseases among patients and staff.
4. Practical implementation of the scientific provisions of hospital hygiene.

This section is devoted to the assessment of the internal environment of treatment-and-prophylactic organizations.

ALGORITHM OF ACTIONS

1. Assess the microclimate.
2. Assess insolation regime.
3. Assess air cleanness.
4. Assess ventilation effectiveness.
5. Assess natural lighting.
6. Assess artificial lighting.
7. Assess sufficient of hospital ward area for 1 bed.
8. Assess air disinfection.
9. Do the total conclusion about indoor environment.

1. Assess microclimate and thermal state of the human body.

Microclimate is assessed according to the all criteria listed in the Table 3.1. If you do not have data for any indicator in your task, write only standard for this indicator.

Table 3.1. Indicators of microclimate and indicators of the thermal state of the human body

Indicator	Standard
Air temperature, °C	see Table 3.3
Temperature difference in horizontal plane, °C	≤2.5
Temperature difference in vertical plane, °C	≤2
Humidity, %	⩽60
Velocity of air, m/s	0.1–0.2
The difference in skin temperature of the forehead and back of the feet in patients, °C	2–4
Skin temperature of back of foot, °C	30–31
Skin temperature of forehead, °C	33–34
Skin temperature of chest, °C	34–35
Subjective patient's assessment of heat sensation, points	2.8–3.6

Microclimate

Indicators	Value (from task)	Standard	Your assessment
Air temperature, °C			
Temperature difference in horizontal plane, °C			
Temperature difference in vertical plane, °C			
Humidity, %			
Velocity of air, m/s			
The difference in skin temperature of the forehead and back of the feet in patients, °C			
Skin temperature of back of foot, °C			
Skin temperature of forehead, °C			
Skin temperature of chest, °C			
Subjective patient's assessment of heat sensation, points			

Conclusion: cooling microclimate.

Make a total conclusion about microclimate in the premise. Microclimate may be allowable, heating or cooling.

Example.

Assess the microclimate in the ward for adults of the therapeutic department.

Indicators	Value (from task)	Standard	Your assessment
Air temperature, °C	19	20–26	↓ Standard
Temperature difference in horizontal plane, °C	3	≤2.5	↑ Standard
Temperature difference in vertical plane, °C	no data	≤2	–

2. Assess insolation regime.

Insolation — direct sunlight exposure of surfaces and spaces. Insolation involves ultraviolet and infrared radiation.

Insolation depends on window orientation to the side of the world:

Windows orientation	North, North-west, North-east	East, South	South-west, South-east	West
Insolation regime	Minimal	Moderate	Maximal	Mixed

Insolation

Windows orientation (from task)	Insolation regime	Required insolation regime	Your conclusion

Required insolation regime depends on the type of hospital premises (Table 3.2).

Table 3.2. Required insolation regime for different hospital premises

Minimal insolation regime	Moderate regime	Maximum insolation regime
Intensive care wards, wards for cancer patients, wards for patients with intoxication (including patients with thyrotoxicosis), patients with some forms of neurological, skin and eye diseases (including wards for patients with burns), bandaging rooms, procedural rooms, operating halls, delivery rooms, ward for patients with hyperthyroidism	Wards of somatic non-infectious departments (for adults and children), wards of infectious departments (for adults and children) postoperative wards, postnatal wards, Infectious boxes and boxed wards	Wards for patients in convalescence stage, wards for children with signs of rickets, wards for patients with limb injuries, wards for patients with tuberculosis, wards for patients with hypothyroidism

Example.

Assess the insolation regime of the wards for patients with hypothyroidism, the windows orient to the north.

Windows orientation	Insolation regime	Required insolation regime	Conclusion
North	Minimal	Maximum	This insolation regime does not correspond to this ward type

3. Assess air cleanness of the ward.

Air cleanness is assessed according to the all criteria listed in the Table 3.4. If you do not have data for any indicator in your task, write only standard for this indicator.

Air cleanness

Indicators	Value (from task)	Standard	Your assessment
Concentration of CO_2, %			
Oxidability, mg/m^3			
Total number of microorganism in air, CFU/m^3			
Number of Staphylococcus aureus			
NH_3 concentration, mg/m^3			
Phenol concentration, mg/m^3			
Formaldehyde concentration, mg/m^3			

Make a total conclusion about air cleanness. Air in the premises may be clean or dirty.

Example.

Assess the air cleanness of the ward for children.

Indicators	Value (from task)	Standard	Assessment
Concentration of CO_2, %	0.08	≤0.07	↑ Standard
Oxidability, mg/m^3	no data	⩽3.9	–
Formaldehyde concentration, mg/m^3	0.001	≤0.003	↓ Standard

Conclusion: air is dirty.

4. Assess ventilation and air disinfection in the ward.

4.1. Assess or calculate air changes per hour.

a) If in your task present data about air changes per hour, compare it with the recommended data (Table 3.3). Make a conclusion about their matching.

Otherwise, go to the item b.

Table 3.3. Microclimate and ventilation standards[1]

Type of wards	Sanitary and microbiological parameters (total number of microorganisms i n air, CFU/m^3)[2]		Permissible air temperature, °C	Recommended air changes per hour, no less than «1» (mechanical ventilation)	
	before work	during work		inflow (+) minimal value	exhaust (-) minimal value
Operating halls, delivery rooms, postoperative wards, intensive care wards	≤200	≤500	21–24	10 (for aseptic rooms), 8 (for septic rooms)	8 (for aseptic rooms), 10 (for septic rooms)

Table continuation 3.3

Type of wards	Sanitary and microbiological parameters (total number of microorganisms i n air, CFU/m³)²		Permissible air temperature, °C	Recommended air changes per hour, no less than «1» (mechanical ventilation)	
	before work	during work		inflow (+) minimal value	exhaust (-) minimal value
Small operating rooms	≤500	≤750	20–24	10	5
Postnatal wards, wards for patients with burns	≤500	≤750	21–23	10	10
Procedural rooms and aseptic dressings rooms, procedural rooms for bronchoscopy	≤300	Number of microorganisms in air is not standardized	22–26	8	6
Boxes and boxed wards in the infectious department	Number of microorganisms in air is not standardized	Number of microorganisms in air is not standardized	20–26	8	10
Wards of infectious department	Number of microorganisms in air is not standardized	Number of microorganisms in air is not standardized	20–26	80 m^3/hour per 1 bed	80 m^3/hour per 1 bed
Wards for patients with thyrotoxicosis	Number of microorganisms in air is not standardized	Number of microorganisms in air is not standardized	15–17	80 m^3/hour per 1 bed	80 m^3/hour per 1 bed
Wards for patients with hypothyroidism	Number of microorganisms in air is not standardized	Number of microorganisms in air is not standardized	24–27	80 m^3/hour per 1 bed	80 m^3/hour per 1 bed

End of the table 3.3

Type of wards	Sanitary and microbiological parameters (total number of microorganisms i n air, CFU/m³)[2]		Permissible air temperature, °C	Recommended air changes per hour, no less than «1» (mechanical ventilation)	
	before work	during work		inflow (+) minimal value	exhaust (-) minimal value
Wards for children of all other departments	≤750	≤1000	23–27	80 m^3/hour per 1 bed	80 m^3/hour per 1 bed
Wards for adults of all other departments	Number of microorganisms in air is not standardized	Number of microorganisms in air is not standardized	20–26	80 m^3/hour per 1 bed	80 m^3/hour per 1 bed
X-ray diagnostic and fluorography rooms, electrophototherapy rooms, massage rooms	Number of microorganisms in air is not standardized	Number of microorganisms in air is not standardized	20–26	3	4

[1]Sanitory rules and norms 2.1.3.2630-10. «Sanitary and epidemiological requirements to medical organizations».
[2]CFU–colony-forming unit.

Table 3.4. Indicators of air cleanness

Indicators	Standard
Concentration of CO_2, %	≤0.07
Oxidability, mg/m^3	≤3.9
Total number of microorganism in air, CFU/m^3	see Table 3.3
Number of *Staphylococcus aureus*	0
NH_3 concentration, mg/m^3	≤0.04
Phenol concentration, mg/m^3	≤0.003
Formaldehyde concentration, mg/m^3	≤0.003

Example.

Assess air changes per hour in the procedural room.

Air changes per hour	Standard	Conclusion
+4–3	+8–6	The inlet ventilation prevails, it corresponds with standard, but air changes per hour are not sufficient

b) Calculate required air changes per hour:

$$V_1=N\times 80\ m^3/hour,$$

where:

V_1 — required volume of supply air, m^3/hour;

N — number of persons in the ward;

80 m^3/hour — recommendation standard ventilation (Table 3.3).

$$V_2=S\times h,$$

where:

V_2 — ward volute, m^3; S — ward square, m^2; h — ward height, m.

$$ACH=V_1/V_2,$$

where:

ACH — air changes per hour.

Example.

Calculate required air changes per hour for the ward (22 m^2×3.5 m) for 3 persons.

$$V_1=3\times 80=240\ m^3/hour$$

$$V_2=22\times 3.5=77\ m^3$$

$$ACH=240/77=3.1$$

Conclusion: air should be changed 3.1 times per 1 hour in this ward.

4.2. Make a conclusion about effectiveness of ventilation.

Ventilation is effective if concentrations of chemical substances in the air correspond to their standards.

5. Assess natural lighting.

Natural lighting is assessed according to the all criteria listed in the Table 3.5. If you do not have data for any indicator in your task, write only standard for this indicator.

Natural lighting

Indicators	Value (from task)	Standard	Your assessment
The natural lighting coefficient, %			
Light coefficient			

Make a total conclusion about natural lighting (sufficient or insufficient).

Table 3.5. Lighting level

Type of premise	The natural lighting coefficient, %	Light coefficient	Illumination level (fluorescent lamps), lx
Adult wards	≥0.5	≥1:5–1:6	≥100
Children wards, intensive care wards, postoperative wards	≥1.0	≥1:5–1:6	≥200

End of the table 3.5

Type of premise	The natural lighting coefficient, %	Light coefficient	Illumination level (fluorescent lamps), lx
Operating halls, small operating halls	May be without natural lighting		≥500
Delivery rooms, procedural rooms, dressing room	≥1.5	≥1:4–1:5	≥500

Example.

Assess natural lighting of the ward for children.

Indicators	Value (from task)	Standard	Your assessment
The natural lighting coefficient, %	1.2	≥1.0	Standard
Light coefficient	no data	≥1/6	–

Conclusion: natural lighting of the ward is sufficient.

6. Assess artificial lighting.

Sufficient of artificial lighting is assessed with specific power.

Specific power is calculated with formula:

$$P = \frac{n \times w}{s},$$

where:

P — specific power, W/m²; n — number of fluorescence lamps; W — power of one lamp, W; S — surface area of premise, m².

Standards of specific power are presented in the Table 3.6.

Table 3.6. The minimal level of required power per one meter of area (W/m²)

Ward square, m²	Required illumination, lx		
	100	200	500
10–14	11.5	23.0	58.0
15–25	9.7	19.4	49.0
26–50	8.0	16.0	40.0
51–150	6.7	13.4	34.0

They depend on the standards of illumination level (present in the Table 3.5). It in turn depends of premise type and class of visual work that is performed in this premise.

6.1. Calculate specific power.

6.2. Fill the table

Artificial lighting.

Indicators	Value (task data)
Surface area of the premise, m^2	
Number of lamps	
Power of one lamp, W	
Illumination, lx	Standard — Table 3.5
Specific power, W/m^2	Standard — Table 3.6
	Calculated according to task data

6.3. Make a conclusion about artificial lighting (sufficient or not sufficient).

Example.

Assess artificial lighting of the ward for adults (surface of the ward — 18 m^2, 4 lamps of 80 W each).

6.1.

$$P = \frac{4 \times 80}{18} = 17.8 \ \frac{w}{m^2}$$

6.2.

Indicators	Value
Number of lamps	4
Power of one lamp, W	80
Surface area of the premise, m^2	18
Illumination, lx	⩾100
Specific power, W/m^2	⩾9.7 standard
	17.8 calculated value

6.3. Conclusion: artificial lighting in the ward is sufficient.

7. Assess sufficient of hospital premises area.

There are two different approaches to assessment of hospital premises area.

a) For some premises, the total area is standardized. It is such premises as infectious box, operating hall, small operating hall, delivery room, procedural room, dressing room.

If you task is about such premise, fill the next table and assess its area using Table 3.7.

Otherwise, go to the item b.

Indicators	Value	Standard	Your conclusion
Surface area of the premise, m^2	(from task)	(Table 3.7)	sufficient/ not sufficient

Table 3.7. Standard of surface area of hospital premises

Type of ward	Surface area of hospital premises, m^2
Infectious box (for 1 bed) infectious box (for 2 beds)	⩾22 ⩾27
Operating hall delivery room small operating room	⩾36 ⩾36 ⩾24
Procedural room dressing room	⩾12 ⩾18

b) For wards, the surface area for 1 bed is standardized. If your task is about a ward, fill the next table and assess task data, using Table 3.8.

Make a conclusion whether surface area for 1 bed is sufficient.

Table 3.8. Standard of surface area for 1 bed in the ward

Type of ward	Surface area for 1 bed in the ward, m^2
Wards for adults: ward in the non-infectious department ward in the infectious department ward for intensive care ward for patients with burns	 ⩾7 ⩾8 ⩾13 ⩾10
Wards for children: ward in the non-infectious department ward in the infectious department ward for intensive care ward for patients with burns	 ⩾6 ⩾7 ⩾13 ⩾9

Indicators	Value
Surface area of the ward, m^2	task data
Number of patients in the ward	task data
Surface area for 1 bed, m^2	standard (Table 3.8)
	calculated data

Example.

Assess the surface area of the ward for adults (infectious disease).

Indicators	Value
Surface area of the ward, m^2	30
Number of patients in the ward	4
Surface area for 1 bed	≥8 (standard)
	7.5 (calculated data)

Conclusion: the surface area for 1 bed is not sufficient.

8. Assess air disinfection.

The bactericidal lamp.

The bactericidal lamp is a low-pressure gas discharge lamp with self-heated cathodes. The lamp envelope is a sealed tube made oi uviol glass that readily transmits radiation at a wavelength of 253.7 nm. An electrical discharge-taking place in the mixture of argon and mercury vapors is a source of radiation, the greater part of which belongs to the range of wavelengths of 253.7 nm, i.e. the range that features the greatest bactericidal efficiency.

The normal operating position of the lamps is horizontal. However, the lamps may be operated in any other position, if required.

The optimum temperature range for the bactericidal lamps is between +18 and +25 °C. Higher or lower ambient temperatures cause a reduction in the lamp bactericidal efficiency, while at +5 °C or below the lamps are difficult to start. With the relative air humidity higher than 70% the bactericidal effect of the ultra-violet radiation is somewhat reduced.

The air in premises may be disinfected by ultra-violet radiation both in the presence and in absence of people.

Screened bactericidal lamps. When the air is to be disinfected in the presence of people, precautions should be taken to reduce bactericidal radiation to a minimum at a level of up to 2 m above the floor. Under no circumstances is it allowed to use non-screened lamps that may be in the field of view of the people. Air disinfection in high premises (higher 3 m) may be performed in the presence of people provided the lamps are mounted in special fittings at a height of not less than 2 m above the floor. The fittings employed should direct the bactericidal flux upwards so that the angle of all rays (both emitted by the lamp directly and reflected by the fittings) should be minimum 5° from the horizontal plane passing through the lamp. The reflector should be designed to direct the luminous flux of the lamp at an angle of 5° to 80° above the horizontal plane. The maximum bactericidal radiation is at a height of 1.8 m above the floor. If the lamps are employed during 24 hours, the maximum radiation in the above zone should not exceed 1 mb/m^2.Premises accommodating large groups of people such as reception rooms in hospitals, waiting rooms in r/w terminals, etc. are recommended to be radiated during the whole period of their use. If a room has no sufficient ventilation, a characteristic smell of ozone may appear in the room after 1.5 to 2 hours of continuous lamp burning. Therefore, it is recommended to switch off the lamps for 30 to 60 minutes after every 2 hours of continuous operation, and thoroughly ventilate the room. Air disinfection by ultra-violet radiation in the presence of people may be as well performed by mounting the bactericidal lamps in local and general recirculation installations. A local recirculation installation is a short metal pipe with bactericidal lamps hidden inside. A fan driven by a small-size electric motor forces the air through the pipe lamps. In general, air recirculation installations, the bactericidal lamps should be mounted in the air ducts of the installations. It is also possible to clean the air supplied to or out of the room by mounting bactericidal lamps in the air ducts of the suction-and-exhaust ventilation system. The lamps should be installed in suction ducts when the incoming air is to be disinfected. It is recommended to arrange screened lamps and local recirculation installations in the way of basic air convection streams of the particular room. The number of screened lamps required for a particular room should be determined based on 1 W (of consumed power) per each 1 m^3 of the room volume.

Non-screened (naked) bactericidal lamps may be employed for air disinfection in the absence of people: during intervals, at nighttime, or in a period specially allotted for the purpose. The number of non-screened lamps required for a particular room should be determined based on 3 W (of consumed power) per each 1 m^3 of the room volume. If the lamps are used for a short period, their power may be several times higher depending upon the time of their operation.

The bactericidal mercury lamps are intended for the disinfection of air in medical institutions, bacteriological laboratories, blood transfusion stations, theatres and cinemas, schools, nurseries and certain industrial shops; for the disinfection of surfaces of enclosures and utensils; for the disinfection of drinking and mineral water; for the protection against bacteria of food stuffs, equipment and packing tare in the food industry.

Protect your eyes using protective goggles with plain glasses when handling a bactericidal lamp.

Calculation of bactericidal lamp number

$$LN = \frac{PD \times V}{CP},$$

where:

LN — lamp number; PD — power density, W/m^3 (see Table 3.9); V — ward volume, m^3; CP — consumed power of 1 lamp, W.

Table 3.9. Power density per unit of volume (W/m^3)

Type of bactericidal lamp	Non-screened (naked)	Screened
Bactericidal lamp from uviol glass*	3	1
High-pressure mercury quartz lamps	10	3

*uviol glass transmits ultraviolet radiation.

Example.

There are 2 non-screened bactericidal lamps of 60 W each in the operating hall ($25\ m^2 \times 3\ m$). Assess the sufficiency of bactericidal lamps.

If non-screened bactericidal lamps are used, power density per unit of volume is $3\ W/m^3$.

$$\text{Operating hall volume} = 25 \times 3 = 75\ m^3$$

Power of 1 lamp is 60 W.

$$LN = \frac{3 \times 75}{60} = 3.75$$

4 non-screened bactericidal lamps **should be** installed in the operating hall.

Therefore, 2 bactericidal lamps are not sufficient for effective air disinfection.

Make a conclusion about air disinfection.

Air disinfection in the ward is effective if total number of microorganism and numbers of Staphylococcus aureus in $1\ m^3$ of air correspond to their standard (see Table 3.3 and 3.4).

9. Do the total conclusion about indoor environment of the ward or premise.

List all violations and offer the preventive measures (Table 3.10)

Table 3.10. Preventive measures

Violations	The preventive measures
Improper microclimate	Use proper ventilation, the air conditioning
Uncorresponded insolation regime	Use of curtains and blinds
	If it is possible, placement patients with other nosological forms in this word; list the nosological forms for which this insolation regime is appropriate
Dirty air	Use proper ventilation, air disinfection
Ineffective ventilation	Increase the volume of inflow or/and exhaust air
Insufficient number of bactericidal lamp, ineffective disinfection	Increase the number of lamps or/and use higher power lamps

End of the table 3.10

Violations	The preventive measures
Insufficient natural lighting	Clean the windows, paint the walls and ceiling in light colors, if possible remove the shading objects, use artificial lighting the whole day
Insufficient artificial lighting	Increase the number of bulbs or/and use higher power bulbs
Insufficient surface area for 1 bed or Surface area of a premise	Decease the number of patients in the ward or/ and increase the volume of inflow or/and exhaust air

Reference

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