REVIEW ARTICLE

Technologization of iatrogenic crime investigation process

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ABSTRACT

Aim: To identify and analyze the factors that mandate the technologization of iatrogenic crime investigation process and to propose actionable strategies for integrating modern technologies and algorithms into investigative practices for this class of criminal proceedings.

Materials and Methods: This research is based on an analysis of official WHO documents, 31 relevant judgments from the European Court of Human Rights (ECHR) concerning adverse medical outcomes, 19 verdicts and decisions from Ukrainian courts on medical malpractice, and statistical data from the Prosecutor General's Office of Ukraine for the period 2016-2021. The primary analysis is supplemented by a review of recent scientific articles from leading academic databases.

Conclusions: It has been proven that although patient harm resulting from the provision of low-quality medical care is very widespread worldwide and often becomes the subject of criminal investigation, Ukraine demonstrates a very low level of investigation and detection of iatrogenic crimes. It is proposed that these shortcomings be corrected through technologization, which includes the algorithmization of investigative actions and the application of the latest technologies.

KEY WORDS: iatrogenic crimes, investigation technologization, digital technologies, iatrogenic crime investigation algorithm

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INTRODUCTION

Patient harm, defined as the impairment of bodily structure or function or any detrimental effect resulting from actions taken during healthcare provision rather than the underlying disease [1], represents a major global issue. According to WHO estimates, approximately one in ten patients experiences harm while receiving medical care, contributing to over 3 million deaths annually worldwide from unsafe practices. This positions patient harm as the 14th leading cause of global morbidity and mortality [2] and often prompts criminal investigations.

A primary contributor to preventable patient harm is diagnostic error, the risk of which is particularly acute in outpatient and primary care settings. In the United States, nearly 800,000 individuals die or suffer permanent disability annually due to diagnostic failures [3]. Another study reveals that 12 million patients in the U.S. are affected by diagnostic errors, a third of which result in patient injury [4]. These errors lead to adverse events in approximately 5% of outpatients and 17% of hospitalized patients [5] and are a leading cause of medical malpractice litigation [6].

Regarding personnel, an analysis of 1,500 patient complaints in China found that physicians were the subject of the majority (53%), followed by logistics staff (19%), nurses (16%), technicians (4%), and administrators (2%) [7]. Nurse fatigue, stress, and burnout are known to cause frequent errors that compromise patient safety [8].

Surgical errors carry the highest risk of severe patient injuries and deaths. It is estimated that intraoperative errors are the main problem in 75% of cases of surgeons' negligent actions [9].

The harm caused to patients can be not only physical, causing adverse consequences or disability, but also psychological, manifesting in anger, persistent feelings of injustice even long after the event. This forces patients to seek compensation through the judicial system [10].

Ukraine demonstrates a very low level of investigation and detection of iatrogenic crimes, referral of indictments to court, and proving the guilt of specific medical workers. Thus, according to the analysis of statistical data from pre-trial investigation bodies, it was established that under Article 140 of the Criminal Code of Ukraine (Improper performance of professional duties by medical or pharmaceutical workers) in Ukraine from January 2016 to December 2021, 4,042 such criminal offenses were registered. At the same time, only in 13 (0.32%) criminal proceedings were medical

workers served with notifications of suspicion, and only 9 (0.22%) proceedings were referred to court with indictments. Moreover, a significant portion of such cases (1,577 or 39.01%) are subsequently closed by pre-trial investigation bodies, primarily because insufficient evidence was established to prove the person's guilt in court [11]. This indicates problems in the investigation of iatrogenic crimes, which can be prevented by optimizing the investigation process by using the latest technological solutions to accelerate the methods of collecting, analyzing, and evaluating evidence.

Given this, investigating iatrogenic crimes requires technologization, including algorithmizing investigative actions and applying the latest technologies.

AIM

To identify and analyze the factors that mandate the technologization of iatrogenic crime investigation process and to propose actionable strategies for integrating modern technologies and algorithms into investigative practices for this class of criminal proceedings.

MATERIALS AND METHODS

To achieve the research objectives, a range of materials was analyzed, including: the WHO Global Patient Safety Action Plan 2021-2030 [12]; the WHO Global Monitoring Report on tracking universal health coverage (2023) [13]; the WHO Global Patient Safety Report (2024) [2]; the WHO World Health Statistics (2025) [14]; and a WHO technical report on patient safety event reporting systems [15]. The analysis also encompassed 31 judgments from the European Court of Human Rights (ECHR) on adverse medical outcomes, 19 decisions from Ukrainian courts concerning medical malpractice, and statistical data from the Prosecutor General's Office of Ukraine (2016-2021). This was supplemented by a review of scientific literature from the past five years sourced from databases such as Web of Science, Scopus, Google Scholar, PubMed, Directory of Open Access Journals (DOAJ), and the Open Ukrainian Citation Index (OUCI).

To achieve the set goal, the following general scientific research methods were used: empirical (observation, description), theoretical (analysis, synthesis, abstraction, generalization, induction, deduction, explanation, classification, etc.), systemic, functional, formal-logical, and others.

The formal-logical method was used to typify investigative actions during iatrogenic crime investigations. The functional method was applied to analyze the causes and consequences of medical care defects. Analysis and synthesis were used to summarize existing scientific perspectives and develop original conclusions.

ETHICS

All sources used in this literature review are publicly available.

REVIEW AND DISCUSSION

A comprehensive review of existing literature and legal precedents reveals that the imperative for technologizing the iatrogenic crime investigation process is predicated on several intersecting challenges: 1) the high and increasing incidence of improper medical care, both globally [5], and in Ukraine [16], with 50% of such cases linked to procedural violations [17]; 2) the absence in many nations of a unified, standardized [15], and transparent system for reporting adverse events and medical errors [12]; 3) the lack of electronic health records in 10% of countries and their poor integration into national healthcare systems in 75% of countries [2]; 4) the tendency for official inquiries to produce cursory reports that attribute adverse outcomes to the patient's underlying condition or classify them as accidents, rather than assessing the quality of care provided [15]; 5) the inherent difficulty for non-specialists to analyze voluminous and complex medical documentation; 6) the challenge of establishing a direct causal relationship between a provider's actions (or omissions) and patient harm or death; 7) the demonstrably low rates of successful investigation, prosecution, and conviction in iatrogenic crime cases. Analysis of Ukrainian court verdicts under Art. 140 of the Criminal Code confirms that acquittals often result from the prosecution's failure to prove guilt definitively [18] or submitting evidence deemed inadmissible or insufficient [19].

For investigators, establishing causality is further complicated by a lack of forensic literature detailing the common causes of adverse medical outcomes and the consequences of different care defects. An analysis of ECHR jurisprudence in this domain has identified several distinct categories of violations at the treatment stage. These include treatment-tactical errors, such as failing to screen for allergic reactions [20, 21], violating safety protocols for injections or blood transfusions [22, 23], making poorly justified decisions on the timing of medical interventions [24], selecting a suboptimal patient management strategy (e.g., observation instead of immediate surgery) [25], and providing inadequate patient monitoring [26]. Beyond these, our analysis also identified organizational and deontological violations. Organizational failings include a lack of care continuity [27], poor coordination between emergency physicians

and hospital administration [25], or other departments [26], inappropriate patient hospitalization [25], and breaches in asepsis and sterilization protocols [26]. Deontological violations encompass failures to adequately consult with the patient or family about their medical history [21], inform them of treatment risks [21], obtain informed consent [21], and uphold patient rights to information and choice of provider [28]. Violations of donor rights, particularly the right to informed consent for organ removal, have also been noted [29, 30]. Importantly, a single adverse event may stem from multiple, compounding violations [21, 26].

Investigators spend much time during the investigation of iatrogenic crimes processing large arrays of documents and establishing a significant number of circumstances (fact of violation of medical care provision standard, type and stage of medical care, patient's physiological state, their behavioral characteristics, professional and personal qualities of the medical worker, etc.) and appointing forensic examinations (forensic medical, pharmaceutical, psychological, criminalistic, etc.). In some cases, they do not manage to qualitatively form the evidence base within the procedurally defined investigation timeframes, which emphasizes the urgent need for algorithmization of both individual procedural actions of the investigator and the entire crime investigation process. This necessity is based on several key aspects highlighted in the works of various authors.

First, despite its complexity, criminal investigation can be broken down into logical, sequential, and repeatable steps to achieve desired results. Forming a mental map (algorithm) of the investigation process allows the investigator to describe the course of their conclusions at any stage of criminal proceedings [31].

Second, investigators during the investigation of iatrogenic crimes mainly perform typical actions, as they solve similar tasks in each investigation. This provides grounds for identifying the optimal sequence of actions in typical investigative situations, which can be presented through criminalistic algorithms and investigative programs [32].

Third, technologization of investigative activity is impossible without its formalization, which consists in ordering and systematizing investigation procedures based on clearly defined rules, methods, and algorithms. This aims to program investigative activity and ensure its effectiveness, objectivity, and legality [33].

Based on this, we propose the following algorithm for investigating iatrogenic crimes: 1) acceptance of a statement or notification about a committed iatrogenic crime; 2) initiation of criminal proceedings and interrogation of the applicant (if present); 3) examination of protocols or reports of internal audit of healthcare institutions (HCI), acts of medical-control commissions, conclusions based on results of clinical-expert assessment of quality and volumes of medical care by clinical-expert commissions and medical councils of HCI; 4) examination of medical documentation (medical record of inpatient, protocol of pathological-anatomical examination, discharge from inpatient care, medical record of outpatient, journals of operative interventions registration in inpatient care and registration of patient admission to inpatient care or refusals of hospitalization, journal of outpatient registration, informed voluntary patient consent for medical procedures, etc.); 5) appointment and conduct of forensic medical examination of medical care quality provision; 6) examination of electronic medical record of the patient - electronic medical records, prescriptions, results of laboratory and instrumental studies, graphic files, scanned images, digital photographs; 7) interrogation of witnesses; 8) appointment and conduct of forensic examinations (computer-technical, pharmaceutical, handwriting, etc.); 9) review of audio and video recordings (if available) that record the time, place (according to file metadata) and nature of actions of the doctor and patient; 10) notification of the medical worker about suspicion and their interrogation.

Implementing modern technologies in investigating iatrogenic crimes, which significantly simplify the collection, storage, and analysis of digital evidence, will allow for faster and more efficient obtaining digital information from electronic devices [34]. In investigating iatrogenic crimes, specifically, investigators use existing digital databases and create their own for storing and quick access to vast volumes of information. This simplifies cross-analysis of information and prevents loss of evidence. Documentation technologies provide increased speed and accuracy in researching large volumes of data in an automated manner, improving their visualization and accessibility for researchers and more effective classification [35].

The integrity and security of digital evidence from the moment of their collection to presentation in court, transparent storage, and protection from falsification and unauthorized access are of great importance. Blockchain technology can ensure such conditions [36], which are mainly associated with cryptocurrencies but can be applied in criminal investigations to provide reliable storage, verification, and protection of digital evidence from unauthorized changes.

Computers in medicine are used as a means of creating and storing medical documentation, as well as elements of diagnostic and therapeutic hardware. Digital forensics tools allow establishing the fact of changing the content of a medical document or the date of its

creation, recovering previously deleted or hidden data (emails, text messages, web browsing history, individual files) from computers, smartphones, and cloud storage (Dropbox Plus, Google Drive Premium, or iCloud Drive). Individual technologies allow searching for computers and other digital information carriers and quickly processing large volumes of data [37].

Smartwatches, fitness trackers, and other medical workers' and patients' gadgets are sources of personal information about their owners, which can serve as evidence of criminal acts when investigating iatrogenic crimes. Search for information about contacts of the suspect (accused) and victim, as well as other substantial evidence, can be carried out in information-telecommunication systems.

Within computer-technical examination, research of computer equipment used in medical equipment can also be conducted. Such research will allow confirming or refuting testimonies of medical workers about malfunctions of diagnostic, therapeutic, surgical, or rehabilitation devices.

Artificial intelligence (AI) is actively used in law enforcement to reduce subjectivity and prevent errors in data interpretation, improving the quality of evidence in court [34]. During the investigation of iatrogenic crimes, the investigator can independently consult one of the AI systems with a request to build an algorithm of their future actions (investigation plan) based on the characteristics of a specific investigative situation.

Language models operating based on artificial intelligence (for example, ChatGPT (Generative Pre-trained Transformer) or Llama (Large Language Model Meta AI)) allow analyzing large volumes of evidence information in the form of text data, extracting essential facts from them, and identifying inconsistencies in testimonies and other evidence information [38]. Some scientists even note that many machine learning algorithms are used in crime investigation, including logistic regression to search for relationships between certain formalized features and the probability of a specific result [32].

The ability of AI to visualize large data arrays (represent them in the form of diagrams, graphs, maps, and other visual forms) [32], allows the investigator to understand and interpret information and analyze it easily. Such tools include Domo, Microsoft Power BI, Tableau, Polymer, Qlik, and IBM Cognos Analytics [39]. The investigator also needs to manage quality and evidential significance of data extracted from large information arrays [40].

During forensic medical examination of corpses, an alternative to traditional autopsy is virtual autopsy (virtopsy) - diagnostic technology based on digital visualization methods (for example, computed and magnetic resonance tomography) for detecting and analyzing changes in the body without conducting traditional autopsy [41]. Its advantages include greater accuracy, evidence integrity, possibility of their review at any stage of criminal proceedings without the need to repeat the procedure, minimization of invasiveness, efficiency, and safety. Virtopsy provides detailed three-dimensional visualization of anatomical structures, which facilitates injury detection and more accurate determination of cause of death [34].

The development of 3D printing technology has led to significant progress in reproducing physical evidence [40]. 3D copies of medical instruments, bodily injuries, internal human organs, bones, and other objects related to iatrogenic crimes can be used in the courtroom for their visual presentation. 3D printing can also be applied when creating anatomical models during preparation for corpse autopsy.

CONCLUSIONS

Our research allows us to assert that patient harm resulting from the provision of low-quality medical care in the form of morbidity and mortality is widespread worldwide and often becomes the subject of criminal investigation. However, Ukraine shows a very low level of investigation and detection of iatrogenic crimes. These shortcomings can be corrected through technologization, which includes algorithmization of investigative actions and application of the latest technologies.

An algorithm of investigative actions for investigating iatrogenic crimes is proposed, consisting of the following stages: 1) acceptance of a statement or notification about a committed iatrogenic crime; 2) initiation of criminal proceedings and interrogation of the applicant (if present); 3) examination and analysis of departmental (special) investigation documents and medical documentation on the patient; 4) appointment and conduct of forensic medical examination of medical care quality provision and (if necessary) other forensic examinations (computer-technical, pharmaceutical, handwriting, psychological, etc.); 5) examination of the patient's electronic medical record; 6) interrogation of witnesses and the victim (in cases where such status is granted); 7) research of audio and video recordings (if available) that record the time, place (according to file metadata) and nature of actions of the doctor and patient; 8) notification of the medical worker about suspicion and their interrogation.

To optimize the process of investigating iatrogenic crimes, we propose using several digital technologies, making it faster, more efficient, and objective, ultimately contributing to protecting patient rights.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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