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Original Article

The establishment of laboratories used in medical faculty education: A qualitative research

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ABSTRACT

One of the essential prerequisites for delivering high-quality education in medical schools is the proper establishment of educational laboratories. This study aims to determine the minimum infrastructure, equipment, and standards required for the establishment of such laboratories by drawing upon the experiences of faculty members involved in the process. This research was conducted using qualitative study design. Semi-structured interviews were held with ten faculty members who had prior experience in laboratory setup. Data were analyzed through content analysis. The study was approved by the Mardin Artuklu University non-Interventional Clinical Research Ethics Committee (decision no: 2024/4-5, date: 16.04.2023). The participants included one professor, two associate professors, and seven assistant professors, with a mean age of 45.2 years. Participants emphasized the importance of long-term planning for laboratory infrastructure and highlighted the need for early procurement of equipment and consumables. A lack of standardized guidelines for laboratory setup was a recurrent theme across interviews. Laboratory establishment is a critical component that directly affects the quality of medical education. The absence of sufficient institutional knowledge and guidance in this area poses significant challenges. This study contributes to the literature by presenting practical insights based on the experiences of faculty members and may serve as a reference for future laboratory planning in medical education.

Keywords: medical education, laboratory establishment, qualitative research, infrastructure planning, medical school

INTRODUCTION

Medical education is the theoretical and practical, preferably student-centered, educational process of basic, internal, and surgical medical sciences courses, designed to train physicians. Practical applications of the undergraduate education process constitute approximately half of the curriculum. Practical applications of basic medical science courses during the first three years of undergraduate education are conducted in student laboratories. Furthermore, laboratories play an important role in postgraduate medical education in the field of basic medical sciences [1, 2]. In a study conducted on medical school students, 62.7% of students stated that they preferred at least 60% of their medical school courses to consist of practical courses [3]. This highlights the importance of laboratories in the education of medical school students. Other studies in the literature indicate that medical school students gain valuable experience before beginning their professional careers through active learning methods, enabling them to accurately convey the concepts and strategies of the profession to students [4].

Within the scope of basic medical sciences; the departments of anatomy, biophysics, biostatistics, physiology, histology and embryology, medical biochemistry, medical biology, medical microbiology, medical education and informatics, and medical history and ethics, as well as their affiliated disciplines, provide hands-on training and conduct research in medical laboratories. Laboratories within the department of basic medical sciences are used in the practical stages of master's, doctoral, and medical specialty training programs offered in numerous multidisciplinary graduate programs established under the leadership of departments affiliated with basic medical sciences.

Factors such as the physical infrastructure, technical equipment, ventilation, lighting, space planning, and security conditions of the laboratories located in the faculty of medicine's basic sciences building are decisive in the quality of the education provided. Student-centered, accessible, and functional laboratory environments, in particular, support cognitive learning and enhance a sense of professional self-efficacy [5]. However, there are no detailed legal regulations or national guidelines regarding the design, standards, and minimum equipment requirements of laboratories in medical schools in Turkey. This creates significant differences in infrastructure and practice across faculties.

While the text titled "minimum conditions for the beginning and continuing of education in medical programs," published by the Yükseköğretim Kurulu [Council of Higher Education], contains some general provisions regarding laboratories, these regulations remain quite superficial and lack details that would guide implementation [6]. In recent years, there has been a significant increase in the number of medical schools and student quotas, putting pressure on existing infrastructure and laboratory capacity.

Existing research demonstrates that laboratory training is effective not only in transferring technical knowledge but also in fostering ethical sensitivity, teamwork, professional attitudes, and a sense of responsibility [1]. However, systematic studies on the planning, management, and assessment and evaluation processes of these educational environments in Turkey are limited.

The most critical phase for laboratories used in medical education is the installation process. Planning errors during the installation, lack of knowledge and experience, and other factors can lead to problems that are difficult to correct in later stages. Therefore, it is crucial to obtain recommendations based on the experiences of faculty members involved in laboratory setup and supported by field data. This study aims to determine the minimum equipment, infrastructure, and standards for the establishment of laboratories used in medical education.

METHODS

This study was approved ethically by the Mardin Artuklu University non-Interventional Clinical Research Ethics Committee with approval dated April 16, 2023, and numbered 2024/4-5. Institutional permission was also obtained from the dean of the faculty of medicine of Mardin Artuklu University with letter numbered 140575, dated April 22, 2024. The research was conducted in accordance with the principles of the Declaration of Helsinki.

The study employed a qualitative research method. The qualitative method aims to deeply understand individuals' experiences, emotions, thoughts, and social interactions; it is a frequently preferred research approach, particularly in the social sciences and humanities [5]. This approach, which aims to reveal participants' perspectives in detail, allows for the acquisition of flexible, contextual, and multidimensional data [5, 7-9].

The characteristic features of the qualitative method include: These elements include focusing on understanding the participants' individual experiences, collecting data in a natural setting, obtaining in-depth information through open-ended questions, and providing detailed coverage of each participant's opinions by working with a small number of participants [5, 7-9]. Our research aimed to access the knowledge, opinions, and experiences of experienced academics in their field, rather than collecting numerical data. Therefore, the qualitative method was considered the most appropriate approach for the purpose of the study.

The research aimed to reveal faculty members' experiences regarding the establishment processes of laboratories used in medical education. For this purpose, a total of ten faculty members, five female and five male, were included in the study. All participants were selected from academics who had direct involvement in the establishment processes of laboratories used for practical training in medical schools and also had practical course experience.

A semi-structured interview form developed by the researcher was used as the data collection tool. The open-ended questions in this form were based on laboratory

Faculty Member's Title, Name, and Surname:
Faculty Member's Age: Faculty Member's Gender:

In Your Opinion on the Establishment of Laboratories Necessary for Medical Education:
1. Which laboratories are essential?
2. What equipment is essential for the laboratory you use as a department?
3. What features are essential for the equipment you use as a department?
4. What features should be considered when purchasing consumables for laboratories?
5. What features should be considered when purchasing equipment for laboratories?
6. What should be considered during the tender process for material procurement?
7. What infrastructure should be established in areas designated for laboratories?
8. What are your thoughts on the minimum equipment and physical conditions for areas designated for laboratories?
9. If the laboratory is multidisciplinary, what should be considered in its operation?
10. "What should be considered for laboratory needs, such as storage, cold storage, chemical storage, etc.?
11. Anything you would like to add:

Thank you
Determination of Experience in the Establishment Process of Laboratories Required for Medical Education

Figure 1. Questions asked to faculty members in the qualitative study titled 'determining experiences in the establishment process of laboratories necessary for medical education' (Source: Authors' own elaboration)

establishment processes that the researcher had previously directly experienced during his work at two different medical schools (**Figure 1**).

The data obtained from the interviews were subjected to content analysis, and the findings were generated by dividing the expert responses into thematic groups [10]. The inclusion criteria for the study were determined as follows:

- being a faculty member of a medical school,
- having experience in setting up laboratories used in practical training,
- having experience teaching practical courses, and
- agreeing to participate voluntarily.

Exclusion criteria were as follows:

- not being a faculty member of a medical school,
- not having experience in setting up laboratories,
- not having taught practical courses, and
- not volunteering to participate.

In this context, the study was structured in accordance with the basic principles of the qualitative research approach, and original findings were obtained based on expert opinion [11].

RESULTS

A total of ten academics participated in the study: one professor, two associate professors, and seven assistant professors with experience in setting up laboratories used in practical training in medical schools. The average age of the participants was determined to be 45.2 years. Data obtained through semi-structured interviews was subjected to content analysis, and the basic application principles and requirements for laboratory setup were systematically outlined based on the faculty members' experiences and opinions.

Participants emphasized that among the essential elements that student laboratories should have, to ensure safety and hygiene, centralized ventilation, heating, and cooling systems, centralized gas, water, and electrical control panels, a sufficient number of sinks, medical waste bins, emergency showers, and eyewash stations should be included. They also stated that laboratories should be equipped with glass-doored lockers, projectors, computers with internet access, card access systems, emergency exits, and ergonomically designed experiment tables. Material data sheets should be filed, warning signs should be displayed, and risk analyses should be conducted to ensure the safe storage and use of chemicals. It was particularly emphasized that experiments should be conducted under the supervision of a faculty member, with the use of personal protective equipment, coats, and gloves mandatory.

Participants stated that each laboratory should be managed by a responsible faculty member, and that employing a sufficient number of technicians and research assistants in laboratories is critical to the uninterrupted continuity of educational activities. It was recommended that bulletin boards be placed at the laboratory entrance to announce practical course schedules, student groups, practice times, and exam information. It was also stated that keeping laboratory notebooks regularly would contribute to the recording of exams and practical applications. It was stated that all laboratories must be equipped with the necessary number of consumables, glass and plastic equipment, kits, and reagents, and that adequate cabinets and shelving systems should be installed for these materials.

For security reasons, it was recommended that camera systems be installed in laboratories, and that audible alerts or timers be installed during exams and practical. It was stated that planning seating areas outside the laboratories where students can wait would contribute to student satisfaction. Participants stated that the multidisciplinary student laboratory to be established: It was stated that departments such as medical biochemistry, physiology, medical biology, pharmacology, and microbiology should be open for shared use. It was stated that at least eight laboratory benches are required for students to participate in practical applications in groups, and the ideal laboratory area should be at least 80 m^2.

It was emphasized that a solution and material preparation room should be located adjacent to the laboratory, and this area should be planned to include equipment such as a fume hood, centrifuge, spectrophotometer, autoclave, vortex, bain-marie, and incubator. It was stated that the student microscope laboratory should contain at least 60 light microscopes, one advanced microscope belonging to a faculty member, a computer, a 4K camera, a projector, and three large screens, and that this laboratory should have a minimum area of 80 m^2.

Laboratories where simulation applications will be conducted should be equipped with original-sized patient models, computer-connected simulation systems, camera infrastructure, patient beds, and stretchers. It was recommended that at least two examination rooms be planned for simulated patient applications. It has been reported that chemical substance storage should be ventilated, have locked cabinets, and be arranged in accordance with the classification of the substances; content information should be included in each cabinet.

Anatomy laboratories require dissection tables, cadaver transport stretchers, morgue units, ventilation, and ample circulation space. It was stated that cadaver storage rooms should be located in addition to these laboratories, and these two areas should be designed in conjunction with each other. Cold storage, laboratory freezers, a -86 °C freezer, and blood and tissue storage areas were also considered indispensable components of research laboratories.

It was emphasized that computer-aided physiology experiment systems should include applications for ECG, EMG, respiratory function tests, and exercise physiology, and that these systems should be designed to develop students' data collection, analysis, and reporting skills. It was recommended that research laboratories include devices such as HPLC, gas chromatography, atomic absorption, microtome, Western Blot, and real-time PCR, and that compatible software and hardware be installed for these devices. It was also stated that sterile areas, biosafety cabinets, nitrogen tanks, and incubators suitable for cell culture and stem cell studies should be available. Fixed shelving systems, adequate ventilation, and locked and controlled access systems were recommended for material storage. It was stated that laboratory technicians' workspaces should be located close to the laboratories.

Participants stated that the most crucial step in planning the equipment and material procurement process is preparing the specifications. It was stated that specifications should prioritize quality, be competitive, but eliminate companies lacking technical competence. It was emphasized that all details for each device and material, including delivery, installation, assembly, training, protective equipment, user manual, warranty period, and service, should be clearly included in the specifications.

Companies should be required to deliver devices with user manuals, document training, respond within 24 hours in the event of malfunctions, and install replacement devices when necessary. It was recommended that spare parts requiring import be produced within a maximum of 15 business days, or the device should be replaced with a new one.

The devices should be high-performance, incorporate up-to-date technological features, be easy to use, be supported by user training, and have a long service life. It was stated that devices should be operable only with mains electricity, and maintenance and calibration services should be sustainable. It was also emphasized that providing demo presentations during device purchases is important for practical verification of technical specifications.

It was stated that anatomy models should be realistic, detailed, durable, functional, ergonomic, and compatible with anatomy atlases; they should provide both visual and educational adequacy. A balance of quality, affordability, longevity, and functionality should be considered in all purchases.

The minimum list of devices, materials, and consumables to be used in medical education is determined as a result of our research given in **Table A1**, **Table A2**, **Table A3**, **Table A4**, and **Table A5** in **Appendix A**.

Finally, it was stated that transparency, legal compliance, open communication, supplier competence, financial security, and technical capacity should be considered in tender processes; processes should be carefully monitored, and interventions should be made when necessary. These findings reveal a holistic framework that should be considered when planning laboratories serving practical education in medical schools.

DISCUSSION

Undergraduate and graduate programs in medical schools are largely based on hands-on training [3]. Studies demonstrating that students benefit more from hands-on courses also support this approach [4]. Functional, comprehensive, and well-equipped laboratories are necessary for effective practical training in basic medical sciences.

However, there is no national guide that defines in detail the physical, technical, and infrastructure standards required for laboratories required for medical education. Studies examining laboratory setup processes for medical education are quite limited in the literature [11]. The vast majority of existing publications are limited to simulation laboratories and do not include systematic evaluations of basic medical sciences laboratories [12, 13].

A review of the legislation highlights the document titled "minimum requirements for the beginning and continuing of education in medical programs," published by the Yükseköğretim Kurulu [Council of Higher Education]. However, this text provides only general definitions of laboratories and does not include comprehensive technical details [6]. On the other hand, the positive effects of simulation-based applications on the acquisition and maintenance of clinical skills have been clearly demonstrated in the literature [14]. However, these data are generally limited to clinical applications, and data on laboratory infrastructures for basic sciences is quite limited [15, 16].

The findings of this study indicate that a large number of devices and consumables are essential for basic medical education laboratories to operate effectively (**Table A1**, **Table A2**, **Table A3**, **Table A4**, and **Table A5** in **Appendix A**). Planning these requirements with a holistic approach during the establishment phase of medical schools is crucial for the quality of education. The budget allocated, especially during the initial establishment phase, must be used effectively, and potential financial and administrative constraints that may be encountered in later stages should be considered.

The significant differences in technical specifications and prices among the devices and materials used in laboratories necessitate careful evaluation of the quality-price balance. In our study, the minimum required devices and materials were determined based on expert opinions, and the technical, administrative, and financial principles regarding the procurement processes were comprehensively evaluated.

Research on simulation laboratories, in particular, has demonstrated that infrastructure planning and technical equipment directly impact the success of education [14]. This situation highlights the gap in the literature on basic science laboratories. The presented study fills this gap and provides a unique contribution to the planning, installation, and equipment processes of basic medical education laboratories.

Furthermore, considering that medical education is not limited to undergraduate level but also requires laboratory support at the postgraduate level, the shortcomings in this area become even more apparent. No study has been found in the literature that systematically addresses the infrastructure and equipment requirements of postgraduate laboratories. This study fills this gap by presenting the necessary laboratory infrastructure for postgraduate education based on expert opinions, making a unique contribution to the literature.

The findings serve as a guide for future field studies and emphasize the need for separate assessments for each type of laboratory. Given the importance of practical training in medical schools, clearly defining the procedures and principles for laboratory installation is critical to the quality of education.

This study presents systematic data, based on expert opinions, on the installation of laboratories required for undergraduate and postgraduate medical school education. It is recommended that experienced teams be assigned, sufficient time allocated, and comprehensive market analyses be conducted during the installation process, particularly during the specification preparation phase. Given the complexity of changes to be made to laboratories after their installation, the planning and implementation processes must be meticulously executed from the outset.

This study contributes significantly to the literature by systematically documenting experiences related to laboratory installation processes. It also serves as a guide for newly established medical schools and health education investments.

CONCLUSION

This study compiled findings from faculty members' experiences regarding laboratory installation processes, a crucial component of practical training in medical schools. Participant opinions reveal that many elements, such as physical infrastructure, technical equipment, human resources, and safety measures, should be considered holistically in laboratory planning. It was understood that significant variations in practice exist among institutions due to the lack of standard guides. The data obtained from the study provide guidance for institutions planning in the field of health education and serve to build a body of knowledge that can contribute to addressing structural deficiencies in the field. The results constitute an original resource that can form the basis for future research of similar

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AI statement: The authors stated that no generative AI tools were used in the preparation of this manuscript.

Declaration of interest: Authors declare no competing interest.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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APPENDIX A

Table A1. Minimum devices and equipment used in laboratories

No	Device/material name	Recommended quantity
1	Macroscopy cabinet	1 unit
2	Bünzen burner and stand	10 units
3	Fume hood	3 units
4	Emergency shower	5 units
5	Vertical material cabinets: glass-doored, shelf-equipped, and locked (metal)	40 pieces
6	Hydraulic cadaver storage basin	1 piece
7	Morgue cabinet	1 piece
8	Hydraulic cadaver transport cart	1 piece
9	Cadaver washing unit	1 piece
10	Faculty member dissection table	1 piece
11	Ventilation and lighting unit	1 piece
12	Student dissection table	6 pieces
13	Embalming device	1 piece
14	Paraffin water bath	1 piece
15	Manual microtome	1 piece
16	Tissue embedding device	1 piece
17	Tissue processing device	1 piece
18	ELISA multimode plate reader	1 piece
19	ELISA plate washer	1 piece
20	UV-student spectrophotometer	7 pieces
21	UV-faculty member spectrophotometer	1 piece
22	Atomic absorption device	1 piece
23	Nitrogen storage tank (50 liters) and nitrogen transfer apparatus	1 piece
24	Liquid nitrogen storage tank (35 liters)	2 pieces
25	Homogenizer	1 quantity
26	Sonicator (homogenizer)	1 quantity
27	Laboratory-type washing and disinfection device	1 quantity
28	Electronic physiology training and experiment set	5 quantity
29	Organ bath	2 quantity
30	Generator	1 quantity
31	Dispenser (fixed, large-volume liquid adder)	4 quantity
32	Repeater pipette set (3 pipettes/set)	3 quantity
33	Rechargeable pipette pump	4 quantity
34	Refrigerator +4 °C (laboratory type)	4 quantity
35	Deep freezer -40 °C	3 quantity
36	Deep freezer -86 °C	1 quantity
37	Dry block heater	2 quantity
38	Vortex	4 quantity
39	Ultrapure water system	1 quantity
40	Refrigerated microcentrifuge	2 quantity
41	Refrigerated centrifuge	2 quantity
42	Spin centrifuge	1 quantity
43	Bain-marie water bath	2 quantity
44	Orbital shaker (medium size)	2 quantity
45	Rotator	2 quantity
46	Magnetic stirrer with heater	2 quantity
47	Microplate shaker	2 quantity
48	Bottle and tube rotator	2 quantity

Table A1 (Continued). Minimum devices and equipment used in laboratories

No	Device/material name	Recommended quantity
49	Biosafety cabinet	2 quantity
50	Oven (105 °C-65 liters, dual/single)	3 quantity
51	Sterilizer	1 quantity
52	Carbon dioxide incubator	1 quantity
53	UV transilluminator	1 quantity
54	Horizontal electrophoresis and power supply	3 quantity
55	Vertical gel protein electrophoresis and power supply	1 quantity
56	Horizontal gel DNA electrophoresis and power supply	1 quantity
57	Cell imager	1 quantity
58	Imaging system	1 quantity
59	Cell counter	1 quantity
60	Benchtop pH meter	3 quantity
61	Analytical balance 220 g	8 quantity
62	Analytical balance 2,000 g	2 pieces
63	Automatic pipette set (faculty member)	36 pieces
64	Automatic pipette set (student)	35 pieces
65	Multi-channel automatic pipette set	6 pieces
66	Ice machine	1 piece
67	Autoclave 85 liters	1 piece
68	Student microscope	100 pieces
69	Educational microscope (UHD camera)	1 piece
70	Fluorescence-inverted microscope	1 piece
71	Stereo microscope	1 piece
72	Laser projector	6 pieces
73	98-inch UHD 8K neo QLED TV	3 pieces
74	Biochemistry and ELISA autoanalyzer	1 piece
75	HPLC device	1 piece
76	Gas chromatography device	1 piece
77	PCR device	3 pieces
78	Real-time PCR device	1 piece
79	Central water purification system (reverse osmosis)	1 piece
80	Medium area work bench	12 quantity
81	Side work bench (L-shaped)	6 pieces
82	Long middle work bench	2 pieces

Table A2. Models used in anatomy and medical skills training

No	Device/material name	Recommended quantity
1	Male muscle figure model	4 pieces
2	Female and male torso models with genitals and internal organs, including head	4 pieces
3	Half head model	5 pieces
4	Facial nerve and blood vessel model	4 pieces
5	Head model with muscles and vessels	5 pieces
6	Fifteen-part brain model	5 pieces
7	Sympathetic nervous system model	4 pieces
8	Nervous system model	2 pieces
9	Cord model in spinal canal	4 pieces
10	Median and frontal section model of the head	4 pieces
11	Five-part brain model	4 pieces
12	Lumbar vertebrae (L2) spinal canal	3 pieces
13	Thoracic vertebrae (Th2) with spinal cord	3 pieces
14	Dura mater and brain model	5 pieces
15	Eye orbit topography model	4 pieces
16	Eyeball model	3 quantity
17	Ear model with pinna	4 quantity
18	Cochlea section model	3 quantity
19	Labyrinth	5 quantity
20	Nose, mouth, and throat cavity model with larynx	4 quantity
21	Nose model	4 quantity
22	Larynx and tongue model	5 quantity
23	Bronchial tree model	4 quantity
24	Larynx	4 quantity
25	Functional larynx model	2 quantity
26	Lung and larynx model	1 quantity
27	Circulatory system model	2 quantity
28	Lymphatic system model	2 quantity
29	Thoracic anatomy model	4 quantity
30	Heart model with conduction system	3 quantity
31	Heart model with diaphragm base	2 quantity
32	Fetal heart	3 quantity
33	Digestive system model	4 quantity
34	Liver model	2 quantity
35	Pancreas model	4 quantity
36	Liver and gallbladder model	2 quantity
37	Urinary organ models	4 pieces
38	Right kidney and adrenaline gland model	3 pieces
39	Kidney, nephron, and glomerulus model	4 pieces
40	Male genital organ model	4 pieces
41	Female genital organ model	4 pieces
42	Median section model of the male pelvis	4 pieces
43	Median section model of the female pelvis	4 pieces
44	Pelvic floor and leg muscles model	5 pieces
45	Foot muscles model	5 pieces
46	Shoulder and arm muscles model	5 pieces
47	Hand muscles model	5 pieces
48	Shoulder joint model	4 pieces
49	Elbow joint model	4 pieces
50	Knee joint model	4 pieces

Table A2 (Continued). Models used in anatomy and medical skills training

No	Device/material name	Recommended quantity
51	Hip joint model	4 pieces
52	Foot joint model (with ligaments)	4 pieces
53	Hand and finger joint model (with ligaments)	4 pieces
54	Skull model (general)	5 pieces
55	Skull model (yes)	4 pieces
56	Skull base and arteries	4 pieces
57	Artificial skull model	3 pieces
58	14-piece skull model	5 pieces
59	Femur model	4 pieces
60	Spine model	1 piece
61	Spine model with pelvis	1 piece
62	Cervical spine	2 pieces
63	Vertebra model set	5 pieces
64	Spinal cord and vertebra set	3 pieces
65	Male pelvis bone model	4 pieces
66	Female pelvis skeleton model	4 pieces
67	Right foot bone model	4 pieces
68	Half pelvis model with lower extremity	4 pieces
69	Arm skeleton model with shoulder	4 pieces
70	Right hand bone model	2 pieces
71	Half human skeleton model	2 pieces
72	Scapula model	4 pieces
73	Clavicle model	4 pieces
74	Humerus model	4 pieces
75	Ulna and radius 4	4 quantity
76	Tibia and fibula model	4 quantity
77	Human skeleton model	5 quantity
78	Brainstem model (cranial nerve nuclei)	5 quantity
79	Spinal cord model	4 quantity
80	Brain ventricles model	4 quantity
81	Female pelvis and posterior abdominal wall model	2 quantity
82	MRI-compatible head section model	4 quantity
83	Head and neck model	2 quantity
84	Tongue and teeth model	4 quantity
85	Heart model (double-enlarged)	3 quantity
86	Female pelvis with ligaments	2 quantity
87	Dura mater model	4 quantity
88	Male pelvis and posterior abdominal wall model	2 quantity
89	Adult intubation model	3 quantity
90	Infant intubation model	3 quantity
91	Adult male IV arm model	3 quantity
92	Adult female IV arm model	3 quantity
93	Intramuscular injection simulator	3 quantity
94	Male catheterization training simulator	3 quantity
95	Intravenous injection simulator	3 quantity
96	CPR training manikin (infant, with electronic display)	3 quantity
97	Adult basic life support manikin	3 quantity
98	Surgical suturing and knotting model	3 quantity

Table A3. Basic laboratory consumables

No	Device/material name	Recommended quantity
1	Glass burette set. 50 ml with stopcock. Metal stand	20 pieces
2	Erlenmeyer flask glass set (8-piece: 10-2,000 ml)	35 pieces
3	Beaker glass set (8-piece: 10-2,000 ml)	30 pieces
4	Graduated cylinder glass set (8-piece: 10-2,000 ml)	25 pieces
5	Plastic graduated cylinder set (8-piece: 10-2,000 ml)	25 pieces
6	Regular flask glass set (8-piece: 10-2,000 ml)	25 pieces
7	Volumetric flask glass set (8-piece: 10-2,000 ml)	25 pieces
8	Glass pipette set (1, 2, 5, 10, and 20 ml)	45 pieces
9	Dark glass vial with screw cap set (5-piece)	25 pieces
10	Glass funnel set (5, 20, and 500 ml)	20 pieces
11	Glass rod set	25 pieces
12	Watch glass 150 mm	20 pieces
13	Slides (straight cut, box of 50)	200 pieces
14	Coverslip 22×22 (box of 50)	200 pieces
15	Thoma slides	10 pieces
16	Glass test tubes (16 mm)	1,000 pieces
17	Glass test tubes with screw caps	600 pieces
18	Glass test tubes narrow (12 mm)	1,000 pieces
19	Glass test tubes long (16 cm)	1,000 pieces
20	PVC plastic test tubes (16 mm)	500 pieces
21	Ceramic mortar and hand (100 cc)	10 pieces
22	Plastic funnel set (5 pieces)	20 pieces
23	Medical waste bags (medium size, 10 pieces)	100 pieces
24	Syringe 10 cc	1,500 pieces
25	Syringe 5 cc	1,500 pieces
26	Eppendorf tubes 0.5 ml (non-sterile)	15 pieces
27	Eppendorf tubes 1.5 ml (non-sterile)	20 pieces
28	Eppendorf tubes 2 ml (non-sterile)	15 pieces
29	Petri dish (plastic)	1,000 pieces
30	Stirring rod (PTFE 6x250 mm)	2 pieces
31	Parafilm dispenser	5 pieces
32	Falcon tubes 50 ml (25-pack)	50 pieces
33	Falcon tubes 15 ml (100-pack)	35 pieces
34	Microbank bacteria storage tubes	200 pieces
35	Magnetic fish set (0.5-5 mm, 4 pieces)	10 pieces
36	Examination gloves (latex, box of 100)	100 pieces
37	Glove bags (100 Packs)	100 pieces
38	Cleaning brush set	3 pieces
39	Loop handle	50 pieces
40	Physiological serum (1,000 cc, bag)	30 pieces
41	Pasteur pipette (box of 500)	10 pieces
42	Pipette pump set (2, 10, 25 ml)	4 pieces
43	Metal spatula set	10 pieces
44	Vacuum blood tubes (EDTA)	400 pieces
45	Vacuum blood tubes (gel)	400 pieces
46	Bunsen burner stand	5 pieces
47	Asbestos wire set (12-20 cm)	5 pieces
48	Washcloth 500 ml	30 pieces
49	Metal spore tube (pack of 10)	40 pieces
50	Parafilm rolls (4×250)	30 pieces

Table A3 (Continued). Basic laboratory consumables

No	Device/material name	Recommended quantity
51	Spectro cuvette (disposable, pack of 100)	10 quantity
52	Pen loop tips	20 quantity
53	Viral DNA/RNA extraction kit	2 quantity
54	Nitrile gloves	100 boxes
55	PCR plate set (0.1-0.2 ml)	5 sets
56	Forceps set (8 different models)	20 sets
57	Genomic DNA isolation kit (100 r×n)	1 quantity
58	Total RNA isolation kit (50 r×n)	1 quantity
59	Pipette tips (0.5-10 µl, boxed, non-sterile)	50 quantity
60	Pipette tips (0.5-10 µl, bag)	15 quantity
61	Pipette tips (10-200 µl, boxed, non-sterile)	50 quantity
62	Pipette tips (10-200 µl, bag)	15 quantity
63	Pipette tips (100-1,000 (µl, boxed)	50 pieces
64	Pipette tips (100-1,000 µl, bag)	15 pieces
65	Microcentrifuge tubes (1.5 ml, DNase/RNase-free)	25 pieces
66	PCR amplification kit (500 r×n)	1 piece
67	Primer (2×20 mer, for beta-globulin gene)	1 piece
68	Restriction endonuclease (DdeI)	2 pieces
69	ExoSAP-IT (1 ml)	2 pieces
70	PCR tubes with caps (0.2 ml, DNase-free, 1,000 ml)	2 pieces
71	PCR grade H_2O (500-1,000 ml)	3 pieces
72	Filter paper (40×40 cm, 200 ml)	4 pieces
73	Plastic rack (compatible with 1.5 ml tubes)	20 quantity
74	Plastic racks (15 ml falcon compatible)	20 pieces
75	Whatman filter papers (125 mm)	5 pieces
76	Chalices	40 pieces

Table A4. Special laboratory consumables and dyes

No	Device/material name	Recommended quantity
1	pH indicator stick	50 pieces
2	pH buffer solutions	6 pieces
3	Dispenser boxes	4 pieces
4	Boxes	4 pieces
5	Filter paper	5 packages
6	Scalpel handles	20 sets
7	Scalpel tips	30 packages
8	Scissors set (5 different models)	3 sets
9	Dissecting needle set (3 pieces)	2 sets
10	Bonnet	20 packages
11	Shoe covers	20 packages
12	Arm cuffs	10 packages
13	Waste bin	10 pieces
14	Bench protective paper	5 pieces
15	Goggles	10 pieces
16	Mask	10 pieces
17	Thermometer	10 pieces
18	Stand	10 pieces
19	Tongs (wooden for tubes)	10 pieces
20	Tongs (steel for tubes)	2 pieces
21	Sterile scalpel tip no: 15 (100 pieces)	10 pieces
22	Surgical set (7 pieces, in bag)	4 pieces
23	Histology preparation training set	6 pieces
24	Wright stain	2 pieces
25	Acridine orange	2 pieces
26	Eosin Y (alcohol-based)	2 pieces
27	Gill III hematoxylin	2 pieces
28	Pipetting reservoir 30 ml (10 pieces/pack)	1 piece
29	Cotton roll	10 pieces
30	Loop handle	20 pieces
31	Loop wire	10 packages
32	Plastic loop	10 packages
33	Petri dish (90 mm)	150 packages
34	Petri dish (150 mm)	60 packages
35	Slide storage box	40 pieces
36	Stool container with spoon	10 packages
37	Nitrocellulose membrane filter	5 packages
38	Agar	1 piece
39	Mueller Hinton agar	1 piece
40	Blood agar base	1 piece
41	EMB agar	1 piece
42	MIO medium	1 piece
43	TSI agar	1 piece
44	Sabouraud dextrose agar (SDA)	1 piece
45	Tryptophan broth	1 piece
46	Urea broth medium	1 piece
47	Simmons citrate agar	1 piece
48	Ziehl-Neelsen stain kit (TB)	1 piece
49	Gram stain set	1 piece
50	Urine container	1,000 pieces

Table A4 (Continued). Special laboratory consumables and dyes

No	Device/material name	Recommended quantity
51	Bead tube	1,000 pieces
52	Low melting point agar	1
53	ECG electrode	5
54	Slide archive cabinet	1
55	Special chemical cabinet	12
56	Phosphate buffer	3 boxes
57	Acetate pen set (4 colors, S-M sizes)	5 sets
58	Citrate buffer	3 boxes

Table A5. Minimum chemical material list required for laboratories

No	Device/material name	Recommended quantity
1	Iron	1 unit
2	Acetic acid (glacial)	5 units
3	Acetone	3 units
4	Acetohydroxamic acid	1 unit
5	DL-alanine	1 unit
6	Ammonia solution 25% GR	2 units
7	Aspartic acid extra pure	1 unit
8	Ammonium sulfate	1 unit
9	Ammonium eisen (III) sulfate	1 unit
10	Ammonium persulfate	1 unit
11	Ammonium peroxy disulfate	1 unit
12	Ammonium hepta molybdate crystal	1 unit
13	Bovine serum albumin	2 units
14	Ammonium oxalate monohydrate	1 unit
15	Acrylamide	2 units
16	Agarose	3 units
17	Adenosine	2 units
18	1-Amino-2-hydroxy-naphthalin sulfonsaure-(4)	1 unit
19	8-aminonaphtalene-2-sulphonic acid	1 unit
20	L(+) arginine hydrochloride (ACROS)	1 unit
21	4-aminoantipyrine-sigma-aldrich	1 unit
22	Ammonium iron (II) sulfate	1 unit
23	Alizarin red	1 unit
24	Alizarin yellow R sodium salt	1 unit
25	Ammonium bicarbonate	1 unit
26	Barbituric acid	1 unit
27	Boric acid	3 units
28	Bromocresol green indicator	2 pieces
29	Butanol extra pure	1 piece
30	Benzoic acid	3 pieces
31	2,4′-bipyridine	1 piece
32	Bromocresol purple	2 pieces
33	Bilirubin	1 piece
34	Brillant blue R	1 piece
35	Bromphenol blue	2 pieces
36	Brij ÒL23	1 piece
37	Caffeine EMPROVE®	1 piece
38	Carmine (powder)	2 pieces
39	Calcium carbonate precipitated GR	3 pieces
40	Chloroform extra pure	3 pieces
41	1-chloro-2,4 dinitro benzene	1 piece
42	Creatine	1 piece
43	Cysteine for biochemistry	1 piece
44	Cadmium sulfate	1 piece
45	Cadmium garanular	1 quantity
46	Copper II sulfate	3 quantity
47	Chloranilic acid	1 quantity
48	Chloramine T trihydrate	1 quantity
49	Cumene	1 quantity
50	Chloroacetic acid	1 quantity

Table A5 (Continued). Minimum chemical material list required for laboratories

No	Device/material name	Recommended quantity
51	Chromotropic acid	1 quantity
52	CAPSO sodium salt	1 quantity
53	Calcium chloride	3 quantity
54	Coomassie brilland blue R250	2 quantity
55	Diethylene glycol	1 quantity
56	Diethyl ether extra puree	2 quantity
57	Dimethyl sulfoxide (D.M.S.O.) extra	2 quantity
58	Dinitrophenol for synthesis	1 quantity
59	DL-dithiothreitol	2 quantity
60	5.5¢-dithiobis (2-nitrobenzoic acid)	1 quantity
61	4-dimethylamino benzaldehyde	1 quantity
62	2,6-di-tert-butyl-4-methylphenol	1 piece
63	Diphenyl carbazone	1 piece
64	Diathyl barbitursaure	1 piece
65	Digitonin crystal	1 unit
66	Disodium hydrogen phosphate	2 units
67	Disodium hydrogen phosphate dodecahydrate	1 unit
68	O-dianisidine	1 unit
69	E.D.T.A. extra	3 units
70	E.D.T.A. disodium salt	2 units
71	Entellan	1 unit
72	Eosin methylene blue	2 units
73	Eosin azulade	1 unit
74	Ethanol (96%) extra	20 units
75	Ethidium bromide	3 units
76	Ethylene glycol	1 unit
77	Ethyl acetate	1 unit
78	Evans blue	1 unit
79	Formaldehyde solution minimum 37%	5 units
80	Fructose	2 units
81	Fuchsin	2 units
82	Basic fuchsin (merck)	2 units
83	Folin-ciocalteu's phenol reagent	1 unit
84	Galactose	2 units
85	Gallic acid	1 unit
86	Glucose	4 units
87	Glutamic acid	1 unit
88	Glutamine	1 unit
89	Glycerol	2 units
90	Glycine	2 units
91	Glucose oxidase	1 unit
92	Gelatin	2 units
93	Giemsa stain	4 units
94	Glutathione-reduced form	1 unit
95	Gram Jensen (gram crystal violet)	1 unit
96	Gram fuchsin solution	2 units
97	Gram sarfanin	1 unit
98	Heptane extra pure	1 unit
99	Heparin	5 units
100	Hexane extra pure	1 unit

Table A5 (Continued). Minimum chemical material list required for laboratories

No	Device/material name	Recommended quantity
101	Hydrochloric acid fuming 37%	2 units
102	Hydrogen peroxide solution 30%	3 units
103	Hydroxyproline	1 unit
104	Hexadecyltrimethyl ammonium bromide	1 unit
105	Bromide	1 unit
106	Mayer's haematoxylin	1 unit
107	Hanks balanced salt solution	1 unit
108	4-hydroxybenzoic acid	1 unit
109	Iodine resublimed	2 units
110	Isoamyl	1 unit
111	Iso propyl alcohol (2-propanol) extra pure	2 units
112	Iron III chloride anhydrous Eisen chloride $FeCl_3$	1 unit
113	Iron II chloride ($FeCl_2$)	1 unit
114	Iron III nitrate chloride ($Fe(NO_3)_3$)	1 unit
115	Insulin	1 unit
116	India ink stain	2 units
117	Iron (II) sulfate heptahydrate	1 unit
118	Crystal violet	3 units
119	Cresol red	1 unit
120	Kovaks indole reagent	2 units
121	Carbol fuchsin dye	3 units
122	Kalium disulfide (Potassium pyrosulfite)	1 unit
123	Kalium hexacyano ferrate (III) crystal	1 unit
124	Lactophenol cotton blue stain	1 unit
125	Lithium sulfate	1 unit
126	Maltose monohydrate	1 unit
127	Mannose	1 unit
128	Mercaptoethanol for synthesis	2 units
129	Mercury (I) chloride	1 unit
130	Mercury (II) chloride extra pure fine crystal	1 unit
131	Methanol extra pure	4 units
132	Malachite green	2 units
133	Methyl orange (C.I. 13025) ACS indicator	2 pieces
134	Methylene blue stain	2 pieces
135	Methylene blue (powder)	2 pieces
136	Methyl red, indicator	3 pieces
137	Magnesium chloride. $6H_2O$	2 pieces
138	Magnesium chloride	3 pieces
139	Manganase chloride	1 piece
140	Methyl violet, indicator, P.A.	2 pieces
141	α-naphthol GR	1 piece
142	Ninhydrin GR	1 piece
143	Nitric acid 65% extra pure	2 pieces
144	Sodium molybdate	1 piece
145	Nitrophenol indicator	1 piece
146	Sodium nitrate	1 piece
147	4-Nitrophenol	1 piece
148	N,N´-methylenebisacrylamide (bisacrialamide)	1 piece
149	Nitroblue tetrazolium (NBT)	1 piece
150	Methylene blue solution	N/A

Table A5 (Continued). Minimum chemical material list required for laboratories

No	Device/material name	Recommended quantity
151	3-nitrophenol	1 unit
152	Oleic acid extra pure	1 unit
153	Oxalic acid dihydrate extra pure	1 unit
154	Oxoglutaric acid	1 unit
155	Quecksilber (II) oxide rot	1 unit
156	Potassium dihydrogen phosphate	2 units
157	Perchloric acid 60% GR for analysis ACS	1 unit
158	Phenol red indicator pH 6.4-8.2 ACS	2 units
159	Paraxon-ethyl	1 unit
160	Phenylalanine for biochemistry	1 unit
161	Phenyl acetate	1 unit
162	Phosphoric acid 85%	1 unit
163	Meta-phosphoric acid	1 unit
164	Periodic acid	1 unit
165	Potassium chloride GR	2 pieces
166	Potassium alum doecahydrate	1 piece
167	Potassium dichromate cryst. extra pure	1 unit
168	Potassium cyanide GR ACS (100)	1 unit
169	Potassium dihydrogen phosphate GR ISO	3 units
170	Potassium fluoride extra pure	2 units
171	Potassium hexacyanoferrate (II) trihydrate GR	1 unit
172	Di-potassium hydrogen phosphate anhydrous GR	2 units
173	Potassium hydroxide pellets extra pure	2 units
174	Potassium Iodate GR ACS, ISO	2 units
175	Potassium iodine	1 unit
176	Di-potassium oxalate monohydrate extra pure	1 unit
177	Potassium sodium tartrate tetrahydrate GR, ACS	1 unit
178	Phenol	2 units
179	Potassium permanganate	1 unit
180	Phenylphosphat dinatriumsalz	1
181	Peroxidase, from horseradish sigma	1
182	Picric acid	1
183	Proline	1
184	Propyl gallate 98%	1
185	Resorcinol GR	2
186	Silver nitrate GR	2
187	Sodium acetate anhydrous GR, ACS	2
188	Sodium azide extra pure	2
189	Sodium carbonate anhydrous GR, ISO	2
190	Sodium chloride GR, ACS, ISO	3
191	Sodium citrate dihydrate GR	2
192	Sodium cyanide pure	2
193	Sodium dihydrogen phosphate dihydrate	3
194	Sodium dodecyl sulfate	2
195	Sodium fluoride GR, ACS, ISO	2 quantity
196	Sodium hydrogen phosphate anhydrous GR	2 quantity
197	Sodium hydroxide pellets pure	3 quantity
198	Sodium iodite	2 quantity
199	Sucrose for microbiology	2 quantity
200	Sodium nitroprusside dihydrate GR ACS	2 quantity

Table A5 (Continued). Minimum chemical material list required for laboratories

No	Device/material name	Recommended quantity
201	Carboxymethyl cellulose sodium salt	2 quantity
202	Sudan III (C.I.26100) LAB	2 quantity
203	Sulfanilic acid for synthesis	1 quantity
204	Sulfosalicylic acid dihydrate for synthesis	2 quantity
205	Sulfuric acid 95-98% extra pure	2 quantity
206	L-cysteine	1 quantity
207	Sodium borohydride	2 quantity
208	Sudan III	1 quantity
209	Sudan IV	1 quantity
210	Sodium metabisulfite	1 quantity
211	Sodium thiosulfate	1 quantity
212	Sodium hypochlorite solution	1 quantity
213	Citric acid	3 quantity
214	Succinic acid anhydrous	1 quantity
215	Safranin O	4 quantity
216	D-sorbitol	2 quantity
217	Tartaric acid GR ACS ISO	2 quantity
218	Trichloroacetic acid cryst. extra pure	2 quantity
219	Tris HCl GR	3 quantity
220	TRISMA base	2 quantity
221	10× tris-boric Acid-EDTA solution	5 quantity
222	Triton X-100 GR	2 quantity
223	Tryptophan	1 quantity
224	Tyrosine	1 quantity
225	L-tyrosine	1 quantity
226	Thiourea	1 quantity
227	Thiobarbituric acid	2 quantity
228	Toluidine blue	2 quantity
229	Urease	2 quantity
230	Urea	2 quantity
231	Valine for biochemistry	1 quantity
232	Vanillin	1 quantity
233	Xylose	2 quantity
234	Xanthine	1 quantity
235	Xyleol orange tetrasodium salt	1 quantity
236	Xylene	3 quantity
237	Zinc acetate dihydrate extra pure	1 quantity
238	Zinc granule	1 quantity
239	Zinc sulfate.7H2O	1 quantity
240	Cholesterol powder	1 quantity
241	Wright stain	2 quantity
242	Acridine orange	2 quantity
243	Eosin Y (alcohol-based)	2 quantity
244	Gill III hemaoxylin	2 quantity
245	Selenium	1 quantity
246	Sodium benzoate	1 quantity
247	Monosodium glutamate	1 quantity
248	Carvacrol	1 quantity
249	Pregabalin	1 quantity
250	Lacosamide	1 quantity

Table A5 (Continued). Minimum chemical material list required for laboratories

No	Device/material name	Recommended quantity
251	Melatonin	1 quantity
252	HFCS 55	1 quantity
253	HFCS 50	1 quantity
254	Lipopolysaccharide	1 quantity
255	Agomelatine	1 quantity
256	Bevacizumab	1 quantity
257	Ranimizumab	1 quantity
258	L-ascorbic acid	1 quantity
259	Alpha-tocopherol	1 quantity
260	Retinol; vitamin A	1 quantity
261	25-OH-vitamin D3	1 quantity
262	Resveratrol	1 quantity
263	Streptozocin	1 quantity
264	Thymoquinone	1 quantity
265	Lutein	1 quantity
266	Lycopene	1 quantity
267	Magnolol	1 quantity
268	Taurine	1 quantity
269	L-histidine	1 quantity
270	Biotin	1 quantity
271	Ferric sulfate	1 quantity