Current Practices and Potential Technological Advancements in Multidisciplinary Tumor Board Workflows: A Scoping Review

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ABSTRACT

Introduction: Cancer remains a leading global cause of death, demanding coordinated, patient-centerd care. Multidisciplinary tumor boards (MTBs) improve outcomes but face time pressure and fragmented data. The German Virtual Reality Multidisciplinary Tumor Board (VR-MTB) project aims to address these gaps by developing an immersive platform that unifies clinical, imaging, and laboratory data and integrates AI-driven decision-support tools.

Methodology: A scoping review was conducted in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines for Scoping Reviews (PRISMA-ScR) to map existing research on tumor boards published between 2020 and 2025. Of 168 records identified, 57 met the inclusion criteria.

Results: The review identified current practices, workflows, and challenges in MTBs. While MTBs improve cancer care through collaborative decision-making, conventional settings face inefficiencies due to fragmented data, time constraints, limited participants engagement, and poor system interoperability. Virtual MTBs (vMTBs) gained traction during the COVID-19 pandemic, showing potential for greater efficiency and inclusion. Barriers to adopting tools like extended reality (XR) and artificial intelligence (AI) include integration issues, resource constraints, resistance to change, and usability concerns, despite demonstrated value in pilot implementations.

Discussion and Conclusion: This scoping review mapped current MTB practices, revealing key workflow gaps and barriers to adopting advanced tools like XR and AI. While vMTBs show promise, successful digital transformation requires standardized processes, stakeholder engagement, integration with hospital systems, and further real-world evidence to ensure clinical impact and user adoption.

KEYWORDS

Multidisciplinary tumor boards (MTBs), cancer care, healthcare workflows, extended reality (XR), artificial intelligence (AI)

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1. Introduction

1.1 Cancer

Cancer remains a major global health issue and a leading cause of death [1, 2]. As per GLOBOCAN 2022 data from the International Agency for Research on Cancer (IARC), approximately 20 million new cancer cases and 9.7 million deaths were recorded worldwide. Lung cancer accounted for nearly 2.5 million cases, making it the most commonly diagnosed, followed by breast, colorectal, prostate, and gastric cancers [3].

Early detection significantly improves survival and plays a critical role in enhancing prognosis and outcomes [4].

1.2 Tumor Boards

Effective cancer treatment requires collaboration among specialists from various fields. By sharing expertise and tailoring care plans to patient needs, professionals ensure personalized and current treatment. There is a growing preference for multidisciplinary team (MDT) strategies in cancer care [5]. The MDT concept emerged in the United Kingdom (UK) during the 1990s and gained traction following the 1995 Calman-Hine plan, which sought to standardize high-quality cancer care across regions [6].

Multidisciplinary management (MDM) in oncology optimizes care by integrating expertise across the entire cancer care continuum [7]. It enhances diagnostic accuracy, treatment planning, and protocol adherence [8]. Multidisciplinary tumor boards (MTBs), also known as multidisciplinary team meetings (MDTMs), are forums where specialists jointly plan individualized cancer treatment [9]. Terms like tumor boards (TBs), tumor conferences, or multidisciplinary cancer conferences (MCCs) are used interchangeably in some institutions [10].

1.3 VR-MTB project

The VR-MTB (Virtual Reality Multidisciplinary Tumor Board) initiative, supported by the German Federal Ministry of Research, Technology, and Space (BMFTR), seeks to enhance cancer care through more effective MTBs. While interdisciplinary oncology teams support optimal treatment decisions, obstacles such as time constraints, fragmented data, and limited imaging access hinder collaboration [11, 12].

To address these issues, the project is developing a virtual reality (VR) platform that merges clinical, imaging, and lab data in a shared immersive environment. Oncology teams can interact with three-dimensional (3D) images and patient data collaboratively in real time. The platform is designed via a needs assessment and integrates artificial intelligence (AI)-driven tools for transcription and organization, improving documentation and interoperability with hospital systems. Ultimately, VR-MTB aims to enhance workflow and clinical decision-making. The solution is being designed for scalability and global adoption.

1.4 Research Questions

This literature review, part of Work Package 2 (WP-2) of the VR-MTB project, focuses on identifying research trends and gaps. Research questions (RQs) were framed using the SPICE framework (Setting, Perspective, Intervention, Comparison, Evaluation), commonly used to evaluate healthcare service delivery and technology implementation [13].

Initial RQs were refined with support from ChatGPT [14], and target clinical, technical, and ethical-regulatory domains. Due to the volume of findings, this review addresses the following five RQs:

1. What are current workflows, practices, and standard operating procedures (SOPs) within multidisciplinary tumor boards?
2. What challenges and inefficiencies are experienced by healthcare professionals during tumor board sessions?
3. How can virtual/remote participation affect team dynamics and collaboration quality?
4. What are the main organizational barriers to adopting advanced tools such as extended reality (XR) and AI-driven decision support technologies in multidisciplinary oncology teams?
5. What strategies are most effective for engaging and convincing clinical, administrative, and information technology (IT) participants to actively involve in the implementation and evaluation of a VR-enhanced multidisciplinary tumor board (VR-MTB) platform?

2. Methodology

This scoping review followed the PRISMA guidelines for Scoping Reviews (PRISMA-ScR) [15, 16]. Scoping reviews are systematic, iterative methods for synthesizing knowledge that map the scope, variety, and characteristics of the literature while identifying research gaps [17]. Article selection followed the PRISMA flow chart, using a three-phase diagram to ensure consistency in data collection [18, 19].

The results of the literature review are shown in Figure 1.

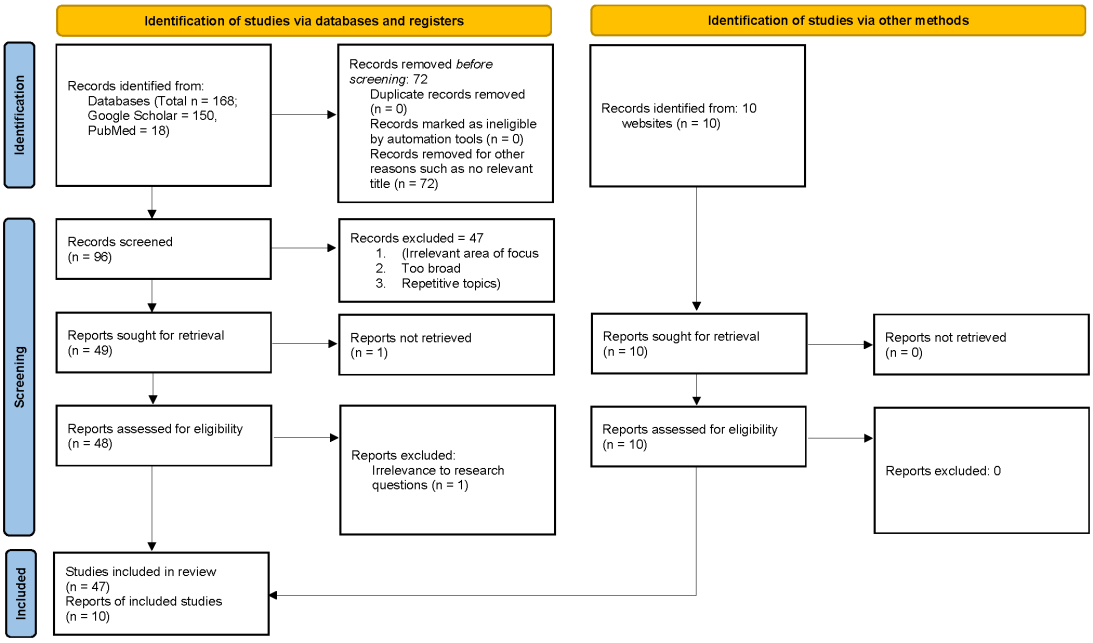


Figure 1: PRISMA flow diagram.

2.1 Identification

A comprehensive search was conducted in Google Scholar and PubMed between March and April 2025, using English terms without restricting study types. Most publications dated from 2020 to April 2025. The SciSpace AI platform was employed to refine the review and align it with research questions [20].

- Searches were research question-driven using semantic matching
- Full-text analysis was performed via its chat interface for deeper insight

Search Terms

Boolean operators (AND/OR) and quotation marks refined the search strategy. The following terms were used:

- ("tumor board" OR "tumor conference" OR MTB OR MDT) AND (workflow OR clinical OR healthcare OR oncology)
- ("tumor board" OR "tumor conference" OR MTB OR MDT) AND (drawback OR disadvantage OR challenge OR cons OR problem OR limitation OR barrier OR obstacle OR "clinical difficulty")
- ("clinical outcome" OR efficacy OR effectiveness OR adherence OR patient care OR survival OR "patient experience") AND ("tumor board" OR "tumor conference" OR MTB OR MDT)
- (user needs OR clinical requirements OR "essential functionalities") AND ("tumor board" OR "tumor conference" OR MTB OR MDT)
- (adoption OR integration OR implementation OR acceptance) AND (“virtual reality” OR “augmented reality” OR “mixed reality” OR “extended reality”) AND ("tumor board" OR "tumor conference" OR MTB OR MDT OR (AI OR "artificial intelligence"))

Out of 168 articles identified (Google Scholar = 150, PubMed = 18), 72 were excluded based on title.

2.2 Screening

Titles and abstracts were initially screened for relevance. Of 96 records, 47 were excluded due to irrelevance, broad scope, or duplication. Inclusion criteria matched the research questions, while exclusions applied to non-English texts, pre-2020 publications, and duplicates. Two pre-2020 studies were retained due to relevance. Full texts were sought for 49 articles, with 48 successfully retrieved. Bibliography citation screening added 10 records (websites = 10).

2.3 Inclusion

A total of 57 records were included (47 from databases, 10 from other sources). Mendeley was used for reference management [21]. All sources were cited in accordance with the journal-specific Vancouver style [22]. The SciSpace Paraphraser tool (by PubGenius Inc.) was used in "Fluent" mode to improve readability [20].

3. Results

3.1 Conventional MTBs

3.1.1 Current workflows and tools used in MTBs

Regular Meetings: Tumor board meeting frequency varies by institution, specialty, patient volume, and cancer type. The American College of Surgeons' Commission on Cancer (CoC) mandates multidisciplinary cancer conferences, with each program defining and documenting their meeting schedule in official policy [23]. CoC Cancer Program standards specify that tumor boards should meet weekly or monthly, depending on the institution’s accreditation. Surveys show 58 % of physicians attend weekly and 25 % monthly [24, 25]. Centers with 25 or more new cancer cases per month usually hold weekly meetings, while those with fewer than 15 cases often meet biweekly or monthly [26, 27]. Regular meetings ensure multidisciplinary evaluation so all treatment options like surgery, radiotherapy, or endoscopic resection are thoroughly considered.

Interdisciplinary Decision-Making: Discussions involve specialists from surgery, oncology, radiology, pathology, and supportive care to address all clinical aspects. Allied health professionals including nurses, psycho-oncology experts, and nutritionists also contribute, with palliative care experts involved when needed [24, 25]. Junior faculty, fellows, and residents participate, contributing to education and career development [28].

One study found 66 % of 102 patients were willing to engage in tumor board discussions, with clearer recommendations linked to greater treatment confidence [27].

Before the Meeting

Procedures vary across institutions due to differing resources and systems. The National Cancer Control Programme (NCCP) emphasizes standardized documentation through tumor-specific SOPs for registration, preparation, execution, and reporting. These are updated by the NCCP Tumour Leads Group, with general guidance for hospitals lacking dedicated teams [29].

Patient Selection and Eligibility Screening: The workflow prioritizes complex or unclear cases, typically managed by cancer care coordinators or junior doctors [30].

Preparation begins with selecting eligible patients—those who:

- Have relapsed or suffer from treatment-resistant malignancies
- Have exhausted conventional therapies
- Show limited tolerance for standard treatments
- Have rare tumors lacking guideline-directed options

Selection is initiated by any provider, with criteria varying by institution. Once deemed eligible, patients are registered for review by the treating physician or directly [31]. Patients are usually informed beforehand that their case will be discussed [27].

Case Submission: Before each meeting, doctors use standardized forms to submit administrative details, history, exam findings, imaging (magnetic resonance imaging [MRI], computed tomography (CT), positron emission tomography (PET)), labs, pathology, and genomic data [25]. Workflows often involve manual data extraction from unstructured sources like pathology reports and referral letters [32]. Once identified, registrars or specialists input key information into standardized electronic systems—a time-consuming process requiring clinical expertise [32].

A study reported Microsoft Access was used to create an MDT template for real-time entry, allowing staff to input and access full patient data, while a senior clinician compiled key points [33]. Some hospitals use Onkostar, which offers structured templates for diagnosis, surgery, pathology, and tumor board input [32]. These ensure consistency and support full case assessment [32]. An agenda with patient demographics, diagnoses, and initial treatment details is shared before meetings [34].

During the Meeting

Meeting Place: Meetings occur in designated rooms. Breast and skin boards use larger structured rooms, while blood and marrow sessions take place in smaller, informal settings to foster deeper discussion [25, 34].

Meeting Protocol and Data Management: Effective MTBs rely on strong leadership. A leader guides discussion and maintains focus. Some centers rotate chairs or use non-voting leaders to encourage openness and reduce bias [30]. Sessions include detailed review of imaging, pathology, and treatment plans like surgery or radiotherapy. Structured agendas ensure discussions stay within time limits, overseen by the chair [29].

Number of Cases: TBs typically review 15–50 cases weekly, varying by institution and cancer type [34].
Meeting Duration: Most sessions last 1–2 hours, with 3–4 minutes per case. One study noted 657–741 cases monthly at one center, averaging 20 per meeting [25, 34].

Tools: Rooms have projectors and large screens for rosters, pathology, imaging, and clinical summaries [34]. Without integrated systems, some boards still use PowerPoint for slides and imaging [34]. A standardized template is used to document discussions, ensuring complete clinical records [29].
Digital tools, including web apps, have been tested for real-time documentation [35].

Final Decision: Recommendations result from consensus discussions. Each specialist contributes their perspective, often leading to revised diagnoses, adjusted treatments, or further tests for personalized care [28, 29].

After the Meeting

Documentation and Protocols: Decisions are documented in patient records to ensure traceability and compliance. The primary consultant implements plans and communicates with patients and general practitioners. All decisions are included in protocols reviewed annually to incorporate new evidence and feedback [25, 29, 36].

Adherence to Guidelines: Recommendations are reviewed for compliance with evidence-based standards [36, 37].

Patient Inclusion and Satisfaction: Recommendations are shared with patients and physicians. Patient preferences are considered, and workflows promote clinical trial participation. A 93 % adherence rate indicates strong communication and follow-through [36].

3.1.2 Challenges

Preparation for Meetings: Traditional MTB preparation lacks standardization, with inconsistent organization and undefined resource needs. This variability causes inefficiencies, insufficient readiness, and missing critical data [38]. A recent survey found many healthcare professionals struggle to attend TBs due to scheduling conflicts. Only 43.9 % of radiologists reviewed imaging beforehand, potentially reducing decision quality [39]. Patient information is often sent via e-mail to an administrative assistant who compiles cases. This fragmented process uses multiple tools—e-mail, Word, PowerPoint—requiring manual data extraction and reformatting [40].

Protocols depend on data from radiology, pathology, and clinical assessments, often stored in separate systems. Integration usually requires manual transfer from hospital information system (HIS) to platforms like Onkostar, causing delays and errors [32]. SOPs rely on manual entry and review, following internal standards emphasizing accuracy but are prone to unintentional errors due to the manual nature [40]. Traditional workflows involve disconnected stages and communication channels, resulting in delays and disrupted meeting productivity [40].

Complexity of Cases: Managing advanced, recurrent, or metastatic cancer is complex due to patient variability and comorbidities, complicating consensus [24]. Case selection and preparation are often inefficient. Clearer criteria could ensure that relevant and complex cases receive focus [41]. Not all cases get equal attention. Complex ones may be reviewed thoroughly, while early-stage or elderly patients' cases may be overlooked, affecting care. Filtering by coordinators or junior staff may introduce inconsistency or bias [26].

Time-Consuming Processes: Preparation time varies by cancer type, specialty, and institution. MTBs are resource-intensive, limiting scalability. Preparing a single case may take 15 to 90 minutes across systems like PubMed and organizational systems [42]. One study reported 11 hours spent preparing 159 cases—over 4 minutes per case—delaying workflow and adding stress during urgent decision-making [40]. TB case discussions average 5.5 to 6.5 minutes, indicating a need for better data consolidation tools [36, 38]. Face-to-face meetings require significant time, with clinicians spending 1.25 million man-hours annually and 50 extra hours monthly on case evaluations [39]. Ineffective time management is common; skilled moderators and improved strategies are needed [41].

TBs often review many cases quickly—for example, 30–50 in under two hours—leading to rushed discussions [34]. Blood and marrow meetings may allow longer discussions but can last up to four hours, risking inefficiencies and participant fatigue [34].

Increased Potential for Errors: Fragmented data forces clinicians to manually search EHRs, increasing risks of errors like incorrect medical record numbers (MRN) or missed cases [40].

Limited Multidisciplinary Engagement: Discussions are often one-way, with physicians presenting and limited input from nurses or dieticians, reducing collaboration [34]. Rigid formats in breast and cutaneous boards create passive audiences, limiting feedback and hindering adaptive treatment planning [34]. Room layouts, especially in some sessions, reinforce hierarchy by placing surgical oncologists at the front, discouraging open discussion [34].

Resource Limitations: Limited specialist access in some areas reduces MTB effectiveness. Mini tumor boards may be used but face similar inefficiencies [24, 41].

Lack of Interoperability: Many health information technology (HIT) systems lack interoperability, delaying information access during meetings and hindering decisions [38]. Switching between tools like e-mail, Word, and PowerPoint reduces efficiency. Asynchronous e-mails delay preparation, limiting review time [40].

Professionals stress the need for tools that integrate clinical, radiological, and molecular data while connecting to current knowledge and collaboration features [43]. Desired features include fast presentation creation, treatment documentation, multi-user access, 3D Digital Imaging and Communications in Medicine (DICOM) support, and an intuitive, easy-to-learn interface [44].

Usability Issues: Most TB tools focus on narrow tasks and lack comprehensive capabilities, frustrating users. Advanced tools like XR and AI systems often have poor usability, reducing adoption [38].

3.1.3 Role of MTBs in Cancer Treatment and Decision-Making

Patient-Centered Care: MTBs prioritize patient needs, values, and preferences, supporting informed decisions. This approach is part of Germany's national cancer plan and clinical guidelines [24, 36].

Improving Outcomes: MTBs improve cancer assessment, organ preservation, and quality of life. Greater involvement correlates with better outcomes [24, 39]. One study showed patients attending three or more MTBs had significantly better survival, suggesting regular discussions support improved outcomes [45].

Although MTBs are common in cancer care, their effectiveness and impact on patient outcomes vary and are not consistently evaluated across healthcare settings [28].

Educational Platform: MTBs support knowledge exchange and continuous learning to keep clinicians updated [24].

Tumor Board Simulation: Simulated MTBs improve preparedness in early medical education [46–48].

3.2 Virtual MTBs

3.2.1 Adoption and Use

The Coronavirus Disease 2019 (COVID-19) pandemic accelerated adoption of virtual MTBs using platforms like ZOOM, enabling remote collaboration and timely decision-making. Virtual multidisciplinary tumor boards (vMTBs) allow all relevant specialists to participate regardless of location [24, 36].

3.2.2 Benefits and Opportunities

A study found that the number of cases reviewed in MTBs is key to effectiveness, with similar case volumes and discussion quality in both in-person and virtual formats [39]. Surveys show many MTB participants find virtual formats more time-efficient and convenient, with strong support for continued use of virtual or hybrid meetings, reflecting a shift toward flexible arrangements [39]. Virtual TBs can improve patient experience by enabling quicker specialist collaboration and decision-making, leading to faster treatment starts and potentially better outcomes through holistic care [39].

3.2.3 Challenges

Although teleconferencing platforms like Zoom became popular during COVID-19, some referring physicians were reluctant to adopt them, citing challenges in integrating teleconferencing into their routines, which could hinder collaboration [36].

3.3 Novel Digital Solutions in MTBs

This section focuses on the key barriers and enabling factors influencing the adoption and implementation of advanced digital solutions, including XR (VR/AR/MR) and AI, in MTBs.

3.3.1 Challenges

Integration with Existing Systems

Clinical workflows span electronic medical records (EMR), labs, and imaging. XR and AI must integrate seamlessly. Research on Navify Tumor Board highlights poor integration with hospital systems as a key barrier [49].

Resistance to Change

Clinicians often resist new technologies due to unfamiliarity or distrust [38]. Concerns include reliability and potential disruptions to established workflows [50]. Staff using e-mail and manual processes are often reluctant to transition due to entrenched habits [40]. Advanced technologies require workflow changes, and ingrained routines cause resistance [50].

Resource Constraints

Financial limitations hinder investment in XR and AI. Costs of acquisition, deployment, and training are often prohibitive [38]. Licensing, hardware, and integration expenses significantly impact adoption [49].

Data Privacy and Security Concerns

Handling sensitive data raises concerns over privacy, requiring compliance and strong safeguards [38].

Lack of Evidence on Effectiveness

Literature lacks consensus on XR and AI's clinical impact. This uncertainty makes stakeholders hesitant [38]. Clear evidence is needed to show benefits to outcomes and workflow. Without it, skepticism remains [50]. If clinicians view tools as barriers, adoption will stall. The NAVIFY study highlights the value of standardized processes and stakeholder involvement [49].

Cybersickness

Cybersickness causes nausea, dizziness, and headaches during XR use. It's visually induced without motion and varies by user experience [51, 52]. Causes include display resolution and wide fields of view. Poor calibration worsens symptoms, even with improved motion tracking [53, 54].

3.3.2 Adoption and Implementation Strategies

Early Engagement

In the NAVIFY project in Taiwan, clinical, admin, and IT stakeholders were engaged early, improving ownership and reducing resistance [49]. Healthcare providers shared experiences in feedback sessions, helping developers tailor features to real-world use. Clinicians tested the system during routine care, helping resolve issues early [50].

Clear Communication of Benefits

Clear communication of benefits, such as time savings and improved information management, can support the adoption of digital MTB solutions [49]. Evidence from pilot studies can also be used to demonstrate how reductions in preparation and discussion time may improve patient care and streamline clinical workflows [49].

User-Focused Design and Co-Creation

NAVIFY was co-developed with clinician input, improving usability and alignment with practice. Ongoing feedback shaped improvements, strengthening trust and functionality [50]. In the NeuroVis project, users shaped design for radiosurgery planning [55]. In the MR-HNTB study, users tested prototypes in simulations, identifying strengths and usability barriers [56]. In IMHOTEP, participants gave usability and clinical feedback via standardized questionnaires [57]. NAVIFY's flexible development allowed continuous updates and collaboration [50].

Education and Staff Training

A tumor board nurse navigator coordinated NAVIFY rollout, offering training and support [50]. Tailored programs should address each group's priorities—workflow for clinicians, integration for IT. Ongoing support ensures engagement and addresses issues quickly. Practical training builds confidence and encourages adoption [49]. Without training, clinicians may struggle to adopt new tools [38]. Studies highlight the value of live training, video tutorials, and standard operating procedures to help users adapt to digital tools [40]. For NAVIFY Tumor Board, a tumor board nurse navigator was added to coordinate training and team organization, ensuring a smooth and efficient transition to the digital tool [50].

NAVIFY Tumor Board was initially introduced with a manual upload option to ease healthcare professionals' transition. The phased rollout, combined with ongoing training and support, allowed clinicians to adapt gradually and ensured consistent learning and problem-solving across teams [50].

Demonstration of Real-World Benefits

NeuroVis developers showcased six cases to demonstrate clarity and efficiency using features like clipping planes and adjustable opacity [55]. Scalability across HoloLens versions and integration with machine learning boosted confidence in future potential [55].

4. Discussion & Conclusion

4.1 Research Aim and Methodological Foundation

The aim of this scoping review was to identify gaps in the current literature for TB workflows that might guide a future systematic review. A PRISMA-ScR–guided search, conducted across Google Scholar and PubMed yielded 168 records; following the removal of duplicates and a three-phase screening process. 47 articles were ultimately included in our study.

4.2 Limitations & Strengths of the Study

4.2.1 Limitations

This review used the PRISMA-ScR methodology with PubMed, Google Scholar, grey literature, and citation tracking but did not cover all databases. The 2020–Q1 2025 date range excluded earlier foundational studies, and English-only screening likely biased results toward North American and Western European sources.

4.2.2 Strengths

The strengths include methodological rigor and transparency; the protocol was adhered to PRISMA-ScR checklists, and utilized concrete framework for research questions. Reviewers conducted screening and data extraction, enhancing inter-rater reliability.

4.3 Interpretation of Findings

4.3.1 Current MTB Landscape and Workflow Gaps

RQ-1: What are current workflows, practices, and standard operating procedures (SOPs) within multidisciplinary tumor boards?

MTBs are an essential part of oncology care, enabling collaborative, case-based discussions to guide evidence-based treatment decisions. Current clinical workflows typically involve regularly scheduled meetings, either weekly or monthly, where multidisciplinary teams of specialists assess patient cases using standardized templates and shared clinical data [25, 34]. SOPs guide many aspects of these workflows, including patient selection, case documentation, meeting structure, and post-meeting follow-up [29]. However, SOP implementation varies between institutions depending on resources, cancer type, and national directives.

Several workflow gaps remain. Data collection is still largely manual, requiring extraction from unstructured clinical documents such as pathology reports and referral letters, which can be time-consuming and error-prone [32]. Some institutions use digital tools like Microsoft Access templates or platforms such as Onkostar to support structured documentation, yet adoption is inconsistent [32, 33]. Additionally, tools like PowerPoint are still used in settings lacking integrated systems, limiting data accessibility and real-time decision-making support [34]. While most MTBs follow a structured process, there is limited standardization across institutions in how patient preferences are integrated into decision-making, and how feedback is used to improve MTB quality [27, 36].

In conclusion, although MTBs are built on coordinated and partially standardized practices, significant variability exists in SOPs, documentation workflows, and digital tool usage. Future improvements should focus on increasing workflow automation, standardizing digital platforms, and enhancing patient-centered practices to strengthen the impact of MTBs on cancer care delivery.

RQ-2: What challenges and inefficiencies are experienced by healthcare professionals during tumor board sessions?

Despite their essential role in multidisciplinary cancer care, MTBs face several persistent challenges that hinder clinical efficiency. One of the primary issues is the inconsistent and time-consuming preparation for meetings. The lack of standardized SOPs across institutions leads to variability in how cases are selected and organized, often resulting in incomplete case information and inefficient use of meeting time [40, 50]. Manual data collection, fragmented workflows using non-integrated tools like e-mail, Word, and PowerPoint, and the need to gather information from isolated systems such as HIS and imaging archives further exacerbate delays and increase the potential for documentation errors [32 ,40].

Time management is a widespread concern. Preparing a single case can require up to 90 minutes, while TB meetings often handle 30 to 50 cases within a tight timeframe, leading to rushed discussions and participant fatigue [34, 42]. Moreover, conflicting schedules and heavy workloads limit the participation of key professionals such as radiologists, which may compromise the quality of case reviews [39].

Multidisciplinary engagement also remains limited. Presentation formats are often rigid, and hierarchical seating arrangements discourage open discussion. Contributions from allied health professionals are minimal unless explicitly invited, which undermines the collaborative nature of MTBs [34]. Additionally, complex or advanced cases dominate the agenda, while early-stage or elderly patients may receive insufficient attention, reflecting inconsistencies in case prioritization [24, 26].

Resource limitations and lack of interoperability between HIT systems further challenge TB operations, especially in under-resourced or rural settings. The absence of integrated platforms delays access to relevant data and necessitates repetitive tasks that reduce [43, 50]. Even where digital tools are adopted, usability issues, steep learning curves, and insufficient multi-user functionalities hinder widespread clinical adoption [44].

In summary, conventional TB settings are constrained by fragmented processes, poor interoperability, limited multidisciplinary input, and usability limitations in existing digital tools. Addressing these challenges through streamlined data integration, well-defined SOPs, improved time and resource management, and user-centered digital platforms is crucial for enhancing the efficiency and clinical value of MTBs.

RQ-3: How can virtual/remote participation affect team dynamics and collaboration quality?

vMTBs have improved accessibility and flexibility, allowing wider participation from specialists regardless of location. Studies show that discussion quality and case volume remain consistent with in-person meetings [39]. Many professionals report time savings and greater convenience, supporting the continued use of virtual or hybrid formats [39].

However, some clinicians find it difficult to integrate teleconferencing into their routines, which may affect collaboration depth [36]. While vMTBs enhance operational efficiency and access to expertise, maintaining engagement and addressing usability concerns are essential for sustaining collaborative quality.

4.3.3 Implementation Barriers

RQ-4: What are the main organizational barriers to adopting advanced tools such as XR and AI-driven decision support technologies in multidisciplinary oncology teams?

The adoption of advanced visualization and AI-driven decision support tools in oncology teams faces multiple clinical and organizational barriers. A major obstacle is the limited integration of these technologies with existing hospital systems such as EMRs and imaging platforms, which creates

workflow inefficiencies and delays [49]. Resistance to change is also common, as many healthcare professionals are hesitant to move away from familiar tools like e-mail and PowerPoint toward digital systems they may perceive as complex or untested [40, 50].

Significant financial constraints further limit adoption. The cost of software licensing, XR hardware, training, and ongoing maintenance can be prohibitive, especially in resource-constrained settings [49]. Concerns around data privacy and regulatory compliance also discourage institutions from deploying new digital systems that manage sensitive patient data [50].

Clinicians and administrators remain cautious due to a lack of strong clinical evidence supporting the effectiveness of XR and AI in improving outcomes or efficiency. The emerging nature of these technologies, combined with limited real-world validation, adds to the skepticism [38]. Additionally, user discomfort such as cybersickness—triggered by head-mounted display (HMD) settings—can negatively affect the experience and limit widespread use [51, 54].

In summary, successful adoption of XR and AI in MTBs requires addressing integration challenges, reducing costs, improving usability, and generating robust clinical evidence to earn trust among healthcare professionals and participants.

RQ-5: What strategies are most effective for engaging and convincing clinical, administrative, and IT participants to actively involve in the implementation and evaluation of a VR-enhanced multidisciplinary tumor board (VR-MTB) platform?

Successful adoption of a VR-MTB platform requires early and active engagement of clinical, administrative, and IT participants. Involving healthcare providers (HCP) from the initial design phase fosters ownership and minimizes resistance, as seen in projects like NAVIFY and NeuroVis where users co-developed features based on real clinical workflows [38, 55]. Co-creation ensures the tool aligns with actual user needs and promotes long-term trust in the system.

Clear communication of benefits is also essential. Demonstrating how VR tools reduce manual data handling and improve decision-making efficiency helps participants recognize their practical value [49]. Training programs tailored to different roles, supported by live sessions, tutorials, and continuous support, further reduce hesitation and promote confidence in using new technologies [40, 50].

Dedicated roles, such as a tumor board nurse navigator, can streamline implementation by coordinating training and providing hands-on support during the rollout [50]. Finally, showcasing real-world use cases and clinical scenarios reinforces the platform's relevance and scalability, helping participants visualize long-term benefits and encouraging sustained participation [55].

In summary, a combination of early involvement, user-centered design, clear communication, customized training, and real-world validation is key to gaining stakeholder buy-in for VR-enhanced MTB platforms.

4.4 Recommendations

4.4.1 Recommendations for Future Research

Future research should concentrate on a number of crucial areas in order to enable the integration of developing technologies and fix the shortcomings found in the present MTB operations.

First, in clinical cancer settings, solid real-world assessments of XR and AI-based solutions are required. While preliminary studies and pilot implementations suggest improvements in efficiency and collaboration, further longitudinal and multi-center studies are required to assess their impact on clinical outcomes, decision quality, and patient experience.

Second, future investigations should explore the cost-effectiveness and scalability of these technologies. Comprehensive economic evaluations, including implementation costs, maintenance requirements, and return on investment, are essential to support informed decision-making by healthcare institutions.

Third, standardization and interoperability should be the main topics of study. It is essential to conduct research on how XR and AI platforms may be integrated with current hospital systems, including laboratory databases, imaging systems, and electronic health records (EHRs). To facilitate smooth data interchange and lessen workflow fragmentation, more research should be done on the usage of standardized frameworks like Digital Imaging and Communications in Medicine (DICOM) and Fast Healthcare Interoperability Resources (FHIR).

Lastly, future studies should focus on ethical, legal, and social implications (ELSI), such as user trust, data privacy, and the transparency of AI-driven decision support. The safe and responsible use of digital technology in cancer care will depend on the establishment of clear regulatory frameworks and best practices.

4.4.2 Implications for Practice and Platform Development

The recurring challenges, including fragmented workflows, poor interoperability between systems, inefficient data management, and the persistent struggle to adopt new technologies, highlight that meaningful digital transformation of MTB practices cannot be achieved without deliberately addressing each of these issues.

This research identifies a number of key factors that are critical for the development, deployment, and successful uptake of digital MTB platforms. A primary requirement is the creation of integrated and interoperable systems that consolidate laboratory, imaging, and clinical data within a single platform. Reducing reliance on fragmented tools such as Word, PowerPoint, and e-mail can significantly enhance both data accuracy and workflow efficiency.

Adoption success strongly depends on usability and user-centered design. Platforms should be intuitive, easy to learn, and aligned with existing clinical workflows to minimize disruption. Incorporating continuous input from healthcare professionals throughout the design and implementation process can further improve system acceptability and long-term sustainability.

Building capacity and providing training are equally essential. Clinicians can better adapt to new technologies, and resistance to change can be reduced, through tailored training programs, ongoing technical support, and clearly defined implementation strategies. The inclusion of dedicated coordination roles, such as tumor board nurse navigators, may further facilitate smooth integration into routine clinical practice.

Clear communication of value is also crucial for promoting adoption. Demonstrating measurable benefits, such as reduced preparation time, improved data accessibility, and enhanced multidisciplinary collaboration, can strengthen stakeholder trust and support investment in digital solutions.

Finally, scalability and adaptability should be prioritized in the design of digital MTB platforms. Systems should be flexible enough to accommodate different institutional contexts, support hybrid meeting formats, and integrate future technological advancements, including AI-driven decision support and immersive virtual reality environments.

Overall, the successful implementation of digital MTB solutions requires not only technological innovation but also careful consideration of workflow integration, user needs, and organizational readiness.

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Conflict of Interest Statement

The authors declare that there is no conflict of interest regarding the publication of this paper.

List of Abbreviations

3D	three-dimensional
AMA	American Medical Association
AI	artificial intelligence
BMFTR	Bundesministerium für Forschung, Technologie und Raumfahrt (German Federal Ministry of Research, Technology, and Space)
CoC	Commission on Cancer
COVID-19	Coronavirus Disease 2019
CT	computed tomography
D	deliverables
DICOM	Digital Imaging and Communications in Medicine
EHR	electronic health record
ELSI	Ethical, Legal, and Social Implications
EMR	electronic medical record
FHIR	Fast Healthcare Interoperability Resources
GLOBOCAN	Global Cancer Observatory
HCP	Healthcare providers
HIS	hospital information system
HIT	health information technology
HMD	head-mounted display
IARC	International Agency for Research on Cancer
IT	information technology
ITB	interdisciplinary tumor board
MCC	multidisciplinary cancer conference
MDM	multidisciplinary management
MDT	multidisciplinary management
MDTM	multidisciplinary team meeting
MR	mixed reality
MRI	magnetic resonance imaging
MR-HNTB	mixed reality head and neck tumor board
MRN	medical record number
MTB	multidisciplinary tumor board
PET	positron emission tomography
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses Scoping Review

RQ	research question
SOP	standard operating procedure
SPICE	setting, perspective, intervention, comparison, evaluation
TB	tumor board
UK	United Kingdom
VR	virtual reality
VR-MTB	virtual reality multidisciplinary tumor board
vMTB	virtual multidisciplinary tumor board
WP	work package
XR	extended reality

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