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Molecular tumor boards implementation in Europe: a scoping review and thematic analysis of challenges and facilitators

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ABSTRACT

Background: Molecular Tumor Boards (MTBs) are increasingly recognized as key instruments for integrating genomic data into clinical decision-making in precision oncology. While evidence suggests that MTBs may improve patient outcomes, their implementation across European healthcare systems remains heterogeneous. This scoping review aims to explore challenges and facilitators of MTB implementation, focusing on feasibility, acceptability, equity, and resource use.

Methods: We conducted a literature search in PubMed, Embase and Web of Science up to 30 June 2026 to identify studies addressing implementation aspects of MTBs in Europe. Eligible studies included any design discussing feasibility, acceptability, equity, or resource use. Statements were extracted and coded using a hierarchical analytical framework based on domains, themes, and subthemes. Statements were classified as challenges or facilitators.

Results: One hundred and six studies were included out of 3307 studies identified. Most studies addressed feasibility (87.7%), followed by equity (47.2%), resource use (44.3%), and acceptability (32.1%). A total of 466 statements were extracted, divided between challenges (43.1%) and facilitators (56.9%). Feasibility challenges included technical and organizational barriers, particularly delays in turnaround time, lack of standardized workflows, and limited interoperability of digital systems. Facilitators included workflow optimization, multidisciplinary coordination, standardized procedures, and decision-support tools. Acceptability challenges involved limited genomic knowledge and readiness among healthcare professionals and concerns regarding the clinical benefits and potential risks of genomic testing among patients, while education and training emerged as key facilitators. Equity challenges included geographical disparities, limited access to clinical trials, and inequalities in access to molecular technologies across countries and healthcare centers; virtual MTBs, regional networks, and centralized services were identified as potential facilitators. Resource use challenges were mainly related to the costs of genomic testing and targeted therapies and uncertainties in reimbursement, whereas facilitators included declining sequencing costs, dedicated funding, and structured reimbursement pathways.

Conclusions: MTB implementation across Europe remains heterogeneous and is influenced by interconnected organizational, technical, educational, equity, and economic factors. Standardized processes, interoperable digital infrastructures, workforce training, equitable access, and sustainable financing may be key to supporting the integration and scalability of MTBs into routine oncology care.

Background

The rapid evolution of precision oncology has profoundly reshaped cancer care. Advances in next-generation sequencing (NGS) and multi-omics technologies have enabled the large-scale identification of actionable molecular alterations, fostering the development of targeted and immune therapies (Edsjö et al., 2024 [1]). Within this context, Molecular Tumor Boards (MTBs) have emerged as multidisciplinary entities able to integrate molecular profiling data with clinical and pathological information to guide personalized treatment strategies for

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cancer patients (Tsimberidou et al., 2023 [2]).

MTBs implementation has been associated with improved clinical outcomes, including higher response rates and improved survival (Russo et al., 2026a [3]), and scientific societies have emphasized the central role of MTBs in advancing biomarker-driven care and in promoting equitable access to innovative treatments (Westphalen et al., 2025 [4]).

However, the effective implementation of MTBs within healthcare systems presents substantial issues, particularly related to their organization and integration into cancer care pathways, with high heterogeneity across European countries (Bartels et al., n.d. [5]). While in some settings MTBs are central in providing recommendations for targeted therapies, in others their role is unclear and fragmented, limiting their effectiveness. Beyond regulatory heterogeneity, MTBs may encounter operational barriers, economic constraints, lack of acceptance from patients and healthcare professionals, and issues in access and participation (Ciliberto et al., 2022; De Micheli et al., 2025; Willemsen et al., n. d. [6–8]).

To date, most of the evidence regarding MTBs has focused on their clinical impact on patient outcomes, with limited attention to the organizational, acceptability, equity and economic dimensions that can limit their optimal implementation.

The aim of this scoping review is to explore the available evidence on the implementation challenges and facilitators associated with MTBs, including feasibility, acceptability for patients and healthcare professionals, equity, and economic considerations. This work complements ongoing efforts to provide a robust evidence base for developing consensus recommendations on the effective and equitable implementation of MTBs in Europe.

Methods

We conducted this scoping review following a predefined protocol registered on Open Science Framework (Russo et al., 2025 [9]). We reported the review in accordance with the PRISMA-ScR checklist (Tricco et al., 2018 [10]).

Search strategy and screening

We performed a systematic literature search in PubMed, Embase and Web of Science to identify studies addressing the implementation of MTBs. We included all studies published up to 30 June 2026, using a combination of the following keywords:

"molecular tumor board OR molecular tumour board OR genomic tumor board OR genomic tumour board OR molecular board OR biology board".

To identify relevant grey literature, supplementary searches were conducted in Google and Google Scholar on 30 June 2026. We screened the first 100 results retrieved from each search engine, ordered according to their default relevance ranking, using the same search string as for the scientific literature search. All results were downloaded and assessed by two independent reviewers, using the same eligibility criteria applied to the bibliographic database search.

After the literature search, we evaluated each study against the following inclusion/exclusion criteria: 1) any study design discussing at least one of the following domains in relation to MTBs: feasibility, acceptability, equity, or resource use; 2) studies conducted in Europe; 3) English-language studies.

The identified studies were uploaded to Covidence software, and then four reviewers (L.R., E.G., N.L., A.S.) independently performed screening based on titles and abstracts. Full texts of the studies identified were retrieved and reviewed by four researchers (L.R., E.G., N.L., A.S.). Eventually, identified studies that met the eligibility criteria were included in the scoping review.

Development of the analytical framework

We developed a hierarchical analytical framework to guide data organization and analysis. The framework consisted of three levels: domains, themes, and subthemes.

At the highest level, we defined four domains based on the GRADE Evidence to Decision framework: feasibility, acceptability, equity, and resource use (Moberg et al., 2018 [11]).

- *Feasibility*: Information related to the practical implementation of MTBs, including technical execution and logistical aspects required for integrating MTBs into standard oncology care. This includes factors such as required infrastructure, personnel, and time commitment from healthcare professionals.
- *Acceptability*: Information related to stakeholders' perceptions and acceptance of MTBs, including perspectives of patients, healthcare professionals, and policymakers. This includes patient preferences, perceived reliability of MTB recommendations, and attitudes toward MTB-guided decision making.
- *Equity*: Information related to fair and equitable access to MTBs across patient populations. This includes the impact of socioeconomic factors, geographic disparities, or other forms of marginalization on access to MTBs and related clinical outcomes.
- *Resource use:* Information related to the costs and economic implications associated with the implementation of MTBs, including sequencing costs, molecular analysis, personnel resources, targeted therapies, and other operational expenses, as well as cost-effectiveness in relation to clinical outcomes and standard of care.

Within each domain, we identified themes as recurring conceptual categories and subthemes as more specific components of each theme. The analytical framework and coding process were documented in a comprehensive codebook, which provides definitions and illustrative examples for all domains, themes, and subthemes. The complete codebook is provided in Supplementary File 1.

We developed the framework iteratively. First, we selected one study per domain to generate an initial set of themes and subthemes. We then piloted and refined the framework using an additional study for each domain, adding new themes where necessary. All authors discussed and agreed on the final structure of the analytical framework before completing the full data coding.

Data extraction and coding

We extracted study characteristics (title, first author, year, DOI, country and study design) using a standardized form. To characterize the type and level of evidence supporting the findings, studies were classified into three categories according to the type of evidence provided:

1. Empirical evidence: RCT, non-randomized trial, prospective or retrospective observational studies, surveys, and qualitative empirical research.
2. Evidence synthesis/structured consensus: systematic reviews, guidelines, consensus statements, Delphi, and formal consensus documents.
3. Expert-based/non-empirical evidence: narrative reviews, expert perspectives, technical/methodological development, institutional description, position papers, letters, editorials and commentaries.

Appraisal results were not used to exclude sources or assign numerical weights to individual statements. Instead, the nature of the underlying evidence was retained throughout the synthesis and examined descriptively across the analytical domains.

We then extracted relevant text excerpts describing aspects of MTB implementation. We defined each excerpt as a statement, representing the unit of analysis. Each statement consisted of one or more consecutive sentences referring to a single implementation aspect. When a passage included multiple distinct aspects, we split it into separate statements.

We assigned each statement to a domain, theme, and subtheme

within the predefined analytical framework.

Finally, we classified each statement as either:

- a challenge, if it described any aspect that limits or hinders the implementation of MTBs, including barriers, limitations, critical issues, or gaps in the practice
- a facilitator, if it described any aspect that may facilitate, improve, or enhance the implementation of MTBs, or that represents a potential advantage compared with clinical practice

Statistical analysis

All analyses were performed in R version 4.5.2. We performed descriptive analyses to summarize the characteristics of the included studies and the distribution of extracted statements across the analytical framework. Categorical variables were summarized using frequencies and percentages.

Quantitative economic data were heterogeneous in perspective, costing approach, currency, time horizon, and unit of analysis, and were therefore synthesized descriptively rather than combined into a common cost estimate. Reported measures included costs per molecular test or sample, costs per complete diagnostic pathway, costs attributable specifically to MTB activities, treatment-related costs, and annual budget-impact estimates.

To assess the consistency of the coding process, we evaluated inter-rater reliability between reviewers using Cohen's kappa (κ) with 95% confidence intervals (CIs). Agreement was assessed separately for (1) the categorization of statements within the analytical framework, including their assignment to themes and subthemes, and (2) the classification of statements as challenges or facilitators. Overall, inter-rater agreement was high, with almost perfect agreement for both theme/subtheme classification (κ = 0.89; 95% CI, 0.86–0.92) and challenge/facilitator classification (κ = 0.85; 95% CI, 0.80–0.90) (Supplementary Table 1).

Results

The literature search retrieved 3101 studies. After title and abstract screening, 224 studies were selected for full-text review, and 102 studies [2–8,12–107] were deemed eligible (Fig. 1). An additional four studies were identified through the grey literature search [108–111] and included in the analysis, resulting in a total of 106 included studies. The main reasons for exclusion of the remaining 120 studies were: congress abstracts (n = 56), no implementation aspects considered (n = 26), studies not based in Europe (n = 24), non-English language studies (n = 12), and an incorrect study design (n = 2) (Fig. 1).

Among the studies included, most addressed feasibility (n = 93; 87.7%), followed by equity (n = 50; 47.2%), resource use (n = 47; 44.3%), and acceptability (n = 34; 32.1%) (Fig. 2). Overall, 68 studies (64.2%) covered at least two implementation domains (Supplementary Table 2). Studies were most frequently conducted in Germany (n = 23), Italy (n = 18), and France (n = 11). Six studies were classified as European collaborative efforts, while for 20 studies, a specific country of origin could not be determined. The number of included studies increased over time, from one study published in 2014 to a peak of 24 studies in 2025, with 11 studies published in the first half of 2026 (Supplementary Table 3).

Regarding the type of evidence, more than half of the included sources (n = 57; 53.8%) provided empirical evidence. A further 9 sources (8.5%) were classified as evidence synthesis/structured consensus, whereas 40 sources (37.7%) provided expert-based/non-empirical evidence (Supplementary Table 3). We extracted a total of 466 statements, with facilitators (n = 265; 56.9%) being more frequently reported than challenges (n = 201; 43.1%) (Table 1). Feasibility accounted for the largest proportion of statements (n = 232; 49.8%), followed by equity (n = 99; 21.2%), resource use (n = 89; 19.1%), and acceptability (n = 46; 9.9%). The distribution of statements across domains varied according to the type of evidence (Table 2). Feasibility represented 47.9% of statements from empirical studies, 60.5% from evidence synthesis/structured consensus sources, and

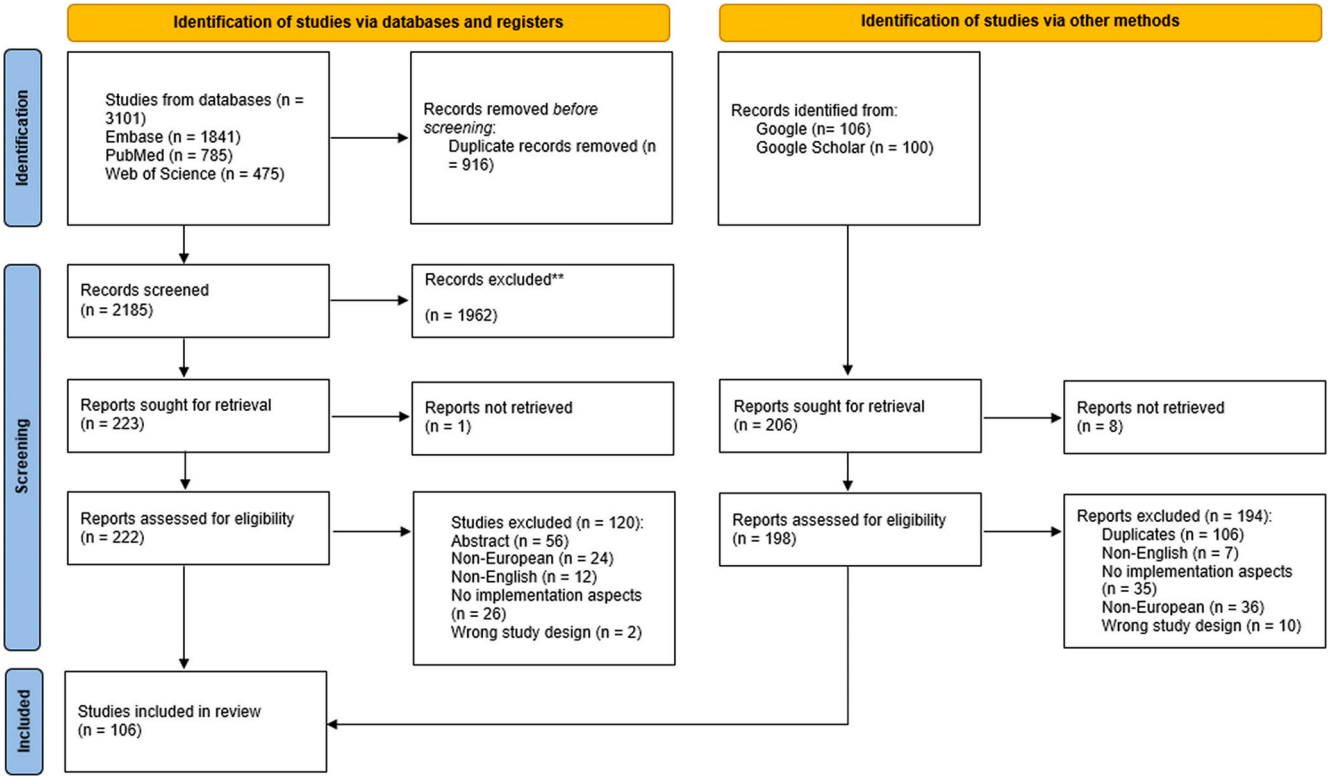


Fig. 1. PRISMA flowchart.

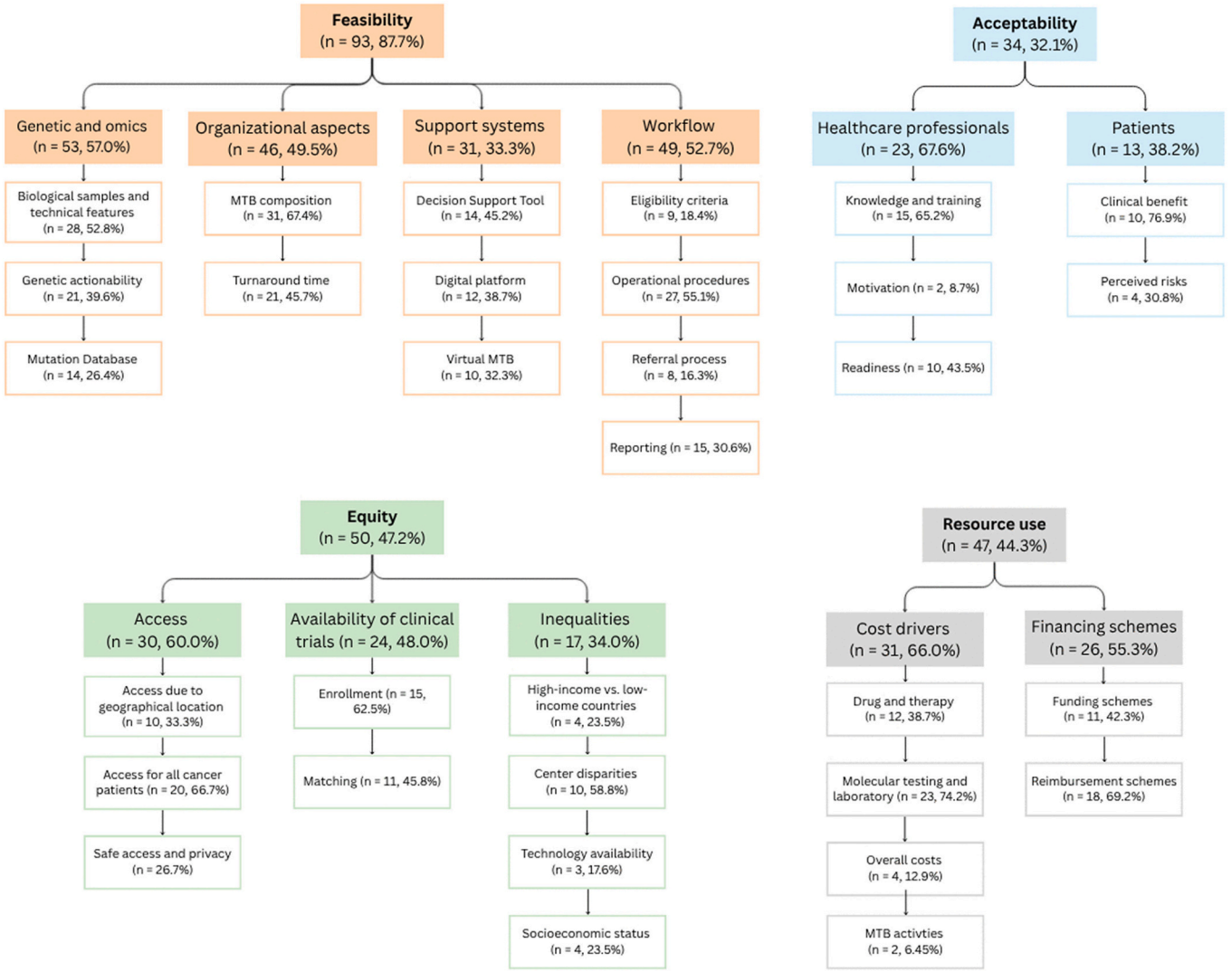


Fig. 2. Distribution of the 106 studies in the four domains. Percentages were calculated hierarchically: domains over the total statements, themes over the corresponding domain total, and subthemes over the corresponding theme total.

50.0% from expert-based/non-empirical sources, whereas acceptability accounted for 9.3%, 2.3%, and 12.8%, respectively. The relative distribution of challenges and facilitators also varied across evidence types and domains, as detailed in Table 2.

Feasibility

Two hundred and thirty-two statements addressed the feasibility of MTBs, which clustered into four main themes: Genetic and omics (29.7%), Organizational aspects (24.6%), Support systems (18.5%), and Workflow of MTBs (27.2%).

Subthemes within Genetic and omics included Biological samples and technical features (46.4%), Genetic actionability (30.4%), and Mutation databases (23.2%). Organizational aspects comprised MTB composition (57.9%) and Turnaround time (42.1%). Support systems included Decision support tools (39.5%), Digital platforms (37.2%), and Virtual MTBs (23.3%). Finally, Workflow encompassed Operational procedures (44.4%), Reporting (25.4%), Eligibility criteria (17.5%), and Referral processes (12.7%).

Challenges

Seventy-two challenges related to the feasibility of MTBs were identified, reflecting the complexity of integrating multidisciplinary expertise, genomic technologies, digital infrastructures, and coordinated workflows into routine clinical practice.

Within Biological samples and technical features, challenges included delays in sample collection and processing, variability in testing approaches, the resource requirements of comprehensive genomic profiling, and the complexity of sequencing and bioinformatics workflows. The large volume and complexity of sequencing data also created challenges for data storage, analysis, and interpretation. Within Genetic actionability, major challenges concerned the interpretation of genomic alterations, including determining their clinical relevance, actionability, and druggability, and translating molecular findings into treatment recommendations. Within Mutation database, challenges included fragmented knowledge resources, limited integration between databases and clinical systems, and difficulties in maintaining standardized and up-to-date variant annotation and evidence.

Challenges related to MTB composition included substantial variability in team structures and the need to ensure appropriate representation of clinical, molecular, bioinformatics, and other specialized expertise. Coordination of multidisciplinary activities and clearly defined responsibilities were also identified as important organizational requirements. Turnaround time emerged as a major challenge, with delays occurring across multiple stages, from sample collection and

Table 1
Characteristics of the 466 statements on the four domains within 106 studies.

Domain/ Themes	Subthemes	Statements n (%)	Challenges n (%)	Facilitators n (%)
Overall		**466**	**201**	**265**
Feasibilty		**232 (49.8)**	**72 (35.8)**	**160 (60.4)**
Genetic and omics	*Overall*	69 (29.7)	25 (34.7)	44 (27.5)
	Genetic actionability	21 (30.4)	8 (32.0)	13 (29.5)
	Biological samples and technical features	32 (46.4)	13 (52.0)	19 (43.2)
	Mutation Database	16 (23.2)	4 (16.0)	12 (27.3)
Organizational aspects	*Overall*	57 (24.6)	23 (31.9)	34 (21.3)
	Turnaround time	24 (42.1)	13 (56.5)	11 (32.4)
	MTB composition	33 (57.9)	10 (43.5)	23 (67.6)
Support systems	*Overall*	43 (18.5)	9 (12.5)	34 (21.3)
	Virtual MTB	10 (23.3)	1 (11.1)	9 (26.5)
	Digital platform	16 (37.2)	7 (77.8)	9 (26.5)
	Decision Support Tool	17 (39.5)	1 (11.1)	16 (47.1)
Workflow	*Overall*	63 (27.2)	15 (20.8)	48 (30.0)
	Eligibility criteria	11 (17.5)	3 (20.0)	8 (16.7)
	Operational procedure	28 (44.4)	6 (40.0)	22 (45.8)
	Reporting	16 (25.4)	4 (26.7)	12 (25.0)
	Referral process	8 (12.7)	2 (13.3)	6 (12.5)
Acceptability		**46 (9.9)**	**24 (11.9)**	**22 (8.3)**
Healthcare professionals	*Overall*	30 (65.2)	15 (62.5)	15 (68.2)
	Knowledge and training	16 (53.3)	7 (46.7)	9 (60.0)
	Motivation	2 (6.7)	2 (13.3)	–
	Readiness	12 (40.0)	6 (40.0)	6 (40.0)
Patients	*Overall*	16 (34.8)	9 (37.5)	7 (31.8)
	Clinical benefit	11 (68.8)	7 (77.8)	4 (57.1)
	Perceived risks	5 (31.2)	2 (22.2)	3 (42.9)
Equity		**99 (21.2)**	**51 (25.4)**	**48 (18.1)**
Access	*Overall*	38 (38.4)	12 (23.5)	26 (54.2)
	Access due to geographical location	12 (31.6)	3 (25.0)	9 (34.6)
	Access for all cancer patients	19 (50.0)	7 (58.3)	12 (46.2)
	Safe access and privacy	7 (18.4)	2 (16.7)	5 (19.2)
Availability of clinical trials	*Overall*	37 (37.4)	20 (39.2)	17 (35.4)
	Matching	15 (40.5)	4 (20.0)	11 (64.7)
	Enrollment	22 (59.5)	16 (80.0)	6 (35.3)
Inequalities	*Overall*	24 (24.2)	19 (37.3)	5 (10.4)
	High-income vs low-income countries	5 (20.8)	4 (21.1)	1 (20.0)
	Center disparities	11 (45.8)	7 (36.8)	4 (80.0)
	Technology availability	4 (16.7)	4 (21.1)	–
	Socioeconomic status	4 (16.7)	4 (21.1)	–
Resource use		**89 (19.1)**	**54 (26.9)**	**35 (13.2)**
Cost drivers	*Overall*	57 (64.0)	37 (68.5)	20 (57.1)
	Molecular testing and laboratory	31 (54.4)	19 (51.4)	12 (60.0)
	Overall costs	4 (7.0)	–	4 (20.0)
	Drug and therapy	19 (33.3)	18 (48.6)	1 (5.0)
	MTB activities	3 (5.3)	–	3 (15.0)
Financing Schemes	*Overall*	32 (36.0)	17 (31.5)	15 (42.9)
	Reimbursement schemes	19 (59.4)	11 (64.7)	8 (53.3)
	Funding schemes	13 (40.6)	6 (35.3)	7 (46.7)

Percentages were calculated hierarchically: domains over total statements, themes over the corresponding domain total, and subthemes over the corresponding theme total. Challenges and facilitators percentages were calculated using the respective column totals as denominators.

molecular testing to bioinformatics analysis, report generation, and MTB discussion. Reported turnaround times varied substantially across studies and could extend to several weeks, potentially affecting timely treatment decisions.

Within Digital platform, challenges included fragmented data sources, limited interoperability between clinical and molecular systems, manual data transfer, and difficulties integrating clinical, molecular, and trial information. The absence or limited availability of structured databases for MTB cases and outcomes further constrained data management and cross-institutional collaboration. Decision Support Tools faced challenges related to the complexity of genomic data interpretation and the need for computational support. For Virtual MTBs, challenges included the need to coordinate remote participation and maintain standardized processes across institutions.

Challenges within Eligibility criteria concerned heterogeneous and sometimes restrictive criteria for MTB referral and patient selection, including the prioritization of patients with advanced disease or limited therapeutic options. Within Operational procedure, challenges included complex and non-standardized workflows, limited time available for individual case discussion, and difficulties in coordinating molecular testing, clinical information, and MTB review. Referral process challenges included inconsistent referral pathways and the absence of standardized systems in some settings. Finally, Reporting challenges included heterogeneous report formats, variable annotation responsibilities, limited visualization of molecular findings, and incomplete systematic follow-up of MTB recommendations and patient outcomes.

Facilitators

One hundred and sixty facilitators were identified, representing strategies to address these challenges, focusing on streamlining processes, optimizing resources, and enhancing multidisciplinary coordination.

Within the Genetics and omics theme, proposed facilitators for Biological samples and technical features included centralizing extended sequencing in high-volume laboratories, tailoring sequencing approaches to clinical needs, and integrating molecular profiling into routine care. Within Genetic actionability, standardized frameworks such as ESCAT and OncoKB and multidisciplinary interpretation supported the assessment of genomic alterations and treatment recommendations. Facilitators within Mutation database included curated knowledge bases, integration of multiple data sources, and automated tools for variant interpretation and identification of therapeutic options.

MTB composition facilitators emphasized defining a core multidisciplinary team with clearly defined expertise and responsibilities. Within Turnaround time, facilitators focused on regular MTB meetings, standardized workflows, and automation to ensure timely molecular assessment, reporting, and treatment recommendations.

For Digital platform, facilitators included interoperable platforms integrating clinical and molecular data and supporting data sharing and follow-up. Decision Support Tools included AI- and machine learning-based approaches to support genomic interpretation, treatment matching, and clinical trial identification. For Virtual MTBs, cloud-based and hybrid formats were identified as approaches to facilitate remote participation and collaboration.

Facilitators within Eligibility criteria included clearer selection criteria and earlier patient referral. Within Operational procedure, standardized workflows, regular meetings, and improved coordination across molecular analysis and clinical assessment supported efficient case management. Referral process facilitators included structured case submission and broader involvement of referring clinicians. Within Reporting, standardized report content and structured documentation of molecular findings and outcomes supported communication, follow-up, and evaluation of MTB recommendations.

Table 2
Characteristics of the 466 statements across the four domains, stratified by type of evidence, from 106 included studies.

	Empirical evidence			Evidence synthesis/structured consensus			Expert-based/non-empirical evidence		
Domain/Themes	**Statements n (%)**	**Challenges n (%)**	**Facilitators n (%)**	**Statements n (%)**	**Challenges n (%)**	**Facilitators n (%)**	**Statements n (%)**	**Challenges n (%)**	**Facilitators n (%)**
Overall	**259**	**110**	**149**	**43**	**15**	**28**	**164**	**76**	**88**
Feasibility	**124 (47.9)**	**35 (31.8)**	**89 (59.7)**	**26 (60.5)**	**11 (73.3)**	**15 (53.6)**	**82 (50.0)**	**26 (34.2)**	**56 (63.6)**
Support systems	**23 (18.5)**	**5 (14.3)**	**18 (20.2)**	**8 (30.8)**	**5 (45.5)**	**3 (20.0)**	**15 (18.3)**	**3 (11.5)**	**12 (21.4)**
Decision Support Tool	10 (43.5)	1 (20.0)	9 (50.0)	2 (25.0)	–	2 (66.7)	6 (40.0)	–	6 (50.0)
Digital platform	9 (39.1)	3 (60.0)	6 (33.3)	6 (75.0)	5 (100.0)	1 (33.3)	4 (26.7)	3 (100.0)	1 (8.3)
Virtual MTB	4 (17.4)	1 (20.0)	3 (16.7)	7 (26.9)	3 (27.3)	4 (26.7)	5 (33.3)	–	5 (41.7)
Workflow	**40 (32.3)**	**9 (25.7)**	**31 (34.8)**	**6 (23.1)**	**2 (18.2)**	**4 (26.7)**	**17 (20.7)**	**4 (15.4)**	**13 (23.2)**
Operational procedure	20 (50.0)	4 (44.4)	16 (51.6)	1 (16.7)	–	1 (25.0)	7 (41.2)	2 (50.0)	5 (38.5)
Referral process	5 (12.5)	1 (11.1)	4 (12.9)	1 (16.7)	1 (50.0)	–	2 (11.8)	–	2 (15.4)
Eligibility criteria	6 (15.0)	1 (11.1)	5 (16.1)	2 (33.3)	1 (50.0)	1 (25.0)	3 (17.6)	1 (25.0)	2 (15.4)
Reporting	9 (22.5)	3 (33.3)	6 (19.4)	2 (33.3)	–	2 (50.0)	5 (29.4)	1 (25.0)	4 (30.8)
Organizational aspects	**26 (21.0)**	**10 (28.6)**	**16 (18.0)**	**8 (30.8)**	**5 (45.5)**	**3 (20.0)**	**23 (28.0)**	**8 (30.8)**	**15 (26.8)**
MTB composition	16 (61.5)	4 (40.0)	12 (75.0)	6 (75.0)	5 (100.0)	1 (33.3)	11 (47.8)	1 (12.5)	10 (66.7)
Turnaround time	10 (38.5)	6 (60.0)	4 (25.0)	2 (25.0)	–	2 (66.7)	12 (52.2)	7 (87.5)	5 (33.3)
Genetic and omics	**35 (28.2)**	**11 (31.4)**	**24 (27.0)**	**7 (26.9)**	**3 (27.3)**	**4 (26.7)**	**27 (32.9)**	**11 (42.3)**	**16 (28.6)**
Genetic actionability	10 (28.6)	2 (18.2)	8 (33.3)	3 (42.9)	2 (66.7)	1 (25.0)	8 (29.6)	4 (36.4)	4 (25.0)
Mutation Database	10 (28.6)	3 (27.3)	7 (29.2)	–	–	–	6 (22.2)	1 (9.1)	5 (31.2)
Biological samples and technical features	15 (42.9)	6 (54.5)	9 (37.5)	4 (57.1)	1 (33.3)	3 (75.0)	13 (48.1)	6 (54.5)	7 (43.8)
Acceptability	**24 (9.3)**	**11 (10.0)**	**13 (8.7)**	**1 (2.3)**	**–**	**1 (3.6)**	**21 (12.8)**	**13 (17.1)**	**8 (9.1)**
Healthcare professionals	**17 (70.8)**	**8 (72.7)**	**9 (69.2)**	**1 (100.0)**	**–**	**1 (100.0)**	**12 (57.1)**	**7 (53.8)**	**5 (62.5)**
Knowledge and training	8 (47.1)	4 (50.0)	4 (44.4)	1 (100.0)	–	1 (100.0)	7 (58.3)	3 (42.9)	4 (80.0)
Motivation	1 (5.9)	1 (12.5)	–	–	–	–	1 (8.3)	1 (14.3)	–
Readiness	8 (47.1)	3 (37.5)	5 (55.6)	–	–	–	4 (33.3)	3 (42.9)	1 (20.0)
Patients	**7 (29.2)**	**3 (27.3)**	**4 (30.8)**	–	–	–	**9 (42.9)**	**6 (46.2)**	**3 (37.5)**
Clinical benefit	6 (85.7)	3 (100.0)	3 (75.0)	–	–	–	5 (55.6)	4 (66.7)	1 (33.3)
Perceived risks	1 (14.3)	–	1 (25.0)	–	–	–	4 (44.4)	2 (33.3)	2 (66.7)
Equity	**56 (21.6)**	**28 (25.5)**	**28 (18.8)**	**11 (25.6)**	**2 (13.3)**	**9 (32.1)**	**32 (19.5)**	**21 (27.6)**	**11 (12.5)**
Access	**22 (39.3)**	**5 (17.9)**	**17 (60.7)**	**7 (63.6)**	**2 (100.0)**	**5 (55.6)**	**9 (28.1)**	**5 (23.8)**	**4 (36.4)**
Access due to geographical location	7 (31.8)	2 (40.0)	5 (29.4)	2 (28.6)	–	2 (40.0)	3 (33.3)	1 (20.0)	2 (50.0)
Access for all cancer patients	12 (54.5)	3 (60.0)	9 (52.9)	3 (42.9)	2 (100.0)	1 (20.0)	4 (44.4)	2 (40.0)	2 (50.0)
Safe access and privacy	3 (13.6)	–	3 (17.6)	2 (28.6)	–	2 (40.0)	2 (22.2)	2 (40.0)	–
Availability of clinical trials	**20 (35.7)**	**11 (39.3)**	**9 (32.1)**	**3 (27.3)**	**–**	**3 (33.3)**	**14 (43.8)**	**9 (42.9)**	**5 (45.5)**
Matching	9 (45.0)	3 (27.3)	6 (66.7)	2 (66.7)	–	2 (66.7)	4 (28.6)	1 (11.1)	3 (60.0)
Enrollment	11 (55.0)	8 (72.7)	3 (33.3)	1 (33.3)	–	1 (33.3)	10 (71.4)	8 (88.9)	2 (40.0)
Inequalities	**14 (25.0)**	**12 (42.9)**	**2 (7.1)**	**1 (9.1)**	**–**	**1 (11.1)**	**9 (28.1)**	**7 (33.3)**	**2 (18.2)**
Technology availability	4 (28.6)	4 (33.3)	–	–	–	–	–	–	–
High-income vs low-income countries	2 (14.3)	2 (16.7)	–	–	–	–	3 (33.3)	2 (28.6)	1 (50.0)
Center disparities	7 (50.0)	5 (41.7)	2 (100.0)	1 (100.0)	–	1 (100.0)	3 (33.3)	2 (28.6)	1 (50.0)
Socioeconomic status	1 (7.1)	1 (8.3)	–	–	–	–	3 (33.3)	3 (42.9)	–
Resource use	**55 (21.2)**	**36 (32.7)**	**19 (12.8)**	**5 (11.6)**	**2 (13.3)**	**3 (10.7)**	**29 (17.7)**	**16 (21.1)**	**13 (14.8)**
Cost drivers	**35 (63.6)**	**22 (61.1)**	**13 (68.4)**	**2 (40.0)**	**2 (100.0)**	**–**	**20 (69.0)**	**13 (81.2)**	**7 (53.8)**
Molecular testing and laboratory	18 (51.4)	11 (50.0)	7 (53.8)	1 (50.0)	1 (50.0)	–	12 (60.0)	7 (53.8)	5 (71.4)
Overall costs	4 (11.4)	–	4 (30.8)	–	–	–	–	–	–
Drug and therapy	12 (34.3)	11 (50.0)	1 (7.7)	1 (50.0)	1 (50.0)	–	6 (30.0)	6 (46.2)	–
MTB activities	1 (2.9)	–	1 (7.7)	–	–	–	2 (10.0)	–	2 (28.6)
Financing schemes	**20 (36.4)**	**14 (38.9)**	**6 (31.6)**	**3 (60.0)**	**–**	**3 (100.0)**	**9 (31.0)**	**3 (18.8)**	**6 (46.2)**
Funding schemes	8 (40.0)	6 (42.9)	2 (33.3)	1 (33.3)	–	1 (33.3)	4 (44.4)	–	4 (66.7)
Reimbursement schemes	12 (60.0)	8 (57.1)	4 (66.7)	2 (66.7)	–	2 (66.7)	5 (55.6)	3 (100.0)	2 (33.3)

Percentages were calculated hierarchically within each evidence type: domains over the total statements for that evidence type, themes over the corresponding domain total, and subthemes over the corresponding theme total. Challenges and facilitators percentages were calculated using the respective column totals within each evidence type as denominators.

Acceptability

Forty-six statements addressed the acceptability of MTBs, which clustered into two main themes: Healthcare Professionals (65.2%) and Patients (34.8%). Subthemes for Healthcare professionals included Knowledge and Training (53.3%), Motivation (6.7%), and Readiness (40.0%). Patient-related subthemes were Clinical Benefit (68.8%) and Perceived Risks (31.2%).

Challenges

Twenty-four challenges related to acceptability were identified. Within the Patients theme, challenges in the Clinical benefit subtheme concerned uncertainty regarding the clinical utility of genomic testing, the risk of clinical deterioration while awaiting genomic results, and the potential for false expectations when molecularly guided treatments may not be available. Challenges within Perceived risks included limited patient understanding of genomic testing and results, as well as concerns about anxiety, stress, family and social relationships, stigmatization, and potential effects on employability or insurability.

Among Healthcare professionals, challenges were primarily related to Readiness, including limited confidence in interpreting genomic information, reluctance to adopt precision oncology approaches, and uncertainty regarding the role of MTBs and digital decision-support tools. Knowledge and training challenges included insufficient genomic knowledge, limited familiarity with NGS panels, and the need for specialized training in molecular diagnostics and interpretation. Finally, Motivation challenges concerned limited willingness to refer patients to MTBs and to incorporate routine genomic testing into clinical workflows, particularly when its clinical utility remained uncertain.

Facilitators

Twenty-two facilitators related to acceptability were identified, predominantly within the Healthcare professionals theme. Facilitators within Knowledge and training included structured education and training programs, continuous interdisciplinary knowledge exchange, and opportunities for clinicians to improve their understanding and confidence in interpreting genomic data. Within Readiness, facilitators included the educational role of MTBs, support from digital decision-support tools, administrative support, and clinicians' increasing confidence in adopting new molecular technologies and incorporating their results into clinical decision-making.

Among Patients, facilitators within Clinical benefit included early referral to MTBs to expand personalized treatment options, facilitate clinical trial enrollment, and improve clinical outcomes. Within Perceived risks, clear communication, informed consent procedures, and transparent discussion of the potential and limitations of genomic testing were identified as strategies to improve patient understanding, autonomy, and trust.

Equity

Ninety-nine statements addressed equity in MTBs. Three main themes emerged: Access (38.4%), Availability Clinical Trial (37.4%), and Inequalities (24.2%). Within Access, the subthemes were Access for all patients (50.0%), Access due to geographical location (31.6%), and Safe access and privacy (18.4%). Within Availability of clinical trials, the subthemes were Enrollment (59.5%) and Matching (40.5%). Inequalities included Center disparities (45.8%), Socioeconomic status (16.7%), High-income vs low-income countries (20.8%), and Technology availability (16.7%).

Challenges

Fifty-one challenges related to equity were identified, including 12 within the Access theme. Key challenges concerned geographical barriers, logistical constraints, and the concentration of molecular expertise and specialized services in selected centers, which may limit access for patients treated in peripheral or underserved settings. Additional challenges related to the selection of patients for MTB evaluation, including restrictive eligibility criteria and the underrepresentation of certain patient groups, as well as concerns regarding privacy and data protection.

Within Availability of clinical trials, challenges primarily concerned limited enrollment despite the identification of potentially eligible patients. Barriers included stringent eligibility criteria, patients' clinical deterioration, geographical distance from trial sites, financial and social constraints, limited availability of suitable trials, and difficulties accessing up-to-date trial information. Challenges were also identified in clinical trial matching, including incomplete or inaccurate matching results and the need for expert review of automated tools.

Within Inequalities, challenges reflected disparities in access to precision oncology across countries, healthcare centers, and socioeconomic groups. Limited availability of molecular technologies and diagnostic tools was particularly evident in low- and middle-income countries, where access to advanced techniques such as comprehensive NGS panels, WES, WGS, RNA sequencing, and liquid biopsy remained restricted. Center-level disparities were also related to the concentration of expertise and advanced diagnostic infrastructure in academic or specialized centers and the lack of standardized MTB and bioinformatics processes across institutions. Socioeconomic disparities further affected access to molecular testing, clinical trials, and molecularly guided treatments, particularly when treatment costs were not reimbursed.

Facilitators

Forty-eight facilitators related to equity were identified, including 26 within the Access theme. Facilitators addressing geographical access included virtual and multi-institutional MTBs, hub-and-spoke models, centralized molecular diagnostics, regional networks, and collaboration between community and academic centers. Facilitators related to access for all cancer patients included comprehensive molecular testing, nationwide or regional initiatives, and networks designed to extend access to expert molecular decision-making across institutions and geographical areas. Within Safe access and privacy, recommendations included strengthening informed consent procedures, ensuring appropriate data access controls, and developing regulatory frameworks to support secure data sharing and cross-border case discussions.

Within Availability of clinical trials, facilitators focused primarily on Matching and Enrollment. Trial-matching platforms and curated, regularly updated trial databases were identified as tools to improve the identification of relevant clinical trials and reduce disparities in trial access. MTBs were also described as a means of identifying clinical trial opportunities, supporting enrollment, and highlighting gaps in available trials. Finally, facilitators addressing Inequalities included collaboration between smaller hospitals and comprehensive cancer centers, local leadership, and strategies to improve access to precision oncology in rural, underserved, and resource-limited settings.

Resource use

Eighty-nine statements addressed resource use in MTBs. Two main themes emerged: Cost Drivers (64.0%) and Financing Schemes (36.0%). Within Cost Drivers, the subthemes included Molecular testing and laboratory (54.4%), Drugs and therapy (33.3%), Overall costs (7.0%) and MTB activities (5.3%). Regarding Financing Schemes, the subthemes included Reimbursement schemes (59.4%) and Funding schemes (40.6%).

Challenges

Fifty-four challenges were identified, mostly within the Cost Drivers theme, with half in the drug and therapy subtheme and half in the molecular testing and laboratory subtheme. A minority were related to the Financing Schemes theme, mainly within the reimbursement schemes subtheme than the funding schemes subtheme.

Within Drug and therapy, the main challenges concerned the high costs of targeted and off-label therapies, as well as hospitalization costs. An Italian budget-impact modeling study projected annual expenditure of €29.9 million for NGS testing and €22.3 million for off-label treatments, corresponding to an overall annual budget of €52.2 million [34]. In a prospective French micro-costing study, a complete molecular diagnosis, including the pathway from biopsy to molecular tumor board discussion, cost €2396 per patient and represented approximately 6% of the total cost of molecularly guided therapy. The latter amounted to €31,269 per patient and was driven primarily by anticancer drugs (54%) and hospitalizations (35%) [44]. In an Italian real-world analysis, the complete diagnostic journey ranged from €3239 to €7357 per patient depending on cancer type and testing strategy, while the MTB evaluation itself cost €113–118 per patient and accounted for only 2–3% of the diagnostic pathway [7].

Laboratory micro-costing also highlighted the importance of personnel and consumables. A Norwegian analysis estimated genomic profiling costs at $2944 per sample, with personnel and consumables accounting for 35% and 34% of the total cost, respectively [98]. Other European studies reporting prices or modelled costs are available in Supplementary Table 4. These estimates were not directly compared because they referred to different technologies, cost constructs, healthcare settings, and denominators.

Overall, the available evidence suggests that the direct

organizational cost of MTB activities represents a relatively small proportion of total expenditure, whereas genomic testing, laboratory personnel and consumables, anticancer drugs, and hospitalizations constitute the principal cost drivers.

Within Molecular testing and laboratory, challenges mainly concerned the economic sustainability of genomic testing, particularly in low-volume settings, where equipment, consumables, maintenance, personnel, data processing, and interpretation contribute substantially to costs. The increasing costs associated with comprehensive genomic approaches, including WES and WGS, and the need to adapt to rapidly evolving technologies were also highlighted. Challenges related to Financing schemes included limited or uncertain reimbursement for molecular testing, MTB activities, and MTB-recommended treatments, particularly off-label therapies, as well as difficulties securing stable institutional or national funding for MTB implementation.

Facilitators

Thirty-five facilitators were identified. Within Cost drivers, facilitators included strategies to reduce molecular testing and laboratory costs, such as the use of comprehensive NGS panels, optimization of sequencing workflows, and declining sequencing costs. Several studies reported that molecular diagnostics and MTB activities accounted for only a small proportion of overall diagnostic or healthcare costs, suggesting a limited financial impact of MTBs. Monitoring out-of-pocket costs was also identified as a strategy to mitigate financial toxicity related to treatment.

Within Financing schemes, facilitators related to Reimbursement schemes included national health system and private insurance coverage of molecular testing and MTB activities, supported by standardized patient pathways, referral criteria, diagnostic quality requirements, and monitoring of clinical outcomes. Funding schemes included dedicated national initiatives, public healthcare coverage, research funding, and collaborative funding models involving healthcare institutions and pharmaceutical companies.

Discussion

This scoping review provides a structured overview of the key challenges and facilitators affecting the implementation of MTBs across European healthcare systems. The feasibility domain was the most frequently addressed, reflecting the strong emphasis of the existing literature on the operationalization of MTBs and the identification of enabling factors to support their integration. Equity and resource use were also addressed in a substantial proportion of studies, highlighting persistent disparities in access to MTB evaluation and clinical trials, as well as important challenges related to the costs and financing of genomic testing and molecularly guided treatments. In contrast, acceptability was the least frequently investigated domain, suggesting that the perspectives, preparedness, and experiences of patients and healthcare professionals remain comparatively underexplored. Overall, the current evidence appears unbalanced, prioritizing technical and organizational aspects while overlooking the perspectives and experiences of those involved in the delivery and use of genomic medicine, which are critical to its comprehensive implementation.

These findings reflect broader trends in the MTB literature, which predominantly emphasizes their scientific value, particularly in interpreting complex genomic data and supporting targeted therapies [2], while paying less attention to systemic, organizational, and social dimensions [112]. This imbalance suggests that, despite increasing adoption, MTB integration remains only partially explored.

Recently, oncology societies have attempted to address this gap by proposing guidelines and consensus statements to standardize MTBs [4,12]. In parallel, the CAN.HEAL project, within which the present review was conducted, aimed to develop operational criteria for MTBs and subsequently produced consensus-based recommendations for their implementation [16,113]. However, effective implementation also depends on the readiness of both healthcare systems and the professionals working within them [114].

Our review highlights persistent gaps in knowledge and expertise that need to be addressed structurally. As also observed in the early development of precision oncology, MTBs, which represents a further evolution of this field, require time for the acquisition of competencies, increased familiarity, and eventual integration into routine clinical practice [115,116]. Patient-related acceptability also deserves greater attention. Concerns identified in the literature included uncertainty regarding the clinical benefit of genomic testing, the risk of generating false expectations, and the potential psychological and social implications of genomic information. Clear communication, transparent discussion of the benefits and limitations of testing, and appropriate informed-consent processes therefore represent important components of MTB implementation. Financial sustainability remains a major barrier. While the intrinsic activities of MTBs (e.g., meetings, production of recommendations) involve relatively limited costs and represent only a small proportion of overall expenditure, expenses related to therapies, hospitalizations, and genomic sequencing are substantial and continue to constrain scalability [7,14].

Sustainable implementation therefore depends not only on reducing the costs of molecular diagnostics through optimized workflows and increasing testing volumes, but also on establishing stable reimbursement pathways and dedicated funding mechanisms. National initiatives, public healthcare coverage, and collaborative funding models involving healthcare institutions and industry were identified as potential facilitators. However, these measures require coherent policies capable of reducing the fragmentation of current financing and reimbursement arrangements.

Addressing these challenges is essential, as without sustainable financing models, large-scale implementation of MTBs is unlikely. Potential facilitators include increasing sequencing volumes to reduce unit costs, fostering public–private partnerships, and integrating MTBs within national networks. However, these measures must be supported by coherent policies that harmonize currently fragmented financing schemes.

Some countries have already taken steps in this direction. In the Czech Republic, MTB-recommended therapies are routinely reimbursed by insurance providers [20]. In Germany, the German Network for Personalized Medicine (DNPM) integrates diagnostics, MTB procedures, and access to drugs under a unified reimbursement framework [117]. In France, the French Genomic Medicine initiative (PFMG2025) has allocated €239 million since 2016 to support precision medicine, including MTBs [118]. Among EU countries, Italy has recently implemented a structured approach. In the 2023 update of the Essential Levels of Care (Livelli Essenziali di Assistenza, LEA), which define the mandatory health services that must be provided to all citizens, the Italian government formally embedded MTBs within regional oncology networks, introduced specific public funding for NGS testing, and linked the prescription of advanced genomic panels to MTB decision-making [119,120].

Equity remains another critical issue. Disparities concerned not only geographical access to MTB expertise, but also access to molecular technologies and clinical trials, with differences across healthcare centers, socioeconomic groups, and healthcare systems with different levels of resources [55].

In this context, alternative organizational models can facilitate MTB participation, including hub-and-spoke networks, centralized molecular diagnostics or virtual MTBs that represent a promising strategy to reduce geographic and social barriers. Virtual MTBs can, indeed, alleviate organizational burdens, while enabling participation from peripheral centers and remote clinicians [77]. However, their implementation requires robust infrastructures for secure data exchange and coordinated workflows [121]. Clinical trial availability also represented a particularly important component, as barriers persisted both in identifying

appropriate trials and in translating potential eligibility into actual enrolment. Digital trial-matching platforms were identified as possible facilitators in enabling access, although their effectiveness depends on accurate and up-to-date information and continued expert oversight.

These challenges are not unique to Europe. Globally, MTB implementation remains heterogeneous and often fragmented. Many Asian countries rely on center-based programs (e.g., Hong Kong [122], South Korea [123]) or no MTB program at all (lower-middle-income countries) [124]. Japan represents a notable exception due to its centralized precision oncology system, mandatory MTB review for reimbursed comprehensive genomic profiling (CGP), and the establishment of a national data repository (C-CAT) [125]. Similarly, in the United States, MTBs are primarily concentrated in academic centers, with significant disparities in access and coverage [126].

The nature of the available evidence should also be considered when interpreting these findings. Although more than half of the included sources provided empirical evidence, a substantial proportion consisted of expert-based or non-empirical publications. Therefore, the recurrence of a challenge or facilitator across the literature should be interpreted as an indication of how frequently that issue has been reported, rather than as a measure of the strength or certainty of the evidence supporting its effect on implementation.

Within this evolving landscape, our review highlights that successful MTB integration depends on addressing multiple, interrelated domains. Focusing solely on clinical effectiveness is insufficient; sustainable implementation requires coordinated action across organizational, economic, and social dimensions. Without such a comprehensive approach, the expansion of precision oncology risks reinforcing existing inequalities rather than reducing them.

Limitations

This study has several limitations. First, the search was limited to English-language studies, which may have resulted in the omission of relevant studies. Although grey literature searches were conducted to broaden the evidence base, relevant unpublished or non-indexed sources may still have been missed. Second, most included studies focused on Western and Northern Europe, with limited representation from Central and Eastern European countries, which may have led to an underestimation of regional disparities and limited the generalizability of the findings to the whole European context. Third, the included literature was heterogeneous in study design and type of evidence, ranging from empirical studies to consensus documents and expert-based publications. Although the nature of the underlying evidence was retained throughout the synthesis, we did not apply a common quality score or weight individual statements according to methodological quality or strength of evidence, as such an approach would not have been appropriate across methodologically diverse sources. Consequently, the frequency with which a challenge or facilitator was reported should be interpreted as an indication of how often an implementation issue was identified in the literature, rather than as a measure of its relative importance, effectiveness, or strength of supporting evidence. Finally, although inter-rater agreement was high, the thematic coding and narrative synthesis approach, while appropriate for a scoping review, inevitably involved a degree of reviewer interpretation and may therefore be subject to some degree of subjectivity.

Despite these limitations, this review provides a foundation for future empirical and policy-oriented research, supporting the development of more balanced, sustainable, and equitable models for MTB implementation.

Conclusions

Our review highlights multiple and interconnected challenges reported in the available European literature on MTB implementation. To address these challenges, a coordinated effort to strengthen organizational infrastructures, harmonize reimbursement schemes, invest in digital interoperability, and enhance professional education and patient engagement is required. Integrating these dimensions will be crucial to achieve effective and equitable implementation of MTBs, supporting more effective and equitable access to precision-oncology services across different European healthcare settings.

CRediT authorship contribution statement

NL: Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing - review and editing. EG: Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing - original draft, Writing - review and editing. LR: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing - original draft, Writing - review and editing. AS: Data curation, Validation, Visualization, Writing - original draft, Writing - review and editing. SB: Conceptualization, Funding acquisition, Methodology, Validation, Supervision, Writing - review and editing. RP: Conceptualization, Formal analysis, Methodology, Validation, Supervision, Writing - review and editing.

Patient and public involvement

Patients and the public were not directly involved in the design, conduct, or reporting of this scoping review. As this study synthesized existing published evidence and did not involve primary data collection from participants, no recruitment or intervention burden was relevant.

Consent for publication

Not applicable.

Ethics declaration

The authors have NOT obtained informed consent from participants or their legal representatives. Patients and the public were not directly involved in the design, conduct, or reporting of this scoping review. As this study synthesized existing published evidence and did not involve primary data collection from participants, no recruitment or intervention burden was relevant.

This study was performed in compliance with relevant laws, regulatory frameworks and guidelines where the research took place.

Human Ethics and Consent to Participate declarations

Ethics committee approval was not required under relevant laws and institutional guidelines. Not applicable. This study is a scoping review based on previously published data and does not involve human participants directly.

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Objectives of the CAN.HEAL project include supporting the implementation of genomics and precision oncology in European healthcare systems, including MTBs. Some of the authors are members of the CAN.HEAL consortium and received funding from the project. The consortium and the funding body had no role in study selection, data extraction, coding decisions, the choice of the analytical domains, the

interpretation of individual sources, the decision to publish, or the preparation of the manuscript.

Data and code availability

The codebook used for the thematic analysis is available as Supplementary File 1. Additional data will be made available upon reasonable request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ctrv.2026.103221.

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