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A Systematic Review Of Digital Health Technology In Preanaesthesia Assessment

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Abstract:
This systematic review includes a discussion on the transformative impact of digital health technology on anesthesia assessments before surgery, discussing technological advancements recorded in EHRs, telemedicine, mHealth applications, AI, and wearable devices. These newer technologies overcome inefficiencies, provide more personalized approaches, as opposed to the resource-intensive and impersonal methods characterizing traditional practices, and improve patient safety. The methodology consisted of a detailed literature search in the databases of PubMed, Scopus, and Web of Science and the Cochrane Library, strictly limiting publication to those released during the last ten years. It has used specific search terms such as "digital health technology," "preoperative anesthesia assessment," and "wearable devices." The evaluation of the English peer-reviewed literature focused on adult care with digital technologies. The exclusion criteria eliminated conference abstracts, articles in any language that was not English, and studies that had no relation to the core subject. Tools used for quality assessment include Cochrane Risk of Bias Tool and the Newcastle-Ottawa Scale. Data extraction emphasized study characteristics, applied digital tools, measured outcomes, and reported challenges. It was a meta-analysis synthesis of the data that aimed to give insights into current applications and future prospects. This review postulates the points through digital innovations where EHRs have improved decision-making, telemedicine has enhanced access in regard to improvements, mHealth with enhanced patient engagement, and AI for predictive insights to tailor anesthesia plans. Despite challenges like data security and integration of technology, promise comes with future AI algorithmic developments, further work in using genomic data, and advances with wearable tech. Tackling these challenges and working towards the development of better interoperability standards helps bring about the full realization of how such digital technologies are revolutionizing the care of patients throughout the perioperative period and improvements in surgical outcomes.

Keywords: *digital health, artificial intelligence anaesthesia preoperative assessment*

Introduction

One area that has undergone revolutionary changes in the practice of most specialties in medicine, including anesthesiology, is the healthcare sector with the inclusion of digital technology.[1] One such change brought about by digital technology is the preoperative anesthesia assessment-important in-patient care that determines whether the patient is prepared for surgery, what risks are to be expected, and how the anesthesia care plan must be managed. Preoperative assessments traditionally relied on in-person consultation, manual documentation, and subjective evaluation methods.[2] These traditional practices, although successful, are typically very time consuming, consumptive of resources, and prone to human mistakes.

However, with the introduction of digital means, science is at crossroads. It is through these digital means, electronic health records, telemedicine, mobile health applications, artificial intelligence, and wearable devices, that the preoperative evaluations are looking different.[3] These digital tools reduce the errors and increase the efficiency of the process so that outcomes improve greatly among the patients. For instance, EHRs allow access to comprehensive data of a patient's medical history so that clinical decisions become more informed, whereas telemedicine provides for remote consultations and thus means greater access to specialist care.

There is an imperative need for a focused review on the subject to better understand what implications these innovations have on such a field. The review would reveal how digital technology minimizes time and resources required to undertake preoperative assessments while greatly improving patient safety since it gives anesthesiologists precise, actionable data. Being equipped with understanding the benefits of such technologies can be informative for best practices and, thus, guide healthcare professionals in their adoption.[4]

Discussing prospects seen in a future that is better may also be included, especially when debate topics revolve around the potential of further development in preoperative care. There is no other avenue for that type of discussion except to discover what barriers are blocking such prospects, the examples of which are data privacy, technology integration, and equitable access.

Methodology

This systematic review aimed to evaluate the overall impact of digital health technology on preoperative anesthesia assessment. The methodology followed several stages to ensure a comprehensive assessment of the existing literature.

Literature Search

Databases including PubMed, Scopus, Web of Science, and the Cochrane Library were searched extensively. Keywords such as "digital health technology," "preoperative anesthesia assessment," "electronic health records" (EHRs), "telemedicine," "mobile health applications" (mHealth), "artificial intelligence" (AI), "machine learning," "wearable devices," and "perioperative care" were used. Articles published in the past ten years were filtered using these terms.

Inclusion and Exclusion Criteria

The study applied predefined inclusion criteria: publications in English related to the preoperative assessment of patients using digital health technologies, published in peer-reviewed journals, and focusing on adult care.

Exclusion criteria included conference abstracts, commentaries, articles lacking access to full text, and publications focused on pediatrics or other non-relevant medical fields.

Data Extraction and Analysis

For the selected articles, data extraction was conducted to collect the characteristics of the studies, the digital tools applied, the outcomes that were measured, and any challenges that were reported. The synthesis of both quantitative and qualitative data was performed with attention to emerging patterns and themes regarding efficiency, patient safety, and technology integration.

Quality Assessment

Tools such as the Cochrane Risk of Bias Tool for randomized trials were used to appropriately assess the quality of the included studies, whereas for observational studies, the Newcastle-Ottawa Scale was employed. As such, this review was rigorous, and conclusions were based on high-quality evidence.

Synthesis

The information thus collected was synthesized narratively, and where appropriate, through meta-analyses to emphasize current and future states of the impact of digital health technology and effectiveness of telemedicine and electronic data collection methods on preoperative assessment of anesthesia.

Figure 1 showing PRISMA statement:

Prospero registration number :

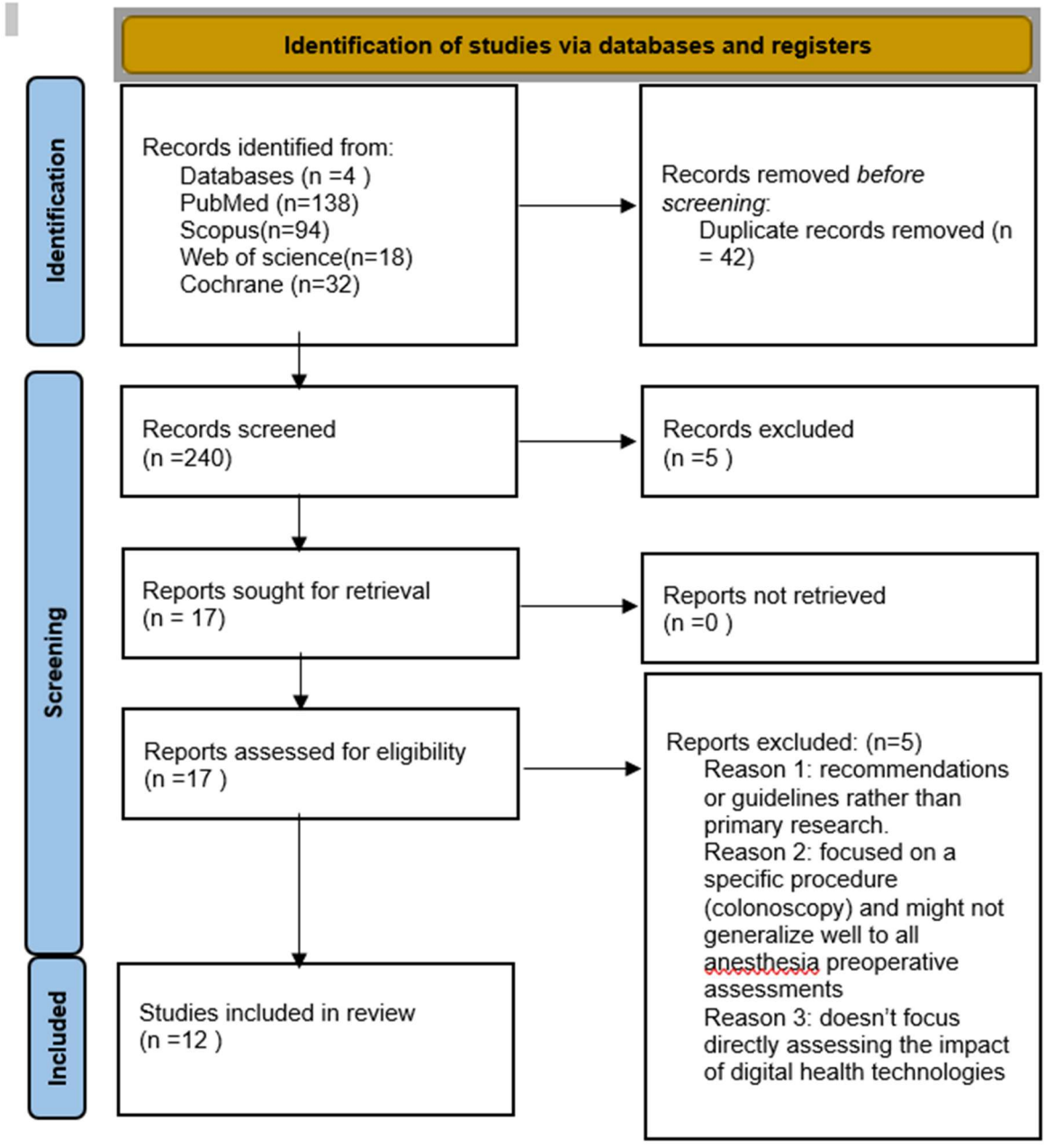

Figure 1 showing PRISMA statement:

Advances in Digital Technology for Preoperative Assessment

1. Electronic Health Records (EHRs): Electronic Health Records have significantly changed the anesthetic landscape as these systems offer a patient's access to a large data set all easily accessible. Anesthesiologists can immediately obtain access to a patient's history, his or her laboratory results, list of medications, and information regarding prior surgeries on EHR systems. For effective identification of possible complications and modification of anesthetic plans according to patients' needs, it is essential to collect great information.[5,6]For example, there is a patient who has been planned for orthopedic surgery with a history complex in cardiovascular conditions. EHRs can quickly refer to the details regarding previous cardiac assessment records of the patient and the echocardiograms. It will be helpful for risk assessment of the patient's cardiac risk and decide if such conditions would need further preoperative cardiac evaluation. Furthermore, it would assist in determining the most ideal choice of anesthetic agents and techniques, thus preventing some perioperative adverse events. Further, integrated EHR systems allow for easy sharing of patient information across those involved in the care of the patient. An example is a diabetic surgical patient whose blood sugar levels are fluctuating. The anesthesiologist working together with endocrinologists and surgeons through the EHR platform can develop a perioperative glucose management plan that covers all aspects of the patient's care. This prevents possible miscommunications or medication errors among members of the team because everyone is kept informed in real-time.

   Most importantly, reflective experiences of healthcare professionals through narrations widely unveil the significance of EHRs in the coordination process. Anesthesiologists have, in this respect, indicated that EHRs reduce preparation time since they do not need to track paper records nor depend on fractured data. In this way, they can spend more time with their patients and even more so on safety. EHRs integration with anesthetic practice at the appropriate level thus streamlines processes while at the same time plays a pivotal role in enhancing patient outcomes through setting premises for properly informed, coordinated, and personalized care.[5,7]

2. Telemedicine and Virtual Assessments: Telemedicine technologies have conveniently transformed the preoperative evaluation process. These can provide real convenience and access to patients and providers alike. As evidenced by studies comparing digital assessments with traditional face-to-face consultations, virtual care offers comparable quality of recovery scores, suggesting that patients can achieve satisfactory outcomes through digital means. The successful integration of video consultations during the COVID-19 pandemic demonstrates the adaptability of preoperative clinics and the potential for ongoing use of telemedicine in enhancing patient accessibility and convenience. [8] Anesthesiologists can evaluate a patient on a virtual platform, taking advantage of video consultations and thereby saving considerable time and resources that would otherwise be spent on in-person visits. For instance, imagine a patient who lives in a rural community, hours from the nearest hospital. This patient requires elective surgery but poses serious logistical barriers to accessing preoperative assessment services. Using telemedicine, the anesthesiologist can reach out to the patient through a secure video platform and have a good review conducted remotely. In the course of this consultation, the anesthesiologist should be able to inquire about the patient's history, drugs they are currently

undergoing, and other symptoms. Partial visual assessment can also be performed if required. For example, one can observe respiratory effort or record physical signs that would require further assessment.

Telemedicine is very helpful to patients who have severe mobility issues, like those suffering from severe arthritis or significant neurological conditions, and cannot commute to hospitals. A practical example would be a patient with Parkinson's disease waiting to undergo surgery. The patient experiences inconvenient and labored travel due to his tremors and poor mobility. Even in this case, the anesthesiologist can assess the baseline neurological status and issues of mobility that may affect anesthesia management through telemedicine. Such remote interaction would allow for a careful discussion of anesthesia risks and formulation of a personalized anesthesia plan without compromising patient safety. This would not only help the patients but also anesthesiologists in better management of their timing and scheduling since several assessments that otherwise would be limited by geographical or time-related constraints are possible. The technology also allows teamwork by making it possible to make fast decisions with multidisciplinary input that would otherwise be difficult because of quick consultations with other specialists. It overall increases accessibility to preoperative care, promotes a patient-centered approach, and, above all, ensures that comprehensive anesthetic evaluations and planning occur for patients even in the underserved areas. [9,10]

3. Mobile Health Applications (mHealth): mHealth applications have emerged as powerful tools for improving perioperative care. Studies describe various applications that facilitate preoperative assessments, including the PreParAPP MSD for postoperative lung function calculation. [11] These applications not only empower patients to engage in their health care but also provide clinicians with efficient data collection and analysis methods. Despite their promise, the literature indicates that many mobile applications require further validation and refinement to ensure optimal implementation in clinical settings. For instance, preoperative assessments have emerged as the most useful applications for mHealth by providing easy means of entering and managing a patient's medical history, medications, allergies, or any other relevant health information. It is a digital approach whereby anesthesiologists can retrieve all critical elements without a snag and thus perform more accurate and efficient examination.

   For instance, consider a patient who is undergoing the most complex of surgical procedures and who uses an mHealth app to input his or her full health history including current medications and known allergies. That information is then available to any member of the anesthesiology team allowing them to quickly identify potential interactions or contraindications to any drugs proposed for anesthesia. By doing so, risks that could occur during surgery can be reduced by orders of magnitude and the patients are safer. Besides acting as a repository for health-related information, mHealth apps can also be used to present personal educational content meant to facilitate an individual's surgical experience. As an example, an app exclusively designed for patients undergoing surgery in an orthopedic nature can be designed to accommodate modules on the process of anesthesia and possible side effects plus post-operative care routine. Such applications can help educate patients about what to expect. It would indeed minimize anxiety and improve compliance with certain preoperative instructions like dietary restrictions or abstaining from certain medications.[12]

It also enhances the patient-provider communication. For instance, a patient who is scheduled for surgery may utilize this application to give the anesthesiologist the information that he has developed a respiratory infection a few days before the surgery date. It enables the health practitioners to modify the anesthetic plan for surgery or delay the same until the patient's health condition improves. Overall, the mHealth apps do not only speed up the collection of critical information that would be essential to the surgery process but also include patients more in their care. Incorporating digital tools in the preoperative process can help healthcare systems reach increased safety, higher efficiencies, and better patient-centered care.[12,13]

4. Artificial Intelligence (AI) and Machine Learning (ML): AI and ML are actually really working on the transformation of preoperative anesthesia assessment, further changing the landscape of that care area. They provide advanced predictive capabilities for improving clinical decision-making. They apply sophisticated algorithms to analyze large datasets in order to identify hidden patterns and valuable insights that would have otherwise remained undetectable by human clinicians. These technologies facilitate better risk stratification and decision-making outcomes and improve the overall patient outcomes.

   One of the more practical applications of AI in anesthesiology could be the development of predictive models of complications that may occur during the perioperative period. For instance, one such AI-driven system could analyze a hospital's database information: age, medical history, laboratory results, and comorbidities, then produce a risk score for something like postoperative respiratory distress or cardiovascular events. An elderly patient who has a background of COPD will be undergoing major abdominal surgery, which an AI system can flag as high risk for respiratory complications. Equipped with this knowledge, anesthesiologists can proactively develop a tailored anesthesia plan, including strategies of respiratory support and postoperative monitoring to cut down on all the risks associated with the surgery.

   An example of a clinical application would be in terms of anesthetic drug selection and dosage optimization. AI may leverage data on previous patients with similar profiles to make suggestions about anesthetic regimens that prevent adverse reactions yet retain efficacy. For example, if there is a patient with known specific sensitivities to certain agents, AI might recommend alternative medications or dosing strategies that had been safe and effective for similar cases to increase safety and individualized care.

   Moreover, AI algorithms learn continually by new data received and improve predictions over time. This dynamic capability is very important in managing those complex and emerging health conditions in complicated cases, where a static model would probably not keep up. Consider an example in a teaching hospital context, where AI systems review incoming data from elective surgeries and may predict trends or emerging risks across patient populations to inform institutional improvements in preoperative care protocols.[14]

5. Wearable Devices: More recently, wearable health technologies, like smartwatches and fitness trackers, are being understood as an asset in the preanesthetic assessment process. The key physiological parameters that may be monitored continuously with these devices include heart rate, oxygen saturation, and activity levels, providing real-time data to significantly enhance the assessment of a patient's health status.

Take a patient with a history of cardiac arrhythmia scheduled for elective surgery. via a smartwatch: The health providers will be able to receive continuous heart rate monitoring data through a smart watch, thus seeing patterns and detecting irregular ones that may not be seen during a single preoperative visit. If the data show that the patient has frequent episodes of tachycardia or bradycardia, the anesthesia team can take immediate actions, such as consulting with a cardiologist or adjusting anesthetic plans, to decrease potential perioperative risks. A patient with suspected sleep apnea may be sent home with a fitness tracker that monitors nocturnal oxygen saturation levels. If there are marked drops in oxygen saturation during sleep, one may then consider a formal sleep study prior to the event with anesthesia. These issues can often be addressed before surgery, and their presence will impact the modifications to perioperative monitoring and anesthesia care tailored to the needs of each patient for enhanced safety and outcomes. Additional value from wearable devices lies in their ability to provide more information about the activity level and physical fitness of patients - both critical considerations when assessing risk for the perioperative period. For instance, low reported daily activity by a fitness tracker may lead to further investigation of cardiopulmonary reserve before the patient undergoes major surgery.[15]

6. Benefits of Digital Technology in Preoperative Anesthesia Assessment

The introduction of digital tools has made preoperative assessment more efficient through streamlining data collection and analysis. This, in turn, helps free up the anesthesiologist from the traditional methods time-eating hassles. With all this increased efficiency, it leaves more time for healthcare professionals to work on decisions related to clinical realms and engage with patients more directly, which in turn leads to a more attentive care environment. Anesthesiologists can make more superior risk assessments and management with access to comprehensive, real-time patient data; hence the patients involved are more likely to avoid adverse surgical events leading to higher patient safety. The use of digital platforms also plays a central role in ensuring patient-centered care.[4,7] They ensure personalized plans in care while encouraging informed participation by patients in the care system, leading to better patient satisfaction. With these channels, patients are empowered to be active participants in their self-management, thereby increasing adherence to preoperative and anesthesia plans. Implementing telemedicine and virtual assessments into the preoperative evaluation will also reduce the number of in-person visits required, with significant savings in resource usage. This method will not only cut down on the health care costs due to the reduction of physical infrastructure and logistical demands but ensure the swift delivery of all the evaluations that the patient needs without taking into account the geographical location of the patients. Therefore, this will be a transformative power in contemporary anesthesiology, as it advocates for a more streamlined, safe, individualized, and cost-effective preoperative care system capable of meeting the evolving demands and expectations of patients.[10,16]

Challenges and Limitations

The growing integration of digital tools into healthcare systems cannot deepen the core need for data privacy and security. Electronic health records, telemedicine platforms, and mobile health applications are gaining popularity in healthcare, which means that sensitive patient information faces a potential breach. It demands strong security systems, as well as a streamlined model of compliance with legal rules such as GDPR and HIPAA, which govern the privacy and security of patient health information. Also, the provision and adoption of digital instruments pose a challenge in that not all patients and healthcare providers can be comfortable or

familiar enough with these instruments to use them effectively. Bridging this digital divide will incorporate user-friendly technological solutions, with incorporation of training and support to ensure access equitably across different populations, including those underserved or geographically remote. At the same time, the new digital solutions should integrate with healthcare systems so that workflow interruption does not occur and continuity of care is ensured. This integrated functionality requires interoperability standards to enable communication and operational interactions between different platforms and technologies without loss of quality or consistency in patients' care. Another associated, developing application of AI systems in healthcare continues to raise intricate regulatory and ethical questions. The role of AI should be transparent and accountable in decision-making; therefore, appropriate regulation should be made to ensure its proper usage without bias in the applications. Clarification of validation and description of AI-related decisions have to be included within governance frameworks that guide the responsible deployment of AI algorithms.

Future Prospects

Advances in digital technology hold much promise for the future of preoperative anesthesia assessment, set to revolutionize and change perioperative care. Of particular interest in this development is the sophisticated AI algorithms. With evolving artificial intelligence, more advanced algorithms can be constructed to reveal more depth in patients' health, thus enhancing the prediction capabilities about risks associated with anesthesia. Such breakthroughs could potentially allow anesthesiologists to better anticipate which complications are going to arise and intervene more selectively. The infusion of genomic data into the health information systems would be another game-changer. As anesthesiologists integrate genetic data into the already digitized health data, they will become able to daily practice ultrapersonalized anesthesia planning. Personalization will determine medications and doses based on one's individual genetic predisposition, maximizing effects while minimizing adverse drug reactions. The future of preoperative assessment is certainly going to be highly influenced by the progress in wearable technology. As these devices continue to develop and advance to deliver minute and constant health monitoring, they will provide key data points that form the basis of risk assessment as well as perioperative planning. With such high-resolution monitoring, subtle physiological changes that precede complications may be detected early on, with opportunities for early intervention. Simultaneously, better interoperability standards are required for this revolution, as they will allow for seamless integration and communication across different digital health systems. It is through universal standards that the health industry can ensure fluid information exchange across its various platforms and providers, hence deepening coordination and continuity of care. Interoperability will support a comprehensive view of patient management with information coming from other sources coalescing to form a full patient profile. Future advances in digital technology therefore hold out the promise of greatly increasing the accuracy, safety, and efficiency of preoperative anesthesia assessments in preparation for a new era of individualized and integrated surgical care.

Conclusion

Digital technology integration in preoperative anesthesia assessment fundamentally modifies the landscape of perioperative care. Online health records, telemedicine, mobile health applications, artificial intelligence, and wearable devices together establish an efficient, accurate, and personal approach to the preoperative process. Access to comprehensive data and active patient engagement promote improved patient safety while virtual assessments also optimize resources for everyone involved. This encompasses data privacy, accessibility, and integration of existing health care systems. The future is promising, as AI, genomic integration, and wearable tech with improved interoperability set to change the system for delivering surgical care as individualized,

predictive, and interconnected. With improvements in anesthesia, the future of better surgical outcomes will, undoubtedly, come through; continued digital innovation will guarantee a better and safer patient experience, making this the crux moment of history in anesthesiology to grow digitally, toward the future of this field.

All the authors have significantly contributed

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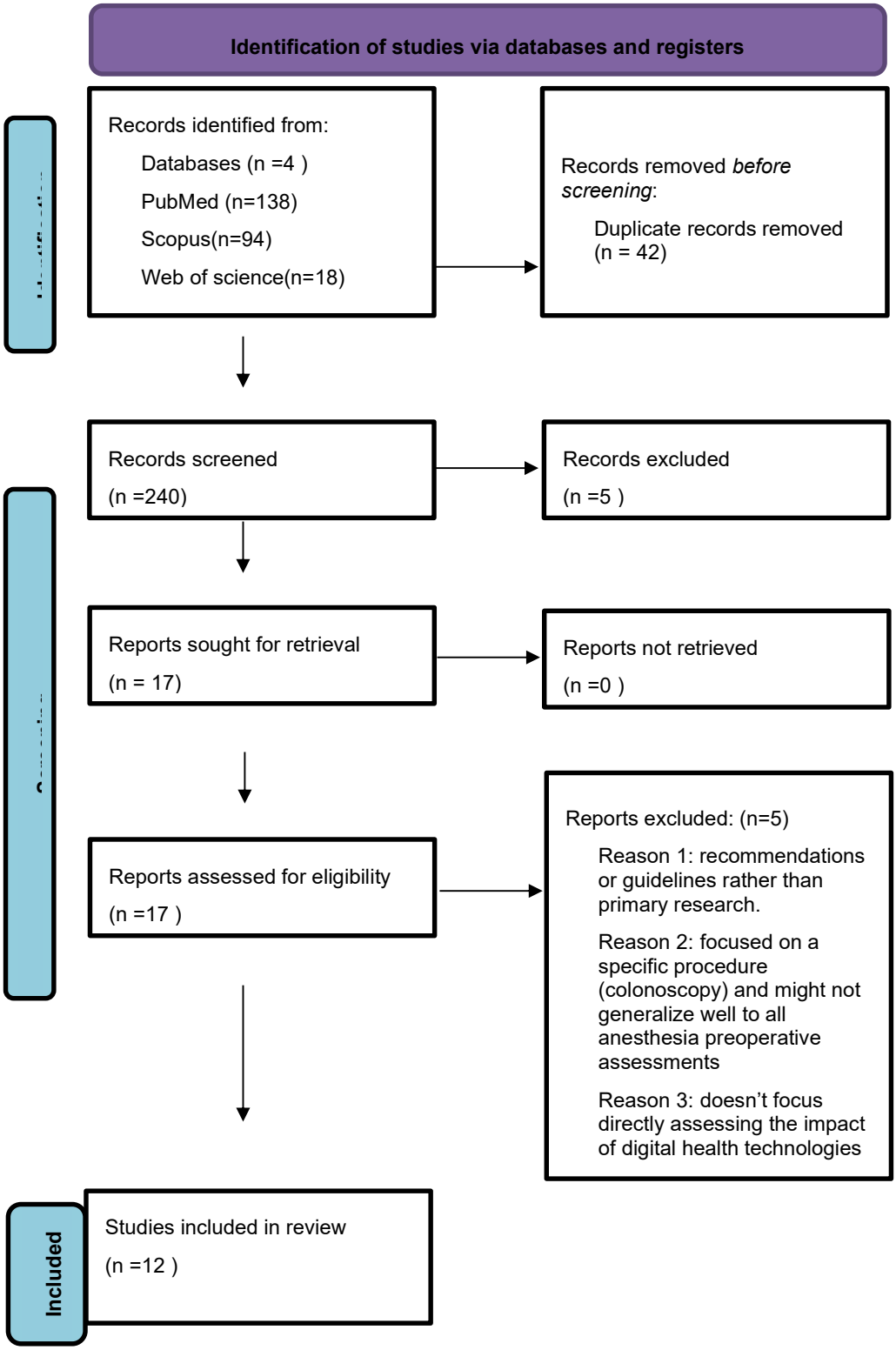
Identification of studies via databases and registers
Records identified from:
Databases (n =4)
PubMed (n=138)
Scopus(n=94)
Web of science(n=18)
Records removed *before screening*:
Duplicate records removed (n = 42)
Records screened
(n =240)
Records excluded
(n =5)
Reports sought for retrieval
(n = 17)
Reports not retrieved
(n =0)
Reports assessed for eligibility
(n =17)
Reports excluded: (n=5)
Reason 1: recommendations or guidelines rather than primary research.
Reason 2: focused on a specific procedure (colonoscopy) and might not generalize well to all anesthesia preoperative assessments
Reason 3: doesn't focus directly assessing the impact of digital health technologies
Included
Studies included in review
(n =12)