Neonatal Bioethics: The Sociotechnical & Ethical Implications of Technological Care

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by Honor Guidelines for Thesis-Related Assignments

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Introduction

Neonatology, a specialized branch of pediatric medicine, focuses on the medical treatment and interventional care of newborns. This progressive field of medicine has evolved and expanded rapidly due to the advent of neonatal intensive care units (NICUs) and today provides life-saving intervention for over 300,000 critically ill infants each year in the United States (J. Martin & Osterman, 2025). Neonatologists and neonatal nurses are some of the frontier healthcare professionals trained to handle the complicated and high-risk health issues faced by these newborns. Interventional needs vary widely, from providing care for respiratory distress to congenital defects, birthing complications and most often prematurity (Séassau et al., 2023). This paper will explore the progression of this field of modern medicine, seeking to illuminate not only the development of medical care-practices but also the broader interwoven nature between biomedical innovation, technological care, and most importantly the bioethical considerations pertinent to the discussion. Here is my question: How does biomedical technology shape neonatal patient-care? And, what bioethical guidance does healthcare professionals follow to understand, learn, and implement biomedical innovation into care practice?

Neonatal care has expeditiously developed due to the integration of various scientific and clinical advancements, overtime coalescing into a newly distinct medical specialty. The development of these efforts helped to reduce the infant mortality rate, ultimately succeeding in eliminating this gap in healthcare (Taha et al., 2023). Unlike other fields, the conception of neonatal intensive care itself is *only* possible due to biomedical technological advancement. Such examples of this technology being the incubator, ventilator system or other advanced respiratory monitoring apparatuses. However, similar to other rapidly developed fields of medicine, as standards of care began to establish, questions regarding the safety, efficacy and protocol of these

intervention models were short-sighted and not deeply discussed. In particular, elements of informed consent and research protocols were morally questionable. Therefore, in the 1960-80s, clinicians and healthcare professionals began to highlight these serious ethical issues in regard to how unproven and experimental treatments should be used to save critically ill newborn babies (Carter, 2007).

Since then, ethical analysis and rigorous research have been conducted to understand the risks and benefits of neonatal care practices. Taken together, both technological biomedical advancements and the need for quality care protocols have mutually shaped each other. Additionally, the framework of bioethics is vitally important in contextualizing how to adequately approach the intersection of technology and medicine, especially when establishing moral care practices for neonates. There are four principles of bioethics, and they are autonomy, beneficence, non-maleficence, and justice. Moving forward, these principles will be a focus throughout the rest of the paper. Currently, there is a problem with the lack of ethical education and guidelines *specifically* targeting how healthcare practitioners should implement novel biomedical technology (Steerling et al., 2022). To address this, neonatology serves as a refined exemplar of how technology interacts with healthcare, highlighting the sociotechnical implications that emerge from society and medicine.

In this paper, I will argue the need for more authoritative ethics guidance for healthcare providers, specifically focusing on the considerations and implications of biomedical technology in neonatal medicine. Proceeding, the literature review will contextualize the important use of biomedical technology in neonatal healthcare by providing a timeline and description of historical neonatal advancements. The goal of this is to demonstrate how past limitations in ethical consideration of technological implementation into NICUs still manifest into current

shortcomings in ethics guidance for providers in patient care today. In my analysis, I will evaluate primary and secondary sources of information consisting of current bioethical codes, guidelines, and opinions. The primary analysis will include an assessment of the American Medical Association's Code of Medical Ethics which is the foremost adhered to interpretation of medical bioethics for contemporary practice. Establishing this groundwork, I will then highlight the limitations in ethical consideration specifically addressing aspects of "Technological Care", also known as care technology or healthtech. There will be commentary about the lack of regulatory guidance for artificial intelligence, a limited range of specialty-specific ethical instruction, and an absence of bioethical adherence in the innovation sector of biomedical technology. With this analysis, I intend to demonstrate how proficient neonatal care relies on a strong ethics code that highlights the need for understanding the development, education, and implementation of technological care in the modern age of American NICUs.

Literature Review

Historically, the concept of neonatal intensive care is relatively new. As late as the 1950's, at-risk birthed infants received minimal post-delivery care and were sent home. In most cases, these babies did not live past their first birthday. During this time, the infant mortality rate in America was 29.2 infants out of every 1,000 births (Field & Behrman, 2003). The standard of neonatal care was minimal, consisting of keeping preterm infants warm in incubators and providing basic nutrition. After the realization of this gap in healthcare, Congress deemed the neonatal mortality rate unacceptable and began producing efforts to combat at-risk births. Thus, the ideal of neonatal specialized care derived from a push in contemporary newborn medicine out of the 1960's. This resulted in the creation of the first Neonatal Intensive Care Unit (NICU) in the United States of America established in 1960 at Yale New Haven Hospital. Around the

same time as the creation of the NICU, immense technological advancements such as the advent of the respiratory and ventilator systems were developed (Baker, 2000). For the first time in modern healthcare, technology was being directly invented for providing neonates life-sustaining care.

One of the most monumental developments was the advent and adoption of the mechanical ventilation system for neonates. In 1965, Dr. Maria Delivoria- Papadopoulos is credited for pioneering the use of "positive-pressure" ventilation for infants suffering from respiratory distress syndrome (RDS). This technological transformation led to the preparation for the creation of continuous positive airway pressure (CPAP) therapy in the 1970s, spearheaded by Dr. George Gregory (Walker, 1989). These feats of innovation significantly improved survival rates among premature infants by preventing lung collapse; thus, reducing the need for the previously invasive mechanical ventilation system. Another breakthrough in neonatal respiratory care was the introduction of surfactant replacement therapy – which reduces air leaks in the lungs. In the 1980s, scientist and neonatologist Dr. Testuro Fujiwara successfully demonstrated the administration of surfactant to preterm infants which again ultimately succeeded in reducing mortality and morbidity rates due to RDS. This achievement, alongside improvements in neonatal respiratory support, led to a significant decline in infant mortality rates (*Postneonatal Mortality Surveillance -- United States, 1980-1994*, 1998). With vast implementation of new medical technologies, the expansion of NICUs quickly followed suit in the 1970s and 1980s – further illustrating the intersection of technology and neonatology. NICUs adopted these various technological and medical care therapies and became specialized centers equipped with neonatal incubators, advanced monitoring systems, and advanced life-support technologies.

As the field of neonatology progressed, ethical considerations became incrementally more important as healthcare providers faced new and groundbreaking ways to provide care for neonates. The ability to sustain extremely preterm infants raised questions of viability, quality of life and long-term outlooks for neurodevelopmental outcomes. Naturally, the leading ethical framework in the field of medicine is bioethics, and the principles of autonomy, beneficence, nonmaleficence, and justice are used by healthcare professionals to provide moral medical care. For the purpose of understanding how these bioethical principles impact the field of neonatology, and why it is important that healthcare providers need to have a deep understanding of them, it is imperative to analyze examples of how they are understood. Therefore, I will examine and provide context for how each principle has impacted the field of neonatology through specific case studies.

Autonomy in the field of medicine is defined as the individual's right to self-determination, thus making their own decisions based on personal choices, values, and preferences. However, this notion becomes complicated when the patient population in neonatology are newborn infants, incapable of speech or personal competence. A case for autonomy commonly found in neonatal intensive care is respect for parental decision-making and informed choice adjacent to that of physician's recommendations. For instance, Extracorporeal Member Oxygenation (ECMO) is a life-saving technology that treats neonates with severe respiratory failure. However, it consists of serious applied risk including bleeding and potential long-term neurological disability. Therefore, physicians alongside parents must make informed decisions about whether to continue treatment or not in consideration of what long-term effect may present. In 1995, "Baby K" was born with anencephaly (a condition where a significant portion of the brain and skull is missing) at Fairfax Hospital in the metropolitan area

of Northern Virginia. The prognosis of the infant was grim, yet the mother insisted on life-sustaining action which included mechanical ventilation and ECMO treatment. However, the medical team at the hospital advised against the treatment, arguing that there was minimal benefit. The hospital believed prolonging the life of the infant was medically ineffective and not in the infant's best interests (Schneiderman & Manning, 1997). A suit was filed over the situation and the Virginian Courts found that the hospital was wrong, stating they were legally responsible for providing care under the Emergency Medical Treatment and Labor Act. This case underscores the importance of knowing when or not to administer technological treatments and the balance between parental autonomy and a medical team's assessments.

The element of beneficence, as a healthcare provider, is known for acting in the best interest of the patient. In neonatology for example, mechanical ventilation has significantly improved survival rates for premature infants with respiratory distress syndrome (RDS). However, aggressive or prolonged treatment may lead to lung injury. Thus, clinicians face ethical challenges in balancing treatment to sustain life with the risk of causing long-term harm (Sangsari et al., 2022). The case of Patrick Kennedy, the premature-born son of the U.S. President John F. Kennedy and First Lady Jacqueline Kennedy were born at 34 weeks gestation presenting with RDS. At this time, there was limited usage of surfactant replacement therapy or advanced ventilation systems. Physicians did their best treating Kennedy's child, but the available technology could not sustain the fragility of the infant's lungs, and he died at two days of age. His death created a push toward biomedical research which led to innovations in surfactant therapy and improvements in neonatal ventilation (Hallman & Herting, 2023). This case exhibits the principle of beneficence; that is, physicians seeking to act in the best interest of the infant even when the technology of the time limited their ability to provide adequate care.

The evolution of surfactant replacement therapy transitions well into an example for understanding the concept of neonatal nonmaleficence, which emphasizes minimizing risks while choosing the least harmful course of action. This therapy is used to treat underdeveloped lungs, reducing the risk of RDS. However, improper administration of the therapy may lead to complications such as infection or airway obstruction. Therefore, physicians must be very knowledgeable and careful to prevent unintended harm and ensure that intervention does not introduce additional risks than benefits. During the early stages of neonatal care from the 1940s and 1950s, standard practice would consist of treating infants with RDS with high concentrations of oxygen. However, researchers in the late 1950s discovered that excessive oxygenation led to premature blindness, leading to a case of thousands of "Blinded Babies" worldwide (Reedy, 2004). This case demonstrates medical nonmaleficence because healthcare providers and medical boards here-on-after needed to modify treatment methods for oxygen administration to reduce the amount of harm it caused, overall finding a balance between short- and long-term efficacy for neonates.

Lastly, justice in healthcare ensures equitable allocation of resources and care for all individuals, regardless of their background, socioeconomic status, ethnicity or other factors. However, in some regions of the country access to quality neonatal intensive care is constricted due to financial or geographic limitations. Therefore, it can be a challenging ethical dilemma of justice to decide how to equitably allocate neonatal care resources, especially in low-income communities. Some hospitals use triage systems, yet these models of care still create disparities for marginalized populations (Schnall et al., 2018). A study from 2020 published by The Journal of the American Medical Association Pediatrics discovered that Black preterm infants have a higher likelihood of dying even when born at the same gestational age and at the same hospitals.

This disparity in care was due to a variety of factors including an unequal allocation of high-level NICUs, an implicit bias in medical treatment services, and other socioeconomic barriers. Other studies suggest Black infants may receive less aggressive medical intervention compared to white infants even when presenting with similar conditions (Travers et al., 2020). Understanding medical justice is crucial for neonatal practitioners to ensure equitable care, mitigate disparities, and uphold ethical principles, ultimately improving health outcomes for all patients.

A review of the principles of bioethics gives insight into the current level of ethics preparedness required of healthcare providers. More so, these case studies regarding bioethics and care practices additionally illuminate the significant intersection between technology and neonatal healthcare. These ethical dilemmas, particularly in neonatal medicine, underscore the ongoing challenge of balancing medical innovation with ethical obligation, an issue that mandates clear, adaptable guidelines for healthcare providers. In the United States, the AMA Code of Medical Ethics was established in 1847 as the first national code for bioethics and is widely recognized as authoritative guidance for physicians by its Opinions of medical ethics provided from the AMA's Council of Ethical and Judicial Affairs. Over time the Code has undergone revisions, most recently being in 2017 after intensive feedback from the medical community requesting a modernization of the guide. An internal review of the code from authors of the Journal of the American Medical Association even stated that the Code has been "fragmented and unwieldy… [while] individual topics were difficult to find" (American Medical Association, 2016). Yet, even with a contemporary renovation of the code, more is to be done to ensure that it is being actively updated to suit the needs of the modern medical landscape. With this being identified, it is important to ask onward of how the actors involved, being healthcare practitioners, researchers or scientists are guided to implement innovative technologies into the

standard of care. I will continue to use the framework of bioethics to contextualize the usage of technological care, specifically in understanding how healthcare professionals are directed to deliver care practices with the implementation of biomedical technology.

Methods

To conduct this research and analysis, I have established a content review of the American Medical Association Code of Medical Ethics. As aforementioned, the AMA Code of Medical Ethics is regarded as the most comprehensive ethics guide for physicians and is therefore why it was selected to review in regard to the guidance it bestows physicians on how to provide technological care. In addition, I have collected secondary sources that analyze the depth of bioethical guidance for healthcare professionals across the United States, how biomedical innovation addresses principles of bioethics, and what new technologies are being developed specifically for neonatal healthcare. The objective is to contextualize the reality of ethical care practices, what practitioners are educated to know, and identify any gaps in this education. Overall, I will be arguing that there must be stronger ethical frameworks for technological care, especially pertaining to the field of neonatology.

Analysis

While not always addressed in the conceptual framework of bioethics, technological care is a nuanced agent in the field of medicine. Even though it is not extensively covered in current medical codes of ethics and practitioner training, the incorporation of biomedical technology has not only made the field of neonatology possible, but has broadly shaped healthcare as a whole. However, the ethical frameworks guiding the integration of biomedical technology, and in particular the American Medical Association Code of Medical Ethics, have not progressed at the

same rate. Further, it is understood that there is an uneven practice of how physicians in the United States receive, learn and use these ethics guidelines – whether that be during medical school, residency, or requirements from a hospital board (DuBois et al., 2002). Therefore, it is critical to expand from the framework of bioethics to be more inclusive of technological care and innovation so that physicians are more likely to familiarize themselves with this area of medicine.

The AMA Code of Medical Ethics provides foundational guidance on medical situations, emphasizing the principles of autonomy, beneficence, nonmaleficence and justice. Yet, its adaptability to address rapidly developing technology is limited, especially in focusing on the field of neonatology. For instance, while the code succeeds in offering general ethical considerations, it lacks directives on the usage of emerging technologies in neonatal care. Additionally, modern developers of biomedical applications are not always taking into consideration bioethics. That is, a study from the Interactive Journal of Medicine investigated how health technology is mentioned in the context of bioethics in literature, finding that out of 250 studies, "Most studies (52.9%, 120/227) had no direct reference to any of the four basic ethical principles" (Steerling et al., 2022). Therefore, given that over half of emerging health technologies are not directly taking into consideration bioethics, it is evermore vitally important that the healthcare professional who uses these technologies in practice should deeply understand how to incorporate them and their socio-technical implications.

The content analysis of the AMA Code of Ethics explores the Opinions that directly mentioned technology, innovative practices, or technological care. Understandably, outlining the difference between medicine and technology can be somewhat arduous; therefore, for the sake of the review biomedical technology is simply defined as "technology used to innovate the standard

of medical care". A systematic review was conducted by scanning the 165 ethical Opinions in the AMA Code of Medical Ethics and identifying those that directly discussed technological topics. These were then grouped into relevant code-categories based on their implications, the three main codes being: Social tech (S), Logistical tech (L), and Biomedical tech (B). Within these categories consisted of subcategories as well. Social and Logistical technical Opinions regarded aspects of social media training, record keeping, or electronic communication systems. However, the purposes of this paper specifically analyze innovative biomedical practices which fall under the category of Biomedical tech. The results found that only 11.5% of the Opinions (19/165), mentioned technology at all. Of that group, seven were coded for biomedical tech (B), and only two for biomedical innovative practices. These were Opinion 4.2.1 Assistive Reproductive Technology, and Opinion 1.2.11 Ethically Sound Innovation in Medical Practice (AMA, Opinion 4.2.1; AMA, Opinion 1.2.11). The latter is the preeminent document that guides any-and-all innovation in medicine, and is a page-and a-half long. While appropriately outlined and capable of providing guidance to physician-innovators, there is more that can be done. Other than the underrepresentation of biomedical technology, the Code of Ethics lacks in other areas as well.

Firstly, there is no categorization of ethical Opinions based on medical specialties; thus, cardiologists and oncologists, general surgeons and neonatologists alike use the same code. Although this provides consistency, it also lacks depth into the specific ethical considerations each specialty experiences. A systematic review published in the BMC Palliative Care highlights how important it is that guidelines and recommendations are specific to medical specialty. For the field of neonatology, this greatly concerns end-of-life decision-making in intensive care units and emphasizes the principle of beneficence – focusing on the infant's best interest (Špoljar et

al., 2025). Nevertheless, the study also identifies challenges in defining these interests, suggesting the need for ethical frameworks tailored to unique circumstances, especially dependent on the medical specialty. Such guidelines enhance decision-making processes and ensure ethical considerations are appropriately aligned with the patient populations that specialists serve. Secondly, there is a conspicuous absence of any mention of artificial intelligence (AI) in the AMA Code of Medical Ethics. Recognizing this need, the AMA has established new principles regarding development, deployment and use of AI in healthcare, but has not incorporated any of these logistics into the Code of Medical Ethics. The omission is particularly concerning given AI's currently advancing role in neonatal medicine. Recent studies highlight AI's application in the field, including monitoring vital signs, prediction algorithms for conditions such as respiratory distress syndrome, risk stratification for complications of intestinal perforation, and AI-driven neuroimaging diagnostics (Chioma et al., 2023). Thus, incorporating AI-specific ethical guidance into the Code of Medical Ethics is essential to ensure rapidly developing technologies are used responsibly, equitably and in alignment with the core principles of bioethics. Bridging this gap within ethical policy in relation to medical ethics, this analysis underscores the critical need for a standardized and unified approach to bioethics training in neonatal technological care. While the AMA Code of Ethics serves as a foundational guide, it is limited with its engagement with emerging technologies and biomedical innovation, suggesting a need to reform. Thus, there must be a continuous evaluation procedure for the AMA Code of Ethics, particularly with the process of creating new policy adoptions to remain up to date with the forever evolving ethical landscape of medicine.

Conclusion

The evolution of neonatology demonstrates an immense intersection of biomedical technology, ethical considerations, and sociotechnical change. From its early origins in incubator technology to the advanced, multi-disciplinary care systems of today, neonatal medicine has continually adapted to both scientific progress and how healthcare is practiced. The historical development of major innovations such as mechanical ventilation and surfactant therapy demonstrates how technological advancements have redefined the limits of viability and survival for premature infants. However, this advancement has led to great discussions of ethical dilemmas, as issues of autonomy, beneficence, nonmaleficence and justice impact intensive care on neonates. From an STS perspective, it becomes evident that neonatology is not only a medical discipline, but a field shaped by technology, cultural and social factors.

Due to the array of ethical considerations, a strong foundation of bioethical code is imperative so that healthcare professionals understand how to properly provide care. As such, the American Medical Association Code of Medical Ethics is one of the foremost leading guides of bioethics, promoting adherence to standardized regulations. Yet, as the future of neonatology will continue to be influenced by emerging biomedical technologies, so should the AMA Code of Medical Ethics. Ethical frameworks guiding neonatal care must continue to evolve alongside technological advancements, securing the pursuit of medical progress. This is incredibly important considering the imminence of futuristic technology, such as that of artificial intelligence. Currently, the future direction needed is to address these limitations by hosting a delegation of the AMA to revise and guide physicians in the areas of innovative medical practices, such as technologies using AI. Therefore, healthcare professionals must be able to rely

on a modern and comprehensive code of bioethics to understand the implications of care practices, especially that of technological care. A standardized process of ethical opinions will ensure equitable and competent care for all patients, including some of the most vulnerable infants.

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