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Criminal Liability Of Medical Robots: Challenges and Opportunities For Future Law Enforcement

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Abstract. *This study aims to determine the challenges and opportunities in Criminal Liability for Errors Committed by medical robots in the future. The method used is normative juridical with statutory and conceptual approaches. This research discusses the criminal liability of medical robots and also the challenges and opportunities in health law regarding medical robots. The results of the study explain the responsibility for actions taken by artificial intelligence systems and robots. Liability is imposed on the manufacturer, operator, hospital, or software programmer connected to the robot. However, the challenge of proving cause, effect and intent in such cases can be very difficult. On the other hand, medical robots can help and relieve health workers in performing medical treatments. This research is expected to be useful in knowing the challenges and opportunities of law enforcement of medical robots, especially in criminal liability.*

Keywords: *Criminal Liability; Law Enforcement; Medical Robots.*

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1. Introduction

Artificial intelligence (AI) and robotics have grown in importance in the healthcare industry in recent decades. Its inception dates back to the 1950s, when stereotactic neurosurgery was performed with antiquated autonomous robots. In 1985, the first robotic surgical system for nerve biopsy was produced, called PUMA 560.[1] In 2000, Da Vinci was authorized for use as the first surgical robotic aid during laparoscopic procedures. Since then, the intuitive surgery has sold more than 6000 units globally.[2]

Nowadays, robotic surgery makes up fifteen to thirty percent of all surgeries performed in certain wealthy nations. Aside from surgery, other clinical applications for robots include physical therapy, prostheses, exoskeletons, sanitation, and virtual nursing assistants.[3] In addition, AI is becoming increasingly complex. The system is now ready for diagnosis interpretation, patient education, dosage recommendations, and more complex health analysis. Proficiency in fields such as radiology, pathology, and medical imaging has been enabled by distance learning techniques. However, even if the majority of AI nowadays has a narrow field of application, AI is being used to increase the number of klinis tanggung jawab memikul.[4]

However, as robots and AI become more prevalent in the healthcare industry, questions about who is willing to take responsibility for unavoidable health problems arise. With otonomous technology rapidly transforming the political landscape, legal and ethical issues need to be addressed promptly. Currently used medical robot categories include bedah, pembantu, eksoskeleton, and virtual cerdas assistants.[5] Similar to the Da Vinci system, a surgical robot is operated by the surgeon via a number of arms that can be fitted with tiny surgical instruments and cameras. These robots provide ease of access, precision, and flexibility in comparison to traditional approaches. Their haptic feedback is, therefore, restricted and reliant on human oversight.[6]

Rehabilitation assistive robots aid in the restoration of motor and physical abilities following surgery or other medical events. They use AI to personalize treatments and carry out quantifiable assessments. Wearable technology called robotic exoskeletons can benefit people with limb impairments and mobility problems. They identify electrical impulses coming from the brain to the afflicted muscles.[7] While intelligent chatbots such as Molly and virtual

[1] Danton S. Char, Nigam H. Shah, and David Magnus, "Implementing Machine Learning in Health Care — Addressing Ethical Challenges," *New England Journal of Medicine* 378, no. 11 (March 15, 2018): 981–83, https://doi.org/10.1056/NEJMp1714229.

[2] Yongde Zhang and Mingyue Lu, "A Review of Recent Advancements in Soft and Flexible Robots for Medical Applications," *The International Journal of Medical Robotics and Computer Assisted Surgery* 16, no. 3 (June 5, 2020), https://doi.org/10.1002/rcs.2096.

[3] Clara J Moerman, Loek van der Heide, and Marcel Heerink, "Social Robots to Support Children's Well-Being under Medical Treatment: A Systematic State-of-the-Art Review," *Journal of Child Health Care* 23, no. 4 (December 3, 2019): 596–612, https://doi.org/10.1177/1367493518803031.

[4] Abdullah Alanazi, "Clinicians' Views on Using Artificial Intelligence in Healthcare: Opportunities, Challenges, and Beyond," *Cureus*, September 14, 2023, https://doi.org/10.7759/cureus.45255.

[5] Mark Coeckelbergh, "Robot Rights? Towards a Social-Relational Justification of Moral Consideration," *Ethics and Information Technology* 12, no. 3 (September 27, 2010): 209–21, https://doi.org/10.1007/s10676-010-9235-5.

[6] Julia Amann et al., "Explainability for Artificial Intelligence in Healthcare: A Multidisciplinary Perspective," *BMC Medical Informatics and Decision Making* 20, no. 1 (December 30, 2020): 310, https://doi.org/10.1186/s12911-020-01332-6.

[7] John Danaher, "Welcoming Robots into the Moral Circle: A Defence of Ethical Behaviourism," *Science and Engineering Ethics* 26, no. 4 (August 20, 2020): 2023–49, https://doi.org/10.1007/s11948-019-00119-x.

nurses assist patients in chats for companionship, health monitoring, and education, they are not equipped to comprehend the complexity of today's complex health challenges. To sum up, medical robots hold enormous promise for precise intervention, intelligent support, and rehabilitation. The primary complaints are still excessive expenses, challenges with usability, and—above all—the lack of clarity about ethical and legal accountability for errors.[8]

This study aims to give a comprehensive examination of the prospects and problems related to medical robots and artificial intelligence systems' criminal liability. This essay will specifically look closely at the following subjects: the idea behind criminal culpability and if it should be extended to non-human entities like robots and artificial intelligence.[9] constraints of the current legal system in dealing with fresh problems brought forward by self-driving medical technology.[10] and the elements that decide whether criminal liability can be placed on the robot, a human operator, or the manufacturer.[11]

The advancement of AI in healthcare is what makes this research significant. In recent years, the field of medicine has witnessed an increase in the use of robotics and artificial intelligence (AI). According to a report, by 2025, the global market for medical robotics is expected to reach $16.74 billion.[12]

Numerous research have demonstrated that biases and mistakes in AI systems can result in therapeutic choices that are harmful or inaccurate.[13] This poses urgent concerns about the moral and legal responsibility of AI and robotic technologies that injure patients needlessly. When something goes wrong, it's frequently challenging to place the full blame on the associated healthcare provider, manufacturer, or operator.[14]

Attributable liability becomes even more complicated when human and computer decisions interact in complex ways. A lack of clarity surrounding criminal culpability will erode public confidence and compromise patient safety as AI use grows.[15] Therefore, it is imperative to establish explicit criminal liability guidelines and rules for AI in healthcare. An additional innovation with intricate technological and legal ramifications is the establishment of moral agency for artificial creatures.[16]

[8] Idris Sancaktar, Burak Tuna, and Mustafa Ulutas, "Inverse Kinematics Application on Medical Robot Using Adapted PSO Method," *Engineering Science and Technology, an International Journal* 21, no. 5 (October 2018): 1006–10, https://doi.org/10.1016/j.jestch.2018.06.011.

[9] Aaron M. Johnson and Sidney Axinn, "The Morality Of Autonomous Robots," *Journal of Military Ethics* 12, no. 2 (July 2013): 129–41, https://doi.org/10.1080/15027570.2013.818399.

[10] Francesca Lagioia and Giovanni Sartor, "AI Systems Under Criminal Law: A Legal Analysis and a Regulatory Perspective," *Philosophy & Technology* 33, no. 3 (September 15, 2020): 433–65, https://doi.org/10.1007/s13347-019-00362-x.

[11] Jing Li et al., "Magnetically-Driven Medical Robots: An Analytical Magnetic Model for Endoscopic Capsules Design," *Journal of Magnetism and Magnetic Materials* 452 (April 2018): 278–87, https://doi.org/10.1016/j.jmmm.2017.12.085.

[12] Koksal Gundogdu, Sumeyye Bayrakdar, and Ibrahim Yucedag, "Developing and Modeling of Voice Control System for Prosthetic Robot Arm in Medical Systems," *Journal of King Saud University - Computer and Information Sciences* 30, no. 2 (April 2018): 198–205, https://doi.org/10.1016/j.jksuci.2017.04.005.

[13] G. Usha* and K. Narasimman, "Tkinter App Based Robot for Medical and Domestic Purposes Using Raspberry Pi," *International Journal of Recent Technology and Engineering (IJRTE)* 8, no. 3 (September 30, 2019): 7708–12, https://doi.org/10.35940/ijrte.C6273.098319.

[14] Jaesoon Choi, "특집호 서문: 의료로봇과 인공지능," *Journal of Institute of Control, Robotics and Systems* 27, no. 5 (May 31, 2021): 321–321, https://doi.org/10.5302/J.ICROS.2021.21.9002.

[15] Nikita Ahuja et al., "Real-Time Cellular-Level Imaging and Medical Treatment with a Swarm of Wireless Multifunctional Robots," *The Journal of Supercomputing* 78, no. 2 (February 21, 2022): 1923–43, https://doi.org/10.1007/s11227-021-03924-z.

[16] Tri Kuntoro Priyambodo, Yudi Prayudi, and Rahmat Budiarto, "ABAC as Access Control Solution for Digital Evidence Storage," *International Journal on Advanced Science, Engineering and Information Technology* 14, no. 1 (February 6, 2024): 37–44, https://doi.org/10.18517/ijaseit.14.1.17502.

It is imperative that the legal void surrounding medical responsibility and liability for errors be filled as AI becomes a crucial component of healthcare. To strike a balance between patient rights, provider responsibility, and technology innovation, this will involve a great deal of legal debate and public participation.[17] Numerous research have demonstrated that biases and mistakes in AI systems can result in therapeutic choices that are harmful or inaccurate. It is unclear, nevertheless, who can be held responsible for a negative occurrence caused by a robot or AI malfunction—the hospital, the manufacturer, the programmer, or the operator.[18]

Due to the lack of clarity surrounding legal responsibilities, patient safety is greatly at risk because accountability is diminished. However, unduly stringent laws can hinder advancements in medical robotics that have the potential to significantly enhance healthcare.[19] Resolving the legal void surrounding criminal attribution following an error remains a critical difficulty when AI becomes a legal issue in medicine.[20] We need a balanced regulatory approach that strikes a balance between provider obligations, patient rights, and technology advancements.[21]

2. Research Methods

3. Results and Discussion

3.1. Medical robots and legal errors

The existing medical legal system places more emphasis on the human stakeholders' carelessness or liability than it does on the robot itself when medical robots inadvertently cause harm. Medical malpractice rules, for instance, look into whether the hospital or the physician

[17] Ampala Khoryanton et al., "Increasing the Quantity and Quality of GeNose 19 Medical Device Gaskets Using Piercing Tools," *International Journal on Advanced Science, Engineering and Information Technology* 14, no. 1 (February 12, 2024): 99–106, https://doi.org/10.18517/ijaseit.14.1.19393.
[18] Oskar Baumann et al., "Intuitive Teaching of Medical Device Operation to Clinical Assistance Robots," *International Journal of Computer Assisted Radiology and Surgery* 18, no. 5 (December 9, 2022): 865–70, https://doi.org/10.1007/s11548-022-02802-0.
[19] Shawn Shaju et al., "Conceptual Design and Simulation Study of an Autonomous Indoor Medical Waste Collection Robot," *IAES International Journal of Robotics and Automation (IJRA)* 12, no. 1 (March 1, 2023): 29, https://doi.org/10.11591/ijra.v12i1.pp29-40.
[20] Arajit Saha et al., "Medbot- Design and Development of Medical Robot for Healthcare Digitalization," *AIUB Journal of Science and Engineering (AJSE)* 22, no. 1 (May 8, 2023): 1–8, https://doi.org/10.53799/ajse.v22i1.257.
[21] V Seethalakshmi et al., "Tele-Presence Robot for Medical Assistance in Hospitals," *Journal of Physics: Conference Series* 1916, no. 1 (May 1, 2021): 012096, https://doi.org/10.1088/1742-6596/1916/1/012096.

who utilized the robot did not provide the necessary level of care.[22] A software developer or maker of robots may be held accountable under product liability law for a malfunctioning system or gadget. In a case study by Singh, there was significant bleeding because a surgical robot malfunctioned during a difficult sinus surgery. The surgical team's failure to act quickly resulted in the patient's death. The issue of humans reacting slowly and depending too much on robots is brought up by this circumstance. [23]

Another case documented is of a robot that unexpectedly died while undergoing a gynecological treatment. In the event that robotic support is abruptly stopped during surgery, patients are particularly vulnerable, even though no harm was done. This story demonstrates how serious a safety concern technological errors may be. According to Hasson, the patient suffered from severe bruising and discomfort as a result of the therapy robot using an improper force. They claim that improved control interfaces and safety measures are required.[24]

Treatment was hampered because AJIMP1, an artificial tool, failed to detect cancer in over 100 cases that were detected. This misdiagnosis highlights the unpredictability of AI testing in the medical domain. Artificial intelligence-programmed chatbot disseminated inaccurate and deceptive information on COVID-19 symptoms, implying that the logic and training data were not consistent.[25] These illustrations highlight the variety of mistakes that medical robots might make, such as programming mistakes, mechanical issues, and inadequate training. Injuries, issues, treatment delays, and even fatalities are among the outcomes, suggesting a larger degree of accountability.

3.2. The dialectic of medical robot liability

[22] Podsedkowski L Fracczak L, Szaniewski M, "Corrigendum," *The International Journal of Medical Robotics and Computer Assisted Surgery* 16, no. 2 (April 20, 2020), https://doi.org/10.1002/rcs.2064.
[23] Tao Wang et al., "Neurosurgery Medical Robot Remebot for the Treatment of 17 Patients with Hypertensive Intracerebral Hemorrhage," *The International Journal of Medical Robotics and Computer Assisted Surgery* 15, no. 5 (October 25, 2019), https://doi.org/10.1002/rcs.2024.
[24] Adam Williams, Bijo Sebastian, and Pinhas Ben-Tzvi, "Review and Analysis of Search, Extraction, Evacuation, and Medical Field Treatment Robots," *Journal of Intelligent & Robotic Systems* 96, no. 3–4 (December 1, 2019): 401–18, https://doi.org/10.1007/s10846-019-00991-6.
[25] Sylwia Łukasik et al., "Role of Assistive Robots in the Care of Older People: Survey Study Among Medical and Nursing Students," *Journal of Medical Internet Research* 22, no. 8 (August 12, 2020): e18003, https://doi.org/10.2196/18003.

Arguments in support of medical robot responsibility, alertness motivated by the possibility of criminal liability for producers or operators. fairness for people injured by robotic devices Justice is violated when wrongdoing goes unpunished.[26] Criminal charges acknowledge the serious risks that come with using technology carelessly or irresponsibly. Criminal prosecution is morally dubious since it is difficult to definitively identify culpability between the interconnected acts of humans and machines.[27] Ignorance of cause puts justice at danger. Criminalization stifles innovation too much, which can hinder technical breakthroughs in healthcare. Certain dangers are inevitable expenses of advancement. The concept of personality, which is based on human abilities like consciousness, is contradicted when non-human beings are given moral agency. Robots are incapable of such things.[28] In summary, there are valid ethical considerations on both sides. A contextual approach is necessary when discussing criminal liability in a specific case, taking into account factors including the evidence, harm, and public interest.

3.3. Criminal liability of medical robots

Actus reus describes a guilty deed or omission that constitutes a tangible part of a crime. Regarding medical robotics, this can include direct mistakes or damage brought about by the robotic system, including surgical mistakes or improper dosage recommendations that cause patient harm or death.[29] Typically, evidence of criminal intent, carelessness, or recklessness is needed to establish mens rea.

When assessing the "mental state" of artificial agents, judges may take into account the foresight of programmers, operators, or corporate policy. Nevertheless, it is difficult to definitively apportion mens rea because to the hazy boundaries of culpability between

[26] Suwito et al., "Contemplating the Morality of Law Enforcement in Indonesia," *Journal of Law and Sustainable Development* 11, no. 10 (October 25, 2023): e1261, https://doi.org/10.55908/sdgs.v11i10.1261.
[27] Viktoriia V. Haltsova et al., "Criminal Law as a Means of Protecting Human Rights and Freedoms in the Modern World," *Journal of the National Academy of Legal Sciences of Ukraine* 28, no. 3 (September 17, 2021): 248–56, https://doi.org/10.37635/jnalsu.28(3).2021.248-256.
[28] Kuldeep Jayaswal, D. K. Palwalia, and Sandeep Kumar, "Performance Investigation of PID Controller in Trajectory Control of Two-Link Robotic Manipulator in Medical Robots," *Journal of Interdisciplinary Mathematics* 24, no. 2 (February 17, 2021): 467–78, https://doi.org/10.1080/09720502.2021.1893444.
[29] Susan E. Collins, Heather S. Lonczak, and Seema L. Clifasefi, "Seattle's Law Enforcement Assisted Diversion (LEAD): Program Effects on Criminal Justice and Legal System Utilization and Costs," *Journal of Experimental Criminology* 15, no. 2 (June 19, 2019): 201–11, https://doi.org/10.1007/s11292-019-09352-7.

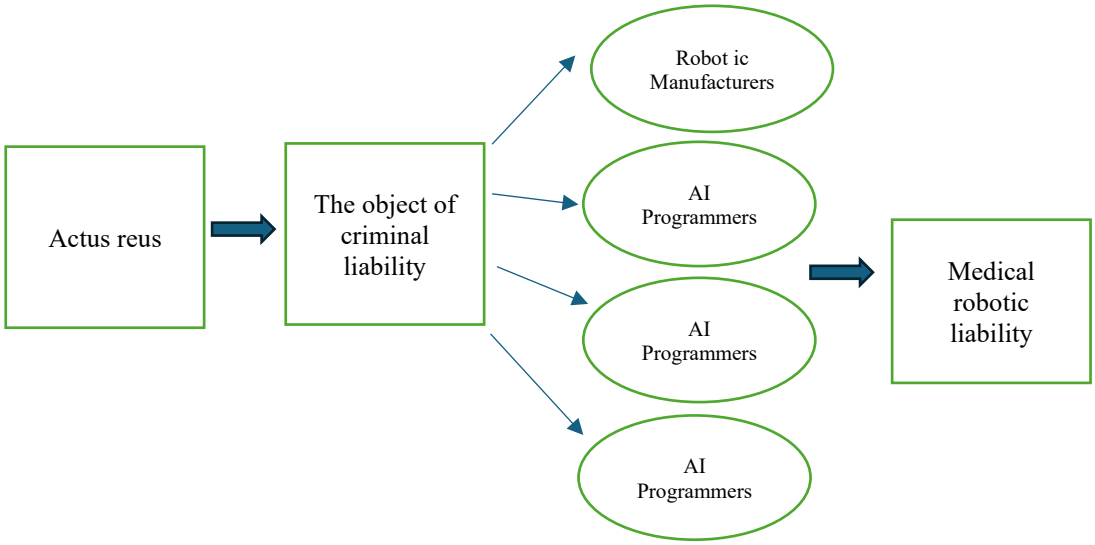
connected artificial actors and human actors.[30] Overall, meaningful attribution of mens rea remains hard both conceptually and legally, even though the actus reus of the AI system can be detected. To clear up this uncertainty, a hybrid strategy might be required.[31]

Numerous legal objects are subject to criminal liability. Among these, Robot Manufacturers may be held accountable for subpar engineering, shoddy construction, or insufficient safety testing that enabled the robot to engage in improper behavior.[32] The intricacy of the supply chain, however, may make it difficult to establish liability when it is distributed across several vendors. If errors in the code consistently result in negative effects, then the AI programmers who created the algorithms that control robotic behavior might be held accountable. That being said, it can be challenging to assess whether members of a big, dispersed development team have been negligent or acting with evident intent.[33]

Healthcare Providers who supervise robot operations, such as physicians, technicians, or hospitals, may be held accountable if patient injuries are caused by poor training, incorrect use, or lack of supervision. However, as systems become more autonomous, human monitoring is becoming less prevalent.[34] Some contend that sufficiently evolved AI can be held criminally liable as moral actors themselves, a point that is currently up for debate. Nonetheless, this is still debatable from a legal and moral standpoint.[35] In actuality, liability frequently entails the convergence of technological and human errors that increase unanticipated hazards.[36] The

[30] Ahmad Fekry Moussa, "Electronic Evidence and Its Authenticity in Forensic Evidence," *Egyptian Journal of Forensic Sciences* 11, no. 1 (December 27, 2021): 20, https://doi.org/10.1186/s41935-021-00234-6.
[31] Wenyuan Liang, Xiaobo Zhou, and Qing Lan, "Position Encoder Analysis and Low Delay Control for a Medical Robot with Six DoFs," ed. Min Xia, *Journal of Sensors* 2022 (March 8, 2022): 1–12, https://doi.org/10.1155/2022/1412068.
[32] Miki Mizuta et al., "Effect of Postoperative Pain Management after Robot-Assisted Radical Prostatectomy: A Study on Reducing Hospital Length of Stay and Medical Costs Using Japanese Nationwide Database," *The Tohoku Journal of Experimental Medicine* 259, no. 1 (2023): 2022.J092, https://doi.org/10.1620/tjem.2022.J092.
[33] Fengda Zhao et al., "Extract Executable Action Sequences from Natural Language Instructions Based on DQN for Medical Service Robots," *International Journal Of Computers Communications & Control* 16, no. 2 (March 3, 2021), https://doi.org/10.15837/ijccc.2021.2.4115.
[34] Yanzhu Hu et al., "Fusion Key Frame Image Confidence Assessment of the Medical Service Robot Whole Scene Reconstruction," *Journal of Imaging Science and Technology* 65, no. 3 (May 1, 2021): 030409-1-030409–9, https://doi.org/10.2352/J.ImagingSci.Technol.2021.65.3.030409.
[35] Alice Ristroph, "Criminal Law as Public Ordering," *University of Toronto Law Journal* 70, no. supplement 1 (February 2020): 64–83, https://doi.org/10.3138/utlj.2019-0066.
[36] Ioannis Kalpouzos, "International Criminal Law and the Violence against Migrants," *German Law Journal* 21, no. 3 (April 8, 2020): 571–97, https://doi.org/10.1017/glj.2020.24.

allocation of accountability necessitates a dynamic legal structure and meticulous examination of the intricate sociotechnical elements that give rise to every unfavorable incident.



3.4. Challenges in criminal liability of medical robots

There are several obstacles in the application of criminal liability of medical robots:

Proving Cause

The intricate relationship that exists between people and semi-autonomous systems makes it very challenging to pinpoint the precise source of an error. Was it a human operator error or a

malfunctioning robot that led to the surgical blunder? It might not make logical to pinpoint just one primary factor.[37]

Lack of Transparency

Many AI systems are black boxes, making it difficult to determine whether or not dangerous or incorrect activities might have been anticipated or avoided. Reasonable accountability judgment is hampered by obscurity.[38]

There is no legal personality

It's still debatable from a legal and moral standpoint whether or not autonomous robots should be held criminally liable. As of right now, robots lack personalities and legal identities.[39]

A Hybrid Cognitive System

The process of assigning fault is made more complex by the strong connections and interdependencies between artificial and human decision-making. Many times, accountability is divided among several human and non-human nodes.[40]

Dual Use Dilemma

[37] Doina Pisla et al., "Safety Issues in the Development of an Innovative Medical Parallel Robot Used in Renal Single-Incision Laparoscopic Surgery," *Journal of Clinical Medicine* 12, no. 14 (July 11, 2023): 4617, https://doi.org/10.3390/jcm12144617.
[38] Jingyu Li et al., "Intelligent Medical Knowledge Robot Based on Knowledge Graph," *Journal of Physics: Conference Series* 2501, no. 1 (May 1, 2023): 012032, https://doi.org/10.1088/1742-6596/2501/1/012032.
[39] and J. Wu Y. Yang, L. Dong, H. Rong, "Retracted: Optimization on Medical Material Distribution Management System Based on Artificial Intelligence Robot," *Journal of Healthcare Engineering* 2023 (May 24, 2023): 1–1, https://doi.org/10.1155/2023/9846162.
[40] Karen Barlow, "Corrigendum: Clinical Safety and Efficacy of a Fully Automated Robot for MRI-guided Breast Biopsy," *The International Journal of Medical Robotics and Computer Assisted Surgery* 19, no. 4 (August 6, 2023), https://doi.org/10.1002/rcs.2540.

The majority of medical robot designs have applications that are both safe and risky. It is inherently difficult to separate developers' criminal accountability for potentially hazardous but practical multipurpose technologies.[41]

When combined, these problems lead to a lack of accountability for criminal penalties related to medical robot mistakes. A new legal framework that takes into account complex automation will be required.

3.5. Opportunities in criminal liability of medical robots

Make regulations that are unique to medical robotics and AI that specify who is liable and accountable in the event that something goes wrong. Establish guidelines that assure openness and supervision during the healthcare robots' development, testing, and implementation phases in order to ensure their safety. Create guidelines and standards that are specific to the unique dangers connected to integrated human-robot settings in the medical field. Laws pertaining to product liability have been modified to take into account the special risks posed by robotics and increasingly self-sufficient artificial intelligence. Changing medical malpractice and negligence legislation to lessen human-robot hybrids' clinical responsibility.[42]

Establish new guidelines and sanctions to promote the responsible application of artificial intelligence. Personhood Lawful Robots depend on a framework of limited legal personality that holds sufficiently sophisticated artificial intelligence systems accountable for destructive independent activities. Develop new legal concepts, such as "electronic persons," to strike a balance between the rights and obligations of robots. Obviously, a multifaceted strategy is required. But rather than depending just on out-of-date theories, it is more crucial to create regulations and standards to proactively handle emerging concerns relating to the integration of humans and artificial intelligence.[43]

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[41] Daniella Awni Abu Yousef et al., "Medical Invention Marketing Strategies on Buying: Surgical Medical Robot," *International Journal of Data and Network Science* 7, no. 2 (2023): 647–56, https://doi.org/10.5267/j.ijdns.2023.3.007.

[42] Nasit Vurgun et al., "Medical Student Experience with Robot-Assisted Surgery after Limited Laparoscopy Exposure," *Journal of Robotic Surgery* 15, no. 3 (June 23, 2021): 443–50, https://doi.org/10.1007/s11701-020-01129-9.

[43] Jung Hwan Lee et al., "User Perception of Medical Service Robots in Hospital Wards: A Cross-Sectional Study," *Journal of Yeungnam Medical Science* 39, no. 2 (April 30, 2022): 116–23, https://doi.org/10.12701/yujm.2021.01319.

4. Conclusion

The existing medical legal system focuses more on the negligence or liability of human stakeholders rather than the robot itself when a medical robot accidentally causes harm. Medical malpractice rules investigate whether the hospital or doctor using the robot did not provide the necessary level of care. Product liability laws can hold software developers or robot manufacturers accountable for malfunctioning systems or devices. Medical robots can make a variety of mistakes, such as programming errors, mechanical problems and insufficient training. These errors can lead to injuries, problems, treatment delays, and even death, indicating a higher level of liability. There are valid ethical considerations on both sides regarding medical robot liability. Arguments in favor of criminal liability for manufacturers or operators include caution motivated by the possibility of criminal prosecution. However, criminalization may stifle innovation and is morally dubious due to the difficulty of identifying fault between humans and machines. Regarding medical robotics, actus reus may include direct fault or damage caused by the robotic system. Mens rea is more difficult to determine due to the blurred boundaries of fault between artificial and human actors. Robot manufacturers, AI programmers, and healthcare providers who oversee robot operations can be held liable for medical robot errors. However, liability often involves a convergence between technological and human errors that increase unforeseen dangers. There are several obstacles in the application of criminal liability of medical robots, including proving causation, lack of transparency, no legal personality, hybrid cognitive systems, and dual-use dilemmas. These issues lead to a lack of accountability for criminal convictions related to medical robot errors. Opportunities to address these challenges include creating unique regulations and guidelines for medical robotics and AI, establishing transparency and oversight during the development, testing, and implementation stages, and developing new legal concepts for “electronic persons”. A multifaceted strategy is needed to proactively address emerging issues related to the integration of humans and artificial intelligence.

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