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Original Research Article

Mongolian Medical Equipment Regulations: Challenges in Clinical Engineering Development

Gerelt-Od Namdag[1], Amarsaikhan Dashtseren[2], and Munkh-Erdene Luvsan[1*]

[1] Department of Health Policy, School of Public Health, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia.
[2] Department of Preventive Medicine, School of Public Health, Mongolian National University of Medical Sciences, Ulaanbaatar, Mongolia.

[*] Corresponding Author Email: munkherdene@mnums.edu.mn

ABSTRACT

To effectively deliver healthcare services, it is essential to strengthen and expand the education system for qualified clinical engineers and technicians. This should be combined with measures such as providing modern equipment to health facilities and making spare parts available. Internationally, one clinical engineer is typically responsible for approximately 100 pieces of equipment, while each large piece of equipment, such as magnetic resonance imaging (MRI), computed tomography (CT), positron emission tomography (PET scan), and angiography machines, is assigned to a dedicated engineer. However, in our country, no standard exists linking the number of engineers to the quantity of medical equipment. The Law on Drugs and Medical Devices, adopted in 2024, stipulates that general hospitals, specialized centers, and specialized hospitals must have a dedicated unit responsible for the use and safety of medical equipment, while other healthcare institutions must employ a full-time or subcontracted engineer. However, biomedical engineers and technicians are not classified as "medical specialists" under the Law on Health. Although four universities nationwide train biomedical engineers and technicians, the number of graduates still does not meet the growing market demand. There is also a need to diversify and develop biomedical engineers in line with international standards, including certification. These findings underscore the need for structural reforms in clinical engineering training, legal recognition, and workforce planning in Mongolia.

Objective: To assess the human resource needs and legal framework for medical equipment specialists and compare them with the WHO and regional country regulations.

Methods: We used analytical, cross-sectional, and descriptive study designs. A total of 272 engineers and technicians were interviewed using a pre-prepared questionnaire that included questions on work experience, postgraduate training, qualification level, and workload. We also reviewed WHO and regional regulations regarding the professional descriptions and certification of biomedical engineers. The data were analyzed using SPSS Statistics 26, and the results are presented in figures and tables.

Results: The study population comprised 72.4% males, 95.6% full-time employees, and 68.8% bachelor's degree holders. However, the majority (90.4%) did not have a specialty degree. Regarding on-the-job and other training, 73.5% had not received any training. The training status of professionals was not dependent on the organization they worked for. However, there was a statistically significant difference between foreign training and manufacturer-provided training. The professionals surveyed had received relatively little training since they started working. As their years of experience increased, the number of manufacturer-organized training sessions also increased. However, there was no relation between years of experience and the number of domestic, foreign, or postgraduate training sessions. Additionally, the number of medical devices managed per engineer varied, and the legal framework regulating social security, rights, and obligations remains insufficient. It also varied compared to WHO recommendations, medical engineering professional descriptions, and certifications across countries in the region.

Conclusion: Clinical engineers and technicians face a heavier workload. The lack of postgraduate training opportunities, an insufficient legal framework, and variations in medical engineering professional descriptions and certifications across countries in the region present significant challenges for the sector. Based on these findings, the study proposes strategic recommendations including legal recognition, certification systems, continuing professional development, and workforce planning policies to address these barriers and strengthen clinical engineering in Mongolia.

Keywords—*Human resources, Healthcare specialist, Legal framework.*

BACKGROUND

In Mongolia, health products and technologies, one of the six main components of the health sector systems developed by the World Health Organization,[1] are regulated by the Law on Health,[2] the revised version of the Law on Drugs and Medical Devices,[3] and the Law on Metrology.[4] To effectively deliver healthcare services, it is essential to strengthen and expand the education system for qualified engineers and technicians of medical equipment. This effort should be complemented by equipping healthcare institutions with modern medical devices and ensuring the availability of spare parts. In Mongolia, the state budget for medical equipment ranged from 9 to 41 billion tugriks between 2017 and 2021. Since 2018, maintenance costs for major technologies such as magnetic resonance imaging (MRI), computed tomography (CT), and angiography devices, previously covered by the organizations' operating expenses, have been separately allocated in the state budget. However, since 2020, healthcare institutions have been responsible for these costs.[5] Article 40.1 of the revised Law on Drugs and Medical Devices states that "Healthcare institutions specified in Articles 15.1.4, 15.1.5, 15.1.7, 15.1.11, 15.1.12, and 15.1.13 of the Law on Health shall have a unit responsible for the use and safety of medical equipment, and other healthcare institutions shall have a full-time or contracted clinical engineer who shall perform the corresponding functions."[3] However, the rights and obligations outlined in Articles 28.1 and 28.4 of the Law on Health, particularly Article 28.1.5, which states that professionals should have the opportunity to "improve their professional skills and participate in postgraduate training at the expense of the institution every five years,"[2] do not apply to clinical engineers. The WHO also published a report titled "Human Resources for Medical Devices: The Role of Biomedical Engineers as part of its Medical Device Technical Series", highlighting the global concern over the need for certification of professionals in the field of Biomedical Engineering (BME).[6]

The Mongolian standard sets the minimum staffing ratio of clinical engineers to technicians (4:2) for both specialized and general hospitals,[7,8] and 1 per 100 pieces of equipment for Family Health Centers,[9] soum (district) and village health centers,[10] and maternity houses.[11] Additionally, the National Center for Blood Transfusion and Research and the National Center for Zoonotic Diseases have a 2:1 ratio,[12,13] while the National Center for Pathology follows a ratio of 1:1.[14] Nevertheless, a report by the Ministry of Health of Mongolia indicated that, in practice, one engineer is responsible for 220 pieces of equipment in central hospitals and specialized centers, while one engineer manages 319 pieces of equipment in both the capital and local areas.[15]

According to the Order No. 439 issued in 2006 by the Minister of Health of Mongolia, one engineer is typically responsible for approximately 100 pieces of medical equipment, with one engineer dedicated to each major device, such as MRI, CT, PET scan, and angiography machines.[16]

The ME Uptime Project (2018), jointly conducted by the Ministry of Health of Zambia and the Tropical Health and Education Trust (THET) with the support of WHO, recommended that "1 BMET per 100 units of equipment is adequate," emphasizing the need for structured biomedical maintenance staffing.[17]

According to the US Bureau of Labor Statistics, the demand for biomedical engineers is projected to grow by 5% from 2022 to 2032, outpacing the growth of many other occupations.[18] This increase is driven by advancements in healthcare technology and the rising demand for medical services due to an aging population.[18]

In Mongolia, two government and two private universities offer training programs for biomedical engineers and technicians. According to the 2023 statistics, approximately 900 engineers and technicians have been trained.[19] Although human resource requirements for medical equipment maintenance were established by the Minister of Health orders in 2006 and 2018, implementation remains limited.[16,20] Only 43% of the 16 healthcare institutions under the Ministry of Health have independent clinical engineering departments. Among the 25 healthcare institutions under the capital city health department, 24% have only 1 to 2 engineers. Moreover, 95% of the 21 provincial healthcare institutions operate with just 1 to 2 engineers and lack dedicated medical technical departments.[15]

Therefore, it is necessary to assess the adequacy of clinical engineers in the healthcare sector and compare the legal framework with that of other countries in the region.

OBJECTIVE

To assess the human resource needs and associated legal framework for medical equipment specialists and compare them with the WHO recommendations and regional country regulations.

METHODS

The study followed an analytic, cross-sectional, and descriptive study design. Human resource needs were assessed through indicators such as employment contract specifications, qualifications, training, years of experience, and workload. A structured questionnaire was used to collect data on the number of engineers and technicians currently working in the medical equipment field, their qualifications, and training from 76 healthcare institutions in the capital and local areas. Additionally, data was collected from 272 currently working specialists, covering job roles, contract types, main specialties, years of experience, and training. Mongolian laws, standards, rules, and regulations related to human resources for medical equipment, as well as WHO recommendations and regulations in regional countries, were also reviewed.

For the descriptive analysis, the mean, standard deviation, and 95% confidence interval of the mean were calculated for quantitative variables with normal distribution. For non-normal distributions, the median and interquartile range were calculated. Outliers in quantitative variables with non-normal distribution (defined as $x \le Q1-1.5IQR$ or $x \ge Q3+1.5IQR$) were removed. After removing outliers, the mean, standard deviation, and 95% confidence interval of the mean were recalculated.

To assess differences in quantitative variables between groups, the Mann–Whitney U test was used for two independent groups, and the Kruskal–Wallis H test was used for three or more groups. Differences were considered statistically significant if the P-value was less than 0.05.

ETHICAL CONSIDERATIONS

The study methodology was discussed at the Institutional Review Board meeting of the Mongolian National University of Medical Sciences on January 21, 2022 (No. 2022/3-01), and permission to conduct the study was obtained.

RESULTS

We surveyed 272 professionals, comprising 83.9% of engineers and technicians working in the healthcare sector. Of the professionals surveyed, 72.4% were males, 95.6% were full-time employees, and 68.8% held a bachelor's degree. However, the majority (90.4%) of specialists did not have a professional degree (Table 1). This is attributed to the lack of a legal framework, professional career development roadmaps, job descriptions, and planning.

TABLE 1. General characteristics of medical equipment specialists in organizations, by percentage.

Indicators	Total, n = 272	MH*	PGH†	RDTC‡	DGH§	DHC‖	SGH¶	SH††	ECMOHSC#	SO**
Gender										
Female	27.6	85.7	26.7	33.3	25.0	37.5	25.0	50.0	27.9	21.6
Male	72.4	14.3	73.3	66.7	75.0	62.5	75.0	50.0	72.1	78.4
Terms of the employment contract										
Contract	4.4	-	8.9	-	-	12.5	50.0	-	4.9	0.9
Full-time	95.6	100.0	91.1	100.0	100.0	87.5	50.0	100.0	95.1	99.1
Education level										
No education	0.7	-	4.4	-	-	-	-	-	-	-
High school	2.6	-	4.4	5.6	-	-	-	-	6.6	-
Bachelor	68.8	71.4	53.3	44.4	87.5	87.5	100.0	50.0	57.4	80.2
Licentiate	19.1	-	35.6	44.4	12.5	12.5	-	-	24.6	9.0
Master	8.8	28.6	2.2	5.6	-	-	-	50.0	11.5	10.8
Qualification										
None	90.4	100.0	77.8	94.4	100.0	87.5	100.0	100.0	90.2	93.7
Consultant	0.7	-	-	-	-	-	-	-	1.6	0.9
Qualified	8.8	-	22.2	5.6	-	12.5	-	-	8.2	5.4

Notes: *Maternal houses, †Provincial General Hospitals, ‡Regional Diagnostic and Treatment Centers, §District General Hospitals, ‖District Health Centers, ¶Soum General Hospitals, ††Specialized Hospitals, Capital Department of Health institutions, #Emergency Centers, Ministry of Health Specialized centers, **Supply Organizations.

TABLE 2. Training of biomedical engineers and technicians, by type of organizations.

Indicators	Total		UB Health Department		Local		Private		Ministry of Health		*P*
	n	%	n	%	n	%	n	%	n	%	
Internal training											0.371
Not attended at all	200	73.5	24	72.7	44	65.7	86	77.5	46	75.4	
Attended	72	26.5	9	27.3	23	34.3	25	22.5	15	24.6	
Foreign training											0.0001
Not attended at all	258	94.9	32	97.0	67	100.0	109	98.2	50	82.0	
Attended	14	5.1	1	3.0	0	0.0	2	1.8	11	18.0	
Postgraduate training											0.140
Not attended at all	187	68.8	23	69.7	44	65.7	84	75.7	36	59.0	
Attended	85	31.3	10	30.3	23	34.3	27	24.3	25	41.0	
Manufacturer training											0.0001
Not attended at all	176	64.7	33	100.0	58	86.6	36	32.4	49	80.3	
Attended	96	35.3	0	0.0	9	13.4	75	67.6	12	19.7	

Notes: Percentages may not add up to exactly 100% due to rounding, institutional differences in respondent numbers, and missing values for some variables.

As for the status of on-the-job and other training received by the surveyed professionals, 73.5% had not received any training. The training status did not depend on the organization they worked for. However, there was a statistically significant difference between the organizations in the availability of foreign and manufacturer training (Table 2).

Table 2 and Figures 1 and 2 show that the professionals surveyed receive relatively little training after starting their occupation. The average duration of postgraduate training is 32 days (95% CI, 22.8–41.2) in government organizations and 19.8 days (95% CI, 9.5–30.1) in private organizations (Figure 1).

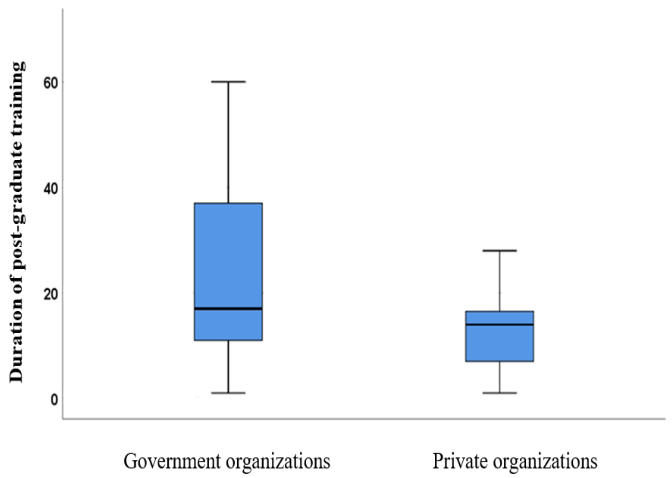

FIGURE 1. Internal training participation by organizations.

Manufacturers are equally represented in government and private organizations, with 17.2 (± 16.3) days of training. The maximum duration of postgraduate training was 93 days in government organizations, while it was 70 days in private organizations, indicating that training was more concentrated in government organizations (Figure 2).

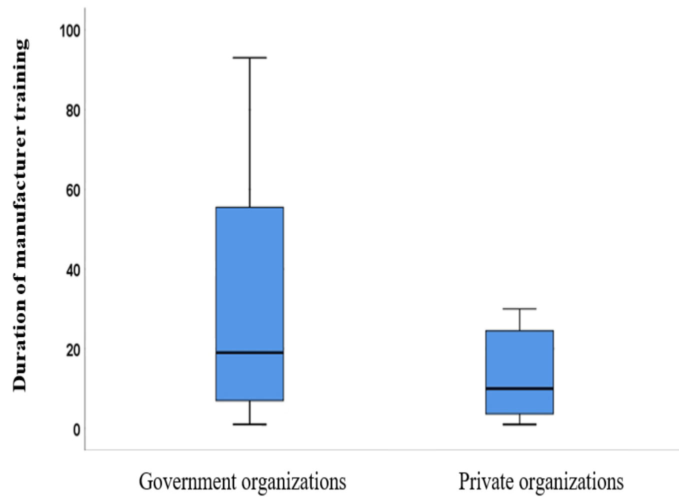

FIGURE 2. Manufacturer training participation by organizations.

As the number of years of experience in the field increases among the surveyed professionals, participation in training organized by the manufacturer increases. However, participation in domestic, foreign, and postgraduate training was not associated with the years of experience (Table 3).

As the number of years of experience in the field increased among the surveyed professionals, participation in training organized by the manufacturer also increased. On the other hand, participation in domestic, foreign, and postgraduate training was not significantly associated with years of experience (Table 3).

TABLE 3. Training of biomedical engineers and technicians, by years of experience.

Indicators	1–3 years		4–6 years		7–9 years		10+ years		*P*
	Number	%	Number	%	Number	%	Number	%	
Internal training									0.437
Not attended at all	72	78.3	39	73.6	32	71.1	51	67.1	
Attended	20	21.7	14	26.4	13	28.9	25	32.9	
Foreign training									0.197
Not attended at all	90	97.8	51	96.2	43	95.6	69	90.8	
Attended	2	2.2	2	3.8	2	4.4	7	9.2	
Postgraduate training									0.064
Not attended at all	71	77.2	37	69.8	30	66.7	44	57.9	
Attended	21	22.8	16	30.2	15	33.3	32	42.1	
Manufacturer training									0.001
Not attended at all	74	80.4	28	52.8	25	55.6	44	57.9	
Attended	18	19.6	25	47.2	20	44.4	32	42.1	

DISCUSSION

In the ISCO-08 system of International Standard Classification of Occupations published by the International Labor Organization-ILO, biomedical engineers are classified under the Group 2149 category, "Engineering professionals not elsewhere classified."[21] In Mongolia, Order No. 16, "National Lists, Classifications and Definitions of Occupations and Jobs", issued by the Minister of Labor and Social Protection on February 10, 2010, Biomedical engineers are classified under the Group 2149 category, "Engineering professionals not elsewhere classified."[22]

The World Health Organization's Medical Devices Technical Series report, Human Resource Development and the Role of Biomedical Engineers, highlights that BME is not officially classified within the health category in international and national occupational classifications.[23] This lack of recognition impacts the assessment and development of the profession, hinders acknowledgment of its critical role, and negatively affects the sustainability of human resources in the health sector.[6] Over the past decade, the rapid advancement of medical science and technology has led to continuous investments in new healthcare technologies, significantly increasing the workload of engineers and technicians.

According to our findings, there are 324 (± 234) pieces of equipment per engineer, which exceeds international standards. This highlights the need for additional professional human resources in the healthcare sector. Additionally, there is a need for continuous training of existing specialists, improvement of the legal framework, and the development and implementation of job descriptions and career development plans. The Law on Drugs and Medical Devices (revised version) mandates that large hospitals establish medical equipment units and requires other healthcare organizations to employ full-time or contracted clinical engineers. However, clinical engineers and technicians are not classified as "medical specialists" under the Law on Health, which regulates social security, rights, and obligations for human resources in the sector. This results in a regulatory gap, violating provisions such as the requirement for professionals to improve their skills and attend postgraduate training at the organization's expense every 5 years.

A study on the prevalence of biomedical engineers per 10,000 population in the WHO Western Pacific Region found that Japan had 1.58, Malaysia 0.82, Mongolia 0.81, and Kiribati 0.27, while China had 0.03 and the Republic of Korea had < 0.01.[24] A study by the WHO (2015) found that the proportion of male engineers (77%) was three times higher than that of female engineers (23%). However, five countries, namely Argentina, Ukraine, Macedonia, Malaysia, and Sudan, reported that the number of female engineers exceeded that of males. In contrast, Laos, Micronesia, Rwanda, Sierra Leone, Tanzania, and Vanuatu did not register any female engineers at all.[24] According to the WHO research, Mongolia has 240 Biomedical or Clinical Engineering specialists.[24]

Regarding the structural organization and human resource supply for the maintenance and reliable operation of medical equipment, as of 2023, 43% of the 16 healthcare institutions under the Ministry of Health had an independent clinical department staffed with 10 to 20 engineers and technicians. In contrast, 24% of the 25 healthcare institutions under the Ulaanbaatar City Health Department (UBHD) had only 1 to 2 engineers, while 95% of the 21 provincial healthcare institutions had just 1 to 2 engineers, without an independent medical technical department.

The WHO emphasizes the need for long-term, sustainable efforts to train highly skilled engineers and technicians to ensure the normal and reliable operation and maintenance of medical equipment. This approach will help reduce maintenance costs and improve the quality of medical care and services.[25]

In Mongolia, medical equipment engineers are referred to as "Biomedical Engineers", regardless of the field they work in (hospitals, supply organizations, factories, etc.). They are also typically certified as consulting healthcare engineers or certified healthcare engineers.[26]

A series of technical documents issued by the WHO has defined BME as follows: "Biomedical engineering" includes equivalent or similar disciplines, whose names might be different, such as medical engineering, electromedicine, bioengineering, medical and biological engineering, and clinical engineering.[27]

However, in some countries, the term “Biomedical engineer” is used interchangeably with “Clinical engineer” in hospitals.

The American College of Clinical Engineering defines a clinical engineer as “a professional who supports and advances patient care by applying engineering and managerial skills to health care technology”.[28]

The Association for the Advancement of Medical Instrumentation describes a clinical engineer as, “a professional who brings to health-care facilities a level of education, experience, and accomplishment which will enable him to responsibly, effectively, and safely manage and interface with medical devices, instruments, and systems and the user thereof during patient care”.[29]

Japan has a government-certified Clinical Engineering Technologist (CET) designation. To become a CET, one must graduate from a university, college, or vocational school with a degree in clinical engineering and pass a national examination. CETs specialize in the operation and maintenance of medical equipment. In 1987, the Clinical Engineering Law was enacted, regulating CETs as medical professionals who specialize in the operation and maintenance of life-saving equipment.[30]

In Taiwan, the Taiwan Society for Biomedical Engineering certifies clinical engineers, medical device technicians, and biomedical engineers. It has been administering formal certification exams since 2007.[30]

In 2005, international clinical engineer certification was introduced in China. The Medical Engineering Division of the Chinese Medical Association organizes the examination. In 2012, the Chinese Registered Clinical Engineer Certification program was launched, with the examination including both theoretical and practical tests.[30]

In Mongolia, medical equipment engineers are awarded consulting and specialized engineering degrees following Order No. 213 of the Minister of Health, dated September 2, 2005, titled “On Organizing Training for Granting Specialist and Consulting Engineering Degrees to Healthcare Engineers.”[26]

These findings demonstrate that despite the establishment of basic legal provisions, significant gaps remain in human resource development and regulation for clinical engineering. The data show limited access to training, a high equipment-to-engineer ratio, and the lack of professional recognition. Compared to WHO, IMDRF, and the regulations of countries like Australia, Japan, Korea, China, and the Philippines, Mongolia’s medical device regulation shows gaps in terminology, classification, post-market surveillance, packaging, labeling, advertising, and disposal. However, import regulations align with international standards.[31]

As highlighted by Ayala (2022), the role of clinical engineering has progressed alongside the increasing complexity of medical technologies—extending beyond equipment maintenance to encompass integrated management, innovation, and participation in policy-making processes.[32]

As Mijares (2023) emphasizes in his study of clinical engineering in Venezuela, the interaction between health technologies and national political systems plays a critical role in determining the quality and accessibility of medical care. The research underscores that sustainable clinical engineering development requires not only technical expertise, but also alignment with coherent public health policies and transparency in procurement and evaluation processes.[33]

Based on the findings and challenges discussed above, the following policy strategies are recommended to strengthen the clinical engineering profession in Mongolia.

Recommendations:

Establish a national certification and accreditation system for clinical engineers, aligned with WHO and IMDRF standards.

Revise the Law on Health to recognize clinical engineers as health professionals, ensuring their inclusion in workforce development and social protection policies.

Develop structured career pathways and continuing professional development (CPD) requirements, including the implementation of a system for mandatory training every 3 to 5 years.

Define institutional staffing norms based on the level of healthcare facilities and the quantity and complexity of medical equipment. Large hospitals should establish dedicated clinical engineering units or departments.

Implement a nationwide technical training program in collaboration with foreign universities and medical equipment manufacturers.

CONCLUSION

Clinical engineers and technicians in Mongolia face significantly higher workloads. The lack of structured postgraduate training, legal recognition in the health sector, and insufficient support for professional development present critical challenges to the field. Internationally, countries such as Japan, Taiwan, and China have adopted national certification systems and legal frameworks that formally recognize clinical engineering as a healthcare profession. Aligning with WHO recommendations and regional best practices, this study recommends establishing a national certification and accreditation system, revising health laws to include biomedical engineers as health professionals, and implementing structured career pathways with mandatory continuing education. These measures will help ensure safe and effective medical device management, improve healthcare service delivery, and foster long-term sustainability of the BME workforce in Mongolia.

AUTHOR CONTRIBUTIONS

Conceptualization, A.D., M.-E.L., and G.-O.N.; Methodology, M.-E.L.; Formal Analysis, M.-E.L. and G.-O.N.; Writing–Original Draft Preparation, M.-E.L. and G.-O.N.; Writing–Review & Editing, M.-E.L.; Supervision, A.D.; Project Administration, M.-E.L.; Funding Acquisition, G.-O.N.

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DATA AVAILABILITY STATEMENT

Not applicable.

CONFLICTS OF INTEREST

The authors declare they have no competing interests.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study methodology was discussed at the Institutional Review Board meeting of the Mongolian National University of Medical Sciences on January 21, 2022 (No. 2022/3-01), and permission to conduct the study was obtained.

CONSENT FOR PUBLICATION

Not applicable.

FURTHER DISCLOSURE

Not applicable.

REFERENCES

1. World Health Organization. Development of Medical Device Policies. World Health Organization; 2011. Available online: https://iris.who.int/bitstream/handle/10665/44600/9789241501637-eng.pdf?sequence=1.
2. Mongolian State Great Khural. Law on Health. Legalinfo.mn - Integrated legal information system of Mongolia; 2011. Available online: https://legalinfo.mn/mn/detail/49.
3. Mongolian State Great Khural. Law on Drugs and Medical Devices /Revised Version/. Legalinfo.mn - Integrated legal information system of Mongolia; 2024. Available online: https://legalinfo.mn/mn/detail?lawId=17140713569541%20.

4. Mongolian State Great Khural. Law on Metrology / Revised Version/. Legalinfo.mn - Integrated legal information system of Mongolia; 2019. Available online: https://legalinfo.mn/mn/detail/14440.
5. Department of Investment, Ministry of Health. Investment in Medical Equipment (unpublished material). 2024.
6. World Health Organization (WHO). Human Resources for Medical Devices: The Role of Biomedical Engineers (WHO Medical Device Technical Series). 2017. Available online: https://iris.who.int/bitstream/handle/10665/255261/9789241565479-eng.pdf?sequence=1.
7. Mongolian Agency for Standard and Metrology. The structure and activity of Specialized Hospital MNS 6330:2017. 2017. Available online: https://estandard.gov.mn/website/masm/standards_details.aspx?code=2ea79180-e0e6-440c-afee-e53a6a71f5d4.
8. Mongolian Agency for Standard and Metrology. The structure and activity of General Hospital MNS 5095:2017. 2017. Available online: https://estandard.gov.mn/website/masm/standards_details.aspx?code=f674ebca-2a3a-4c45-ad22-72bc454af49f.
9. Mongolian Agency for Standard and Metrology. Family Group Practice's structure and function. MNS 5292:2017. 2017. Available online: https://estandard.gov.mn/website/masm/standards_details.aspx?code=8edfe00f-5b7b-40cd-a675-545686ed1907.
10. Mongolian Agency for Standard and Metrology. Structure and activity of Sum, Village's Health Center. MNS 5081:2013. Available online: https://estandard.gov.mn/website/masm/standards_details.aspx?code=317690e7-852c-4e53-b8c2-e2979cdc18c8.
11. Mongolian Agency for Standard and Metrology. Health care technology. Structure and function of Maternity home; MNS 6188:2010; 2010. Available online: https://estandard.gov.mn/website/masm/standards_details.aspx?code=0580a699-7e2a-4855-87b4-7d16f87d2dbd.
12. Mongolian Agency for Standard and Metrology. Structure and Function of the National Center for Transfusion Medicine. MNS 6674:2017; 2017. Available online: https://estandard.gov.mn/website/masm/standards_details.aspx?code=3d248324-414e-4232-8618-daea79856c52.
13. Mongolian Agency for Standard and Metrology. Structure and Function of the National Center for Zoonotic Diseases MNS 6675:2017; 2017. Available online: https://estandard.gov.mn/website/masm/standards_details.aspx?code=7eb432ac-8d15-437e-9cf8-7820663bdb4f.
14. Mongolian Agency for Standard and Metrology. Structure and Functions of the National Center for Pathology MNS 6676:2017. 2017. Available online: https://estandard.gov.mn/website/masm/standards_details.aspx?code=0fa04aad-a748-4b9d-9604-e67e3ccdada6.
15. Ministry of Health of Mongolia. Medical Equipment Evaluation (unpublished material). 2017.
16. Ministry of Health. Approval of General Requirements for the Composition, Organization, and Activities of Medical Equipment Engineers and Technicians (unpublished material). 2006.
17. Mol CR. Final Report of the Medical Equipment (ME) Uptime Project. 2018. Available online: https://www.globalhealthpartnerships.org/wp-content/uploads/2018/05/180329-Final-Report-ME-Uptime-Project.pdf.
18. U.S. Bureau of Labor Statistics (USBoL). Biomedical Engineers: Occupational Outlook Handbook Website Title: Occupational Outlook Handbook. 2023. Available online: https://www.bls.gov/ooh/architecture-and-engineering/biomedical-engineers.htm#tab-6.
19. Mongolian Medical Engineering Society. Number of Medical Equipment Engineers and Technicians Graduated (unpublished material). 2025.
20. Ministry of Health. Approval of General Requirements for the Composition, Organization, and Activities of Medical Equipment Engineers and Technicians (unpublished material). 2018.
21. International Labour Organization (ILO). International Standard Classification of Occupations (ISCO-08). Available online: https://www.ilo.org/sites/default/files/wcmsp5/groups/public/%40dgreports/%40dcomm/%40publ/documents/publication/wcms_172572.pdf.
22. Ministry of Social Security and Labor. Lists of National Occupations and Jobs Lists, Classifications and Definitions (unpublished material). 2010.

23. World Health Organization (WHO). Human Resources for Medical Devices: The Role of Biomedical Engineers (WHO Medical Device Technical Series). 2017. Available online: https://iris.who.int/bitstream/handle/10665/255261/9789241565479-eng.pdf?sequence=1.

24. World Health Organization. Global Atlas of Medical Devices.; 2022. Available online: https://www.who.int/publications/i/item/9789241512312.

25. World Health Organization. Needs Assessment for Medical Devices WHO Medical Device Technical Series. 2011. Available online: https://iris.who.int/bitstream/handle/10665/44562/9789241501385-eng.pdf?sequence=1.

26. Order No. 213 of 2005 by the Minister of Health: "On Granting Consulting and Professional Engineer Titles to Medical Equipment Engineers."

27. World Health Organization. Health Technology Assessment of Medical Devices WHO Medical Device Technical Series. 2011. Available online: https://www.who.int/publications/i/item/9789241501361.

28. Bauld, T.J. The definition of a clinical engineer. *J Clin Eng*. 1991; 16(5):403–405. https://doi.org/10.1097/00004669-199109000-00011.

29. Goodman, G. The profession of clinical engineering. *J Clin Eng*. 1989; 14(1):27–37. https://doi.org/10.1097/00004669-198901000-00008.

30. Wear, J.O. Certification in the United States, Canada and Asia. *Glob Clin Eng J*. 2018;(0)1:15–22. https://doi.org/10.31354/globalce.v0i1.29.

31. Namdag, G.-O., Luvsan, M.-E., Dashtseren, A. A Study on the Legal Environment of Medical Devices and Enhancing the Regulatory System. 2025;7(1):25–31. https://doi.org/10.31354/globalce.v7i1.189.

32. Ayala, R. Clinical Engineering Role in the Development of Emergency Use Medical Devices. *Glob Clin Eng J*. 2022;4(3):47–49. https://doi.org/10.31354/globalce.v4i3.137.

33. Mijares, R. Clinical Engineering and health policies in Venezuela: challenges and achievements in a changing political context. *Glob Clin Eng J*. 2023;6(1):36–45. https://doi.org/10.31354/globalce.v6i1.161.