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Principles and Workflow of Biobanking: A Practical Guide for Pathologists

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Abstract

Biobanking has become an integral part of modern biomedical research, yet many pathologists and other scientists remain unfamiliar with its practical principles and daily workflow. Given their central role in specimen handling, quality control, and patient data retrieval, pathologists are naturally positioned to engage with biobanking, although the discipline is often perceived as distant from routine clinical practice. This guide provides a structured, practical overview of biobanking as practiced across Europe, intended to familiarize pathologists and other scientists with its fundamental steps. It begins with the ethical and legal framework underlying biobank operations. Then, it describes the interfaces between biobanks and providing institutions, before detailing the sample workflow and documentation requirements for fluid specimens, fresh frozen tissue, and formalin-fixed paraffin-embedded tissue, as tracked through a Biobank Information Management System. Subsequent sections address the linkage between biological samples and clinical data, storage conditions specific to each sample type, and the structured access policy overseen by a Use and Access Committee. The guide further outlines the documentation required for sample and data provision, the mechanisms for acknowledging biobank contributions and tracking research impact, and the financial considerations underlying long-term biobank sustainability. By consolidating these principles into a single, accessible resource, this guide aims to lower the barrier of entry into biobanking for pathologists and other scientists approaching the field for the first time, and to support their active participation in a process central to translational and precision medicine research.

Introduction

Over the past decade, pathologists have moved increasingly beyond diagnostic microscopy into molecular biology and more demanding basic research. This shift has placed them at the center of the biobanking process, where they handle and prepare specimens, retrieve patient and tumor characteristics, and oversee several of the quality control steps that determine whether a sample is fit for future use (Annaratone et al. 2021; Hewitt 2011).

Biobanking, however, still feels distant and abstract to many clinicians and scientists, more a repository or paperwork exercise than part of daily practice. In reality, it has become a cornerstone of modern research and innovation (Annaratone et al. 2021; Hewitt 2011). According to ISO 20387:2018, a biobank is defined as a legal entity performing acquisition, collection, preparation, preservation, testing, analysis and distribution of biological material and associated data (ISO 2018). Across Europe, a growing number of countries already operate active biobanks, many of which participate in larger infrastructures such as the Biobanking and BioMolecular Resources Research Infrastructure - European Research Infrastructure Consortium (BBMRI-ERIC) (BBMRI-ERIC, n.d.).

This guide serves as a practical introduction for pathologists and other scientists to the basic steps and principles of biobanking: its workflow, costs, infrastructure, and the roles of those involved, together with

the specimens handled, their storage environment, and the quality control requirements that govern every step under standardized practices.

Ethical Framework - Data Protection

There are ethical and legal rules that must be followed to ensure that both the donors and their data are properly protected throughout the biobanking process. These rules can be grouped into four broad categories: informed consent, ethical governance, data protection, and ethical, legal and social issues.

Regarding informed consent, the procurement of human tissues or cells is authorized only after all mandatory consent requirements have been met (European Parliament and Council 2004; Mendy et al. 2017). Information must be provided to potential donors through a participant information sheet and consent form (European Commission 2019; European Parliament and Council 2004; Mendy et al. 2017). The recognized consent types include a consent waiver, opt-out, specific (opt-in), broad, and dynamic consent, with broad consent being the recommended model for cancer biobanks (Mendy et al. 2017). Special populations, such as minors, mentally incapacitated adults, and emergency situations, as well as deceased donors, carry specific content requirements. The consent form itself must cover collection, storage, processing, distribution and potential destruction of specimens, data linkage, researcher access including commercial partners, return of aggregate results, handling of incidental findings, and the right to withdraw. The person administering consent must not coerce the participant, must encourage open discussion, and must inform the participant of their rights, risks, and benefits. Whenever additional sampling or data collection takes place, consent must be reconfirmed, and if the biobank's scope changes, re-consent must be obtained (Hewitt 2011; Mendy et al. 2017).

On ethical governance, mandatory approval from an Independent Ethics Committee (IEC) or Institutional Review Board (IRB) is required before operational start, and the biobank protocol along with all associated documents must be approved by an independent research ethics committee, with approval renewed whenever documents are amended. All tissue establishments must be accredited, designated, authorized or licensed by a competent authority before commencing activities, and remain subject to regulatory inspections. A Responsible Person must be designated, holding at minimum a university degree in medical or biological sciences and two years of practical experience. The governance body must include a steering committee, executive group, ethics oversight committee, scientific oversight committee, data and sample access committee, and patient representatives, and a legacy and disaster recovery plan must be in place to guide specimen and data transfer or destruction (European Parliament and Council 2004; Mendy et al. 2017; World Medical Association 2013).

With regard to data protection under the General Data Protection Regulation (GDPR), biological samples are pseudonymized rather than fully anonymized, preserving the capacity to provide feedback to donors and to reconnect samples to clinical information. All data, including genetic information, must nonetheless be rendered anonymous so that neither donors nor recipients remain identifiable to third parties. The proposed European Medicines Agency/International Council for Harmonization (EMEA/ICH)

nomenclature for data identifiability distinguishes between Identified, Coded, Anonymized, and Anonymous data. Data security measures must safeguard against unauthorized additions, deletions, or modifications to donor files and must guarantee traceability of donations, with traceability data retained for at least 30 years after clinical use (Annaratone et al. 2021; European Parliament and Council 2004; Hewitt 2011). GDPR compliance rests on the principles of confidentiality, integrity, availability, and system resilience, and all user access activity must be logged and retained for at least one year (Engels et al. 2024). Member biobanks also have access to the BBMRI-ERIC GDPR Code of Conduct for Health Research (BBMRI-ERIC, n.d.).

Finally, on Ethical, Legal and Social Issues (ELSI), BBMRI-ERIC provides practical guidance on AI, the European Health Data Space (EHDS), data protection, ethics, and gender and diversity considerations (BBMRI-ERIC, n.d.). Material Transfer Agreements (MTA) and Data Transfer Agreements (DTA) are required for all sample and data sharing, and standardized templates are strongly recommended (Annaratone et al. 2021). Agreements with third parties must be written, must specify responsibilities and detailed procedures, and must be made available to the competent authority upon request, with intellectual property and benefit-sharing clauses documented per agreement (European Parliament and Council 2004; Hasan et al. 2025). Among the most challenging ELSI issues are cross-border sample and data transfer, use by commercial researchers, creation of cell lines, and research involving high-penetrance disease genes (Mendy et al. 2017).

Biobank Interfaces to Providing Institutions

A biobank does not operate in isolation, but relies on close cooperation with several hospital departments, each contributing a distinct part of the specimen's journey. Among these, the pathology department, the clinical departments, and laboratory medicine play the most crucial roles (Fig. 1).

The pathology department (Fig. 1, upper panel) controls the preanalytical phase for all solid tissue specimens, assessing and ensuring the adequacy of fresh tissue sampling in a way that does not impact the final diagnostic process. It curates the formalin-fixed paraffin-embedded (FFPE) specimen archive, acting as tissue curator, performs histological quality control (QC) covering tumor cell proportion, necrosis, and fibrosis assessment, and manages cold ischaemia time and time to formalin fixation (Annaratone et al. 2021; Guerrera et al. 2016; Hewitt 2011). It may also incorporate digital pathology into biobank quality assurance (QA) procedures (Wei and Simpson 2013). Its interface with the biobank follows a defined sequence: surgical specimen handover, FFPE archive management, fresh tissue freezing, histological QC, digital pathology QA, and finally Standard PREanalytical Code (SPREC) coding (Betsou et al. 2025).

The clinical departments (Fig. 1, middle panel) serve as the primary source of patient consent, clinical data annotation, and longitudinal sample collection coordination. They coordinate fluid sample collection during routine clinical care across the pre-operative phase, during therapy, at follow-up, and at relapse (Annaratone et al. 2021), and provide structured linkage of clinical data to biobank samples,

including diagnosis, treatment, outcome, and ICD-10 coding. They also participate in Use and Access Committee review and stakeholder governance (Engels et al. 2024; Hewitt 2011). Their interface follows the sequence of consent procedures, clinical data linkage, longitudinal sampling coordination, and ICD-10 diagnosis coding.

Laboratory medicine (Fig. 1, lower panel) manages the collection and initial processing of fluid biospecimens such as blood, plasma, serum, urine, and cerebrospinal fluid (CSF) obtained during routine diagnostic workup, and is involved in the collection of whole blood and derivatives for liquid biopsy (Annaratone et al. 2021). It is responsible for pathogen and infectious disease screening, and all tests required for donors must be carried out by a qualified, accredited laboratory (European Parliament and Council 2004). Its interface proceeds through fluid collection, primary centrifugation, DNA/RNA extraction, pathogen screening, and SPREC coding (Betsou et al. 2025).

Sample Workflow & Documentation - Biobank Information Management System (BIMS)

Every specimen that enters a biobank follows a defined, traceable workflow, documented step by step in the Biobank Information Management System (BIMS), which is summarized in Table 1.

Fluid Samples (Liquid)

Fluid specimens, including blood, plasma, serum, urine, broncho-alveolar lavage (BAL), cerebrospinal fluid (CSF), ascitic fluid, and pleural fluid, as well as liquid biopsy components such as circulating free DNA (cfDNA), circulating tumor cells (CTCs), and exosomes (EXO), each follow their own dedicated preanalytical pathway before they can be safely stored.

The process begins with patient identification and consent, during which written informed consent is verified as being on file, all accompanying documentation is checked for compliance before the sample is accepted, sample type eligibility is confirmed against the approved ethics protocol, and the patient's pseudonym identifier (ID) is recorded (European Parliament and Council 2004). The BIMS record at this stage captures the patient ID, consent, ethics approval number, date, and sample type.

Collection follows, with the sample taken into the appropriate primary container per standard preanalytical code (SPREC), such as ethylenediaminetetraacetic acid (EDTA), heparin, citrate, or Streck tubes, and the collection time and collector ID recorded (Betsou et al. 2025; Greytak et al. 2020). This corresponds to SPREC-Element 1 (sample type) and SPREC-Element 2 (primary container), along with collection date, time, and collector ID in the BIMS.

During the pre-centrifugation phase, the delay between collection and first centrifugation is documented, along with the temperature condition, whether room temperature or refrigerated, and its duration; the

ideal is less than 30 minutes at room temperature for most fluids. This is recorded as SPREC-Element 3, together with temperature and delay duration (Betsou et al. 2025; Greytak et al. 2020).

Centrifugation itself requires documentation of speed (g-force), temperature, duration, and braking, along with data on a second centrifugation step if applicable, corresponding to SPREC-Elements 4 and 5 (Betsou et al. 2025; Greytak et al. 2020).

A post-centrifugation delay is then tracked, documenting the time between the end of centrifugation and aliquoting at a defined temperature, ideally less than one hour, recorded as SPREC-Element 6 along with temperature (Betsou et al. 2025).

QC involves visual inspection for haemolysis and lipaemia, volume verification, and, where applicable, molecular QC such as RNA integrity number (RIN), cfDNA concentration, and fragment length profile. The QC outcome is recorded, and the sample must be confirmed as fit for purpose for the intended downstream analysis; samples that do not meet defined QC criteria must be quarantined and documented, and non-conformities reported per the biobank's adverse event reporting system (BBMRI-ERIC, n.d.; European Parliament and Council 2004; Hewitt 2011; ISO 2018). The BIMS fields here include haemolysis, lipaemia, volume, RIN, cfDNA concentration, fragment length profile, QC outcome, and non-conformity.

Aliquoting and labelling involve dividing the sample into cryotubes or polypropylene (PP) tubes, labelling with a unique barcode, assigning a unique sample ID per aliquot, and recording the number of aliquots; all labels must contain the information required to ensure full traceability and must comply with labelling requirements (Betsou et al. 2025; European Parliament and Council 2004). This is documented as tube type, volume, barcode, aliquot ID, number of aliquots, and confirmation of correct labelling.

Lastly, long-term storage follows SPREC, with PP tubes kept at -85°C to -60°C or cryotubes in liquid nitrogen vapor phase below – 135°C, or as per study-specific protocol. Temperature is continuously monitored with an automated alarm system, the number of freeze-thaw cycles is recorded, and storage conditions must comply with defined requirements and be maintained under continuous controlled conditions (European Parliament and Council 2004; Greytak et al. 2020). This corresponds to SPREC-Element 7 (Betsou et al. 2025), alongside the temperature log, freeze-thaw cycles, storage date and time, and storage location.

Fresh Tissue (Frozen)

Fresh, frozen tissue specimens, obtained through surgical resections, core biopsies, and endoscopic biopsies, and subsequently snap frozen or embedded in optimal cutting temperature (OCT) medium, as well as material destined for patient-derived organoid (PDO) and patient-derived xenograft (PDX) generation, require particularly careful and rapid handling in order to preserve their molecular integrity.

As with fluid samples, the workflow begins with patient identification and consent, verifying written informed consent, checking documentation compliance, confirming that the diagnostic process is not compromised, and recording the patient pseudonym ID (Annaratone et al. 2021; European Parliament and Council 2004); the BIMS captures patient ID, consent, ethics approval number, surgery date, and diagnostic priority.

Specimen type and collection are then documented per SPREC, including the collection method, such as surgical excision, biopsy, or surgical excision in a vacuum container, and the pathologist must be notified immediately upon excision (European Parliament and Council 2004). This is recorded as SPREC-Elements 1 and 2 (Wei and Simpson 2013), along with specimen description, surgeon ID, and pathologist notification.

Warm ischaemia time, the interval from blood vessel ligation to surgical excision, should ideally be less than 20 minutes (Annaratone et al. 2021; Guerrera et al. 2016; Hewitt 2011) and is recorded per SPREC as Element 3.

Cold ischaemia time, from surgical excision to snap freezing or stabilisation, should ideally be less than 20 minutes at room temperature; vacuum sealing combined with controlled transport at 4°C is recommended (Annaratone et al. 2021; Betsou et al. 2025; Zhang et al. 2019). This is recorded as SPREC-Element 4, together with transport temperature and vacuum sealing status.

Pathologist sampling and QC involve assessment of sample adequacy, including tumor cell proportion, necrosis, and fibrosis, verification of tissue composition before banking with a cryosection, and macro or microdissection if required; involvement of the pathologist is essential, and the QC outcome is recorded (Annaratone et al. 2021; Hewitt 2011; Zhang et al. 2019). Fields include pathologist ID, tumor cell content, necrosis grade, fibrosis grade, cryosection, and QC outcome.

Snap freezing or Optimal Cutting Temperature (OCT) embedding follows, using liquid nitrogen or OCT, while avoiding drying artefacts, prolonged exposure to room temperature, and crushing artefacts during handling. Multiple aliquots are obtained where possible to minimize freeze-thaw cycles, and for patient-derived organoid (PDO) generation, fresh tissue must be processed within defined time limits (Demyan et al. 2022). This corresponds to SPREC-Element 5 (fixation/stabilization type) (Betsou et al. 2025), along with freezing method, freezing date and time, and PDO generation and timing.

Aliquoting and labelling involve dividing tissue into cryotubes or OCT blocks, labelling with a unique barcode, and making cryostatic sections available for downstream analyses without thawing the entire block; aliquot weight is documented, and labels must ensure full traceability (Annaratone et al. 2021; European Parliament and Council 2004). Recorded fields include tube or block type, barcode, aliquot ID, aliquot weight, number of aliquots, and correct labelling.

Long-term storage again follows SPREC, using cryotubes in liquid nitrogen vapor or liquid phase, or a mechanical freezer, with continuous temperature monitoring and alarm systems, recording of freeze-

thaw cycles, and storage conditions maintained under continuous controlled conditions, corresponding to SPREC-Element 7 with temperature log, storage date and time, and storage location (Betsou et al. 2025; European Parliament and Council 2004; Zhang et al. 2019).

Formalin-fixed, paraffin-embedded (FFPE) Tissue

Formalin-fixed, paraffin-embedded tissue (FFPE), encompassing surgical specimens, core biopsies, and archival blocks, along with the haematoxylin and eosin (H&E) slides, immunohistochemistry (IHC) slides, tissue microarrays (TMA), DNA/RNA extracts, and digitally scanned slides derived from them, is the most widely archived specimen type in pathology and follows its own well-established preparation pathway.

The workflow again opens with patient identification and consent, verifying written informed consent and documentation compliance, confirming the diagnostic process is not compromised, recording the patient pseudonym ID, and documenting sample type per SPREC; archival FFPE material may be used under specific conditions (Annaratone et al. 2021; European Parliament and Council 2004; Hasan et al. 2025). The BIMS captures patient ID, consent, ethics approval number, whether the material is archival, diagnostic priority, and sample type as SPREC-Element 1.

Gross pathology examination follows, in which the pathologist performs a macroscopic examination of the surgical specimen and selects representative tissue blocks for FFPE processing, using residual material only, while the collection type is documented per SPREC (Annaratone et al. 2021; Betsou et al. 2025). This is recorded as SPREC-Element 2, together with specimen description (weight and size), pathologist ID, diagnostic priority of the selected blocks, and tumor size.

Warm ischaemia time, from blood vessel ligation to surgical excision, is recorded per SPREC as Element 3; for surgical resections it is typically brief but must still be documented, since it contributes to nucleic acid degradation alongside cold ischaemia time (Annaratone et al. 2021; Betsou et al. 2025).

Cold ischaemia time, from surgical excision to formalin immersion, should ideally be less than 30 minutes, with a target of under 60 minutes; cold fixation at 4°C is recommended when a transport delay is anticipated (Annaratone et al. 2021; Betsou et al. 2025; Li et al. 2022). This is recorded as SPREC-Element 4, along with transport temperature and fixation start time.

Formalin fixation uses 10% neutral buffered formalin (NBF) as the standard fixative, with an optimal fixation time of 8 to 28 hours, and the fixation temperature is recorded. This corresponds to SPREC-Element 5 (fixation type), fixation temperature, and SPREC-Element 6 (fixation time) (Annaratone et al. 2021; Betsou et al. 2025; Li et al. 2022; Prentice et al. 2018).

Paraffin embedding and block production follow standard histological tissue processing through graded alcohols, xylene, and paraffin, producing a paraffin block with a unique identifier, whose integrity is

confirmed by a quality H&E section (European Parliament and Council 2004). Documented fields include block ID, processing date, processing protocol, and H&E section quality outcome.

Pathologist QC and sectioning involve assessment of sample adequacy for tumor cell proportion, necrosis, and fibrosis, with sections cut at 4 to 5μm for IHC, fluorescence in-situ hybridization (FISH), and nucleic acid extraction; digital scanning of slides for a digital pathology archive is ideal, and pathologist involvement is essential (Annaratone et al. 2021; Hewitt 2011; Wei and Simpson 2013). Fields recorded include pathologist ID, tumor cell content, necrosis grade, fibrosis grade, number of sections cut, IHC markers, and slide scanning status.

Where applicable, nucleic acid extraction from FFPE sections is performed, with quality metrics documented including DNA integrity number (DIN), RIN, A260/280 ratio, and total yield; quality criteria are study-specific, and the sample must be confirmed as fit for purpose for the intended downstream analysis (Annaratone et al. 2021; Hewitt 2011). Recorded fields include extraction method and standard operating procedure (SOP), DIN, RIN, A260/280 ratio, total yield, and quantification method.

Long-term storage follows SPREC, with FFPE blocks kept at room temperature, 2 to 10°C, or -18 to -35°C, while FFPE unstained sections are stored at -20°C to prevent RNA degradation; IHC, ISH, RNA, and DNA are well preserved in unstained sections stored up to 24 months under controlled conditions. Temperature is continuously monitored with an automated alarm system, and traceability data must be retained for at least 30 years after clinical use (European Parliament and Council 2004; Ramsower et al. 2022). This corresponds to SPREC-Element 7 (Betsou et al. 2025), along with temperature log, storage date and time, storage location, and section and block storage temperatures.

Table 1
Overview of the sample workflow for biobank specimens.

Fluid Samples (Liquid)	***Fresh Tissue (Frozen)***	***FFPE Tissue***
Patient Identification & Consent	Patient Identification & Consent	Patient Identification & Consent
Collection	Specimen Type & Collection	Gross Pathology Examination
Pre-centrifugation	Warm Ischaemia Time	Warm Ischaemia Time
Centrifugation	Cold Ischaemia Time	Cold Ischaemia Time
Post-centrifugation Delay	Pathologist Sampling & QC	Formalin Fixation
Quality Control (QC)	Snap Freezing / OCT Embedding	Paraffin Embedding & Block Production
Aliquoting & Labelling	Aliquoting & Labelling	Pathologist QC & Sectioning
		Nucleic Acid Extraction (if applicable)
Long-term Storage	Long-term Storage	Long-term Storage

FFPE, Formalin-Fixed Paraffin-Embedded; OCT, Optimal Cutting Temperature.

Linkage to Clinical Data

A biological sample alone has limited research value unless it is meaningfully linked to the clinical information behind it.

Biobanks are large collections linked to relevant personal and health information (Annaratone et al. 2021), so that biological specimens and associated data are always connected, with the associated data spanning clinical, epidemiological, and pathological domains.

The clinical data elements linked to each sample include the diagnosis by ICD-10 code, tumor histotype, pathological staging, and biomarker status; treatment history covering surgery, chemotherapy, radiotherapy, and targeted agents; demographic information such as date of birth, sex, body mass index (BMI), and smoking status; and longitudinal follow-up data on response, relapse, and survival status. Genomic and omics data are linked per study protocol, including whole exome sequencing (WES), whole genome sequencing (WGS), single nucleotide polymorphism (SNP) arrays, and nuclear magnetic resonance (NMR) metabolomics. All linkage is performed via a pseudonymization key held exclusively by the biobank, and all data must be rendered anonymous so that neither donors nor recipients remain identifiable to third parties (European Parliament and Council 2004; Mendy et al. 2017). Clinical data linkage may be implemented through interoperable standards such as health level seven fast healthcare interoperability resources (HL7 FHIR) (Engels et al. 2024), as used in the BBMRI-ERIC federated infrastructure (BBMRI-ERIC, n.d.).

Storage Conditions

Once collected and processed, each sample type must be preserved under specific storage conditions to safeguard its long-term quality.

The following table (Table 2) defines recommended storage conditions per sample type, according to SPREC v4.0 (Betsou et al. 2025) and ISBER Best Practices (Snapes 2023). Temperature monitoring with automated alarms is mandatory for all storage conditions (ISO 2018).

Table 2
Storage conditions of biobanked specimens by sample type

Sample Type	*Container*	*Temperature*	*Monitoring*
Plasma	PP tube 0.5-2 mL or Cryotube 1–2 mL	less than − 135°C LN or -85 to -60°C	Continuous temp log, Alarm system
Serum	PP tube or Cryotube	-85 to -60°C	Continuous temp log
Whole Blood	Original primary container	-35 to -18°C	Temp log
Urine	PP tube 5 mL or more, or 0.5-2 mL	-85 to -60°C	Temp log
CSF / Other Fluids	Cryotube 1–2 mL	less than − 135°C LN	LN level monitoring
Fresh Frozen Tissue	Cryotube 1–2 mL or OCT block	less than − 135°C LN or -85 to -60°C	Continuous temp log, LN sensor, Alarm
PDX / PDO Cultures	Cryotube 1–2 mL	LN less than − 135°C	LN continuous monitoring
FFPE Block	Paraffin block (sealed)	RT or 2–10 ° C or -18 to -35°C	Humidity control, Temp log
FFPE Sections / TMA	PP tube or sealed slide box	-20°C	Temp log

CSF, cerebrospinal fluid; FFPE, Formalin-Fixed Paraffin-Embedded; LN, liquid nitrogen; OCT, optimal cutting temperature; PDO, patient-derived organoids; PDX, patient-derived xenografts; PP, polypropylene; RT, room temperature; TMA, tissue microarrays.

Sample Access Policy - Use & Access Committee

Access to stored samples and data is not automatic, but follows a structured request and review process overseen by a dedicated committee.

The access request workflow begins with a feasibility query, in which the researcher searches available biosamples via the BBMRI-ERIC Sample Locator or the biobank catalogue (BBMRI-ERIC, n.d.); a federated FHIR query returns aggregated counts only, with no individual patient data transmitted (Engels et al. 2024). The researcher then submits a formal application containing scientific justification, sample and data specification, ethical approval reference, institutional affiliation, and intended data use (Mendy et al. 2017). An internal scientific committee carries out a scientific review evaluating study purpose and sample adequacy, typically following the feasibility analysis and cost agreement (Hasan et al. 2025). The biobank then verifies ethics and consent, confirming that the requested use falls within the donor consent scope; broad consent covers most research uses, while genomic research and industry use are verified specifically (Annaratone et al. 2021; Hasan et al. 2025). The Use & Access Committee (UAC)

then deliberates and issues a decision (Mendy et al. 2017), either approving, approving with conditions, or rejecting the request, with all decisions documented in BIMS along with reasoning and date, taking into account the non-renewable nature of specimens when setting priorities for access. Before any sample or data release, an MTA and/or DTA must be signed (European Parliament and Council 2004; Hasan et al. 2025); these agreements must be written, must specify responsibilities and detailed procedures, and must be made available to the competent authority upon request, with the contractual process representing the primary hurdle in practice. Ultimately, samples and data are released (European Parliament and Council 2004; Hasan et al. 2025). Samples are dispatched with shipment documentation, data are released in the agreed format, post-release use is monitored per MTA terms, residual sample handling is defined per agreement, and distribution conditions must comply with defined quality and safety requirements.

The UAC is an independent governance body established to oversee access requests, protect donor interests, and ensure scientifically sound and ethically appropriate use of biobank resources (Annaratone et al. 2021; European Parliament and Council 2004). It is composed of the biobank director, who chairs the committee and holds operational oversight and final accountability; a pathologist, who serves as the sample quality expert and key personnel for tissue-based resources; a clinician, who acts as the disease and clinical data expert; a data manager or bioinformatician, responsible for information technology (IT) systems, BIMS management, and GDPR compliance; an ethicist or legal counsel, responsible for consent review, ELSI, and MTA drafting and review; and a patient representative, who brings the donor interest and public benefit perspective (Fig. 2). The UAC meets on a defined schedule, such as monthly, all decisions are documented in BIMS, and an appeals process must be defined and publicly available (Hasan et al. 2025).

As regards access policy parameters, eligible users include academic researchers, both internal and external, pharma and biotech companies (allowed by 57% of biobanks), diagnostic companies, and procurement brokers. Use restrictions tied to informed consent, such as genomic research limitations or commercial use, apply in 62% of biobanks, with all restrictions documented in the MTA. Regarding the residual sample policy, 42% of biobanks require destruction of remaining material after project completion, 17% allow additional use with notification, 8% allow secondary use within the same organization, and 29% require new applications (Hasan et al. 2025). For export authorization, 29% of biobanks require it for cross-border transfers, which are verified case by case, with the BBMRI-ERIC Negotiator facilitating cross-site communication (BBMRI-ERIC, n.d.; European Parliament and Council 2004; Hasan et al. 2025). The fee structure is generally fee-for-service, with costs attributed to sample acquisition and processing (95%), facilities and administration (82%), and storage (64%), and higher fees applied to industry partners in 78% of biobanks. On visibility, only 28% of biobanks have their inventory on an external-facing platform, though the BBMRI-ERIC Sample Locator and Directory provide structured discoverability (BBMRI-ERIC, n.d.; Hasan et al. 2025; Mendy et al. 2017), and high-level access policies should be publicly available.

Documentation of Sample & Data Provision

Once access is approved, the release of samples and data to researchers must also be carefully documented.

Sample and data provision involves several documented steps (Fig. 3). Shipment documentation includes a sample manifest covering the aliquot ID, SPREC code, QC result, storage history, and chain of custody record, with export permits attached if required (Hasan et al. 2025). Every dispensed sample is logged in BIMS as a provision record (Annaratone et al. 2021; Engels et al. 2024; European Parliament and Council 2004), capturing recipient, project, date, volume, and lot number, with the sample inventory and residual volume updated immediately. A data package of clinical metadata is released according to the approved data model, de-identified per GDPR, with a DTA executed prior to release. Each sample preparation SOP is assigned a unique ID (Annaratone et al. 2021) through SOP ID assignment and deposited in a centralized database, and this ID is later reported in the methods section of resulting publications. The recipient must then provide receipt confirmation (European Parliament and Council 2004), confirming arrival and condition of samples within a defined timeframe, with any discrepancy or non-conformity reported to the biobank and documented in BIMS. Last of all, post-release monitoring requires end-users to submit annual progress reports and an end-of-project report (Hasan et al. 2025; Mendy et al. 2017), including information on resulting publications and patent applications.

Follow-up: Acknowledgment & Bioresource Research Impact Factor (BRIF)

The relationship between biobank and researcher does not end once samples are provided. It continues through acknowledgment and tracking of the resulting research output.

Acknowledgment and impact tracking center on several mechanisms. Publication tracking through the (BRIF) initiative systematically tracks and quantifies the use of a bioresource in the academic literature, with a unique digital identifier, analogous to a digital object identifier (DOI), assigned to each biobank to cite and acknowledge its use in publications and research projects (Hasan et al. 2025; Mendy et al. 2017). Mandatory acknowledgment is required by 83% of academic biobanks (Hasan et al. 2025), which reference the biobank by name in publications as their primary requirement when releasing samples to users, with the exact wording specified in the MTA. Tracking the use of bioresources in the literature relies on tools such as the Citation of BioResources in journal Articles (CoBRA) guideline, the Open Journal of Bioresources (OJB), and BRIF metrics (Bravo et al. 2015); CoBRA standardizes how bioresources are cited in journal articles, while OJB provides a platform for formal biobank publication. Output monitoring tracks publication rates annually through biobank management, noting that industry collaboration typically yields lower publication rates than academic research, with an annual output report compiled for the governance body and funders (Hasan et al. 2025). Just as importantly, SOP transparency in publications requires that the sample preparation SOP ID be reported in the methods section (Annaratone et al. 2021), allowing other scientists to verify sample quality and compare results across biobanks.

Cost Calculation & Recovery

Running a biobank comes at a cost, so in order to ensure its long-term sustainability, a clear and fair approach to funding and cost recovery is required.

Biobanks require funding for development, staff management, and long-term maintenance, with primary costs ranked from sample acquisition and processing, to facilities and administration, storage, sample distribution, contractual agreements, and legal support. The procurement of tissues and cells must be carried out on a non-profit basis; cost recovery is acceptable but must remain strictly limited to reimbursement of operational costs and must not generate profit from donated specimens. Additionally, fee structures must be transparent, justifiable, and accessible to all stakeholders (Annaratone et al. 2021; European Parliament and Council 2004; Hewitt 2011; Snapes 2023).

A major sustainability problem is the underuse of biospecimens and data. It is stated (Hasan et al. 2025) that only 25% of academic biobanks were confident their inventory was being fully utilized. This underutilization is not only a practical problem but an ethical one, since biobanks make an implicit promise to donors that their samples will be used for research. Federated discovery tools, such as the BBMRI-ERIC Sample Locator, and transparent cost models published on biobank websites, help improve utilization rates and researcher confidence (Engels et al. 2024; Klingler et al. 2021). Moreover, ensuring long-term sustainability remains difficult, since biobanks cannot be sustained by cost recovery alone and long-term institutional support is essential. Financial sustainability ultimately requires a cost recovery policy based on user fees that reflect the true costs faced by biobanks.

Counteract measures to consider include public-private partnerships, such as those between public sector biobanks and pharmaceutical companies, and addressing the interests of funders, researchers, and participants. Biobanks should demonstrate their value to society and public benefit, and measure their outputs. They should also ensure access to quality tissue specimens and procure a high number of biobanking projects. In addition, they should aim to achieve high project completion rates and high user satisfaction rates.

Conclusion

Biobanking, once perceived as an unfamiliar concept, rests in fact on a series of concrete, well-defined steps, from consent and specimen handling to storage, access, and long-term follow-up. Pathologists, given their central position in specimen handling and quality control, are naturally positioned to engage with this process, not as external observers but as active participants in it. This guide has aimed to make that path more familiar, offering a first, practical entry point into the principles and workflow of biobanking.

Declarations

Ethical considerations: Not applicable.

Consent to participate: Not applicable.

Consent for publication: Not applicable.

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Authorship confirmation statement

I, Marina Sassi, hereby declare that I am the sole author of this manuscript and fulfil this role by meeting the International Committee of Medical Journal Editors (ICMJE) four criteria of authorship, i.e.:

1. I have contributed substantially to the conception and design of the work, and the acquisition, analysis, or interpretation of data for the work; AND
2. I have drafted the work and have reviewed it critically for important intellectual content; AND
3. I have the final approval of the version to be published; AND
4. I agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Furthermore, my role as an author according to the Contributor Roles Taxonomy (CRediT) is described as follows:

- Conceptualization, Marina Sassi
- Methodology, Marina Sassi
- Project administration, Marina Sassi
- Supervision, Marina Sassi
- Visualization, Marina Sassi
- Writing – original draft, Marina Sassi
- Writing – review & editing, Marina Sassi

Note: the above roles are applicable to this manuscript.

As the sole author of the manuscript, I take full responsibility of the review and approval of the manuscript prior to submission.

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Figures

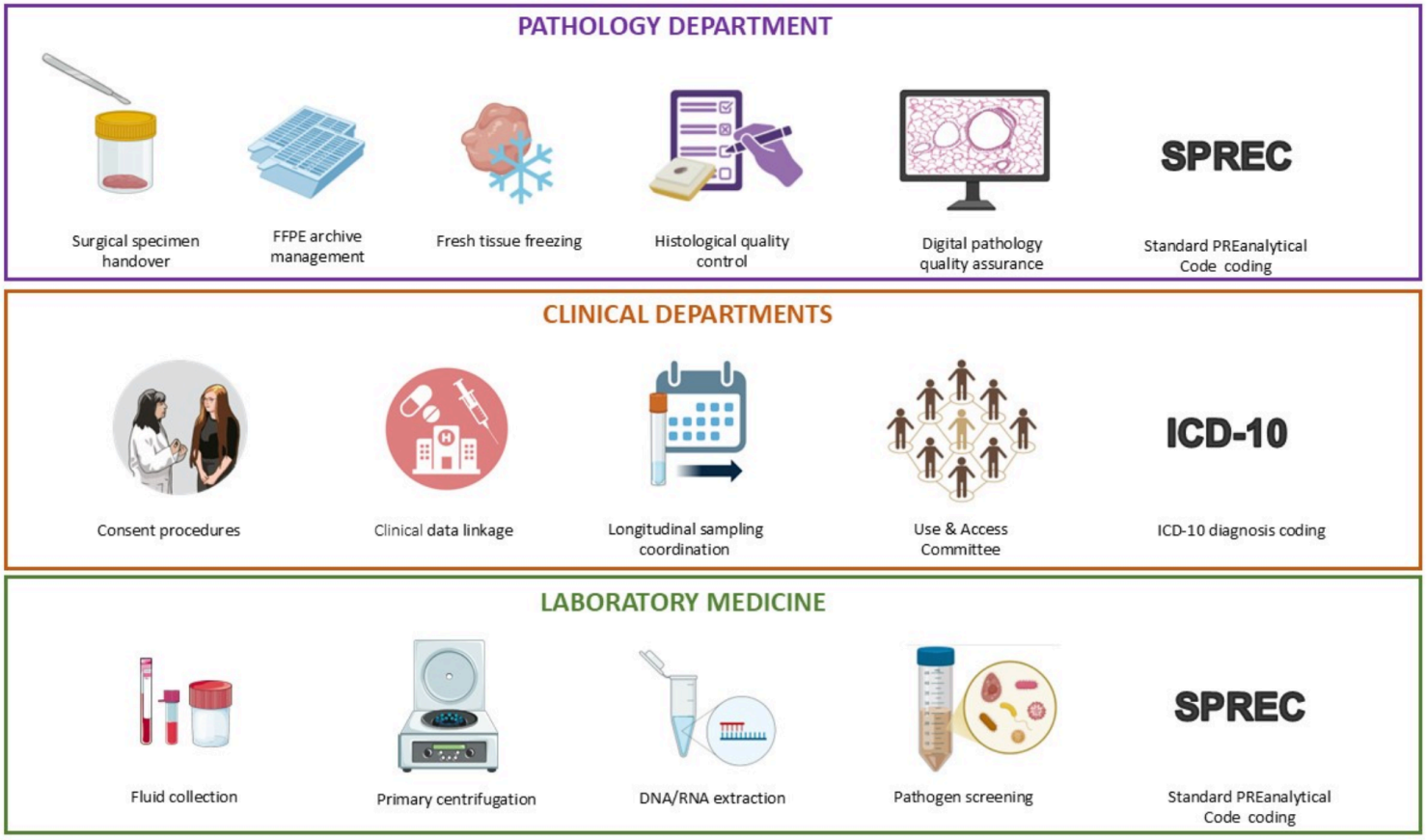

Figure 1

Biobank interfaces with providing institutions. The three main hospital departments contributing to the biobanking process.

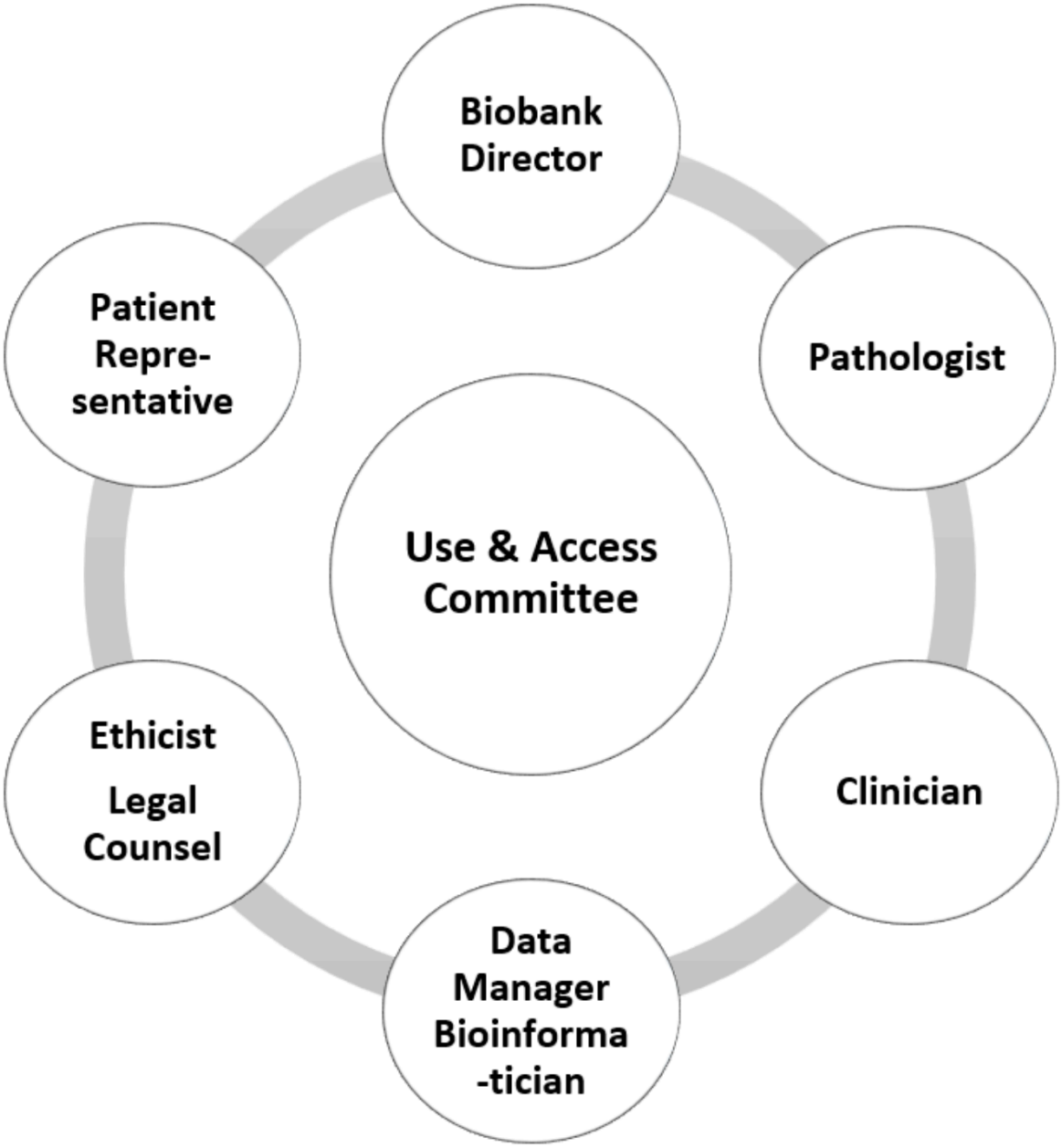

Figure 2

Members of the dedicated governance body. The Use & Access Committee is composed of six members, the biobank director, pathologist, clinician, data manager/bioinformatician, ethicist/legal counsel, and patient representative, who jointly oversee requests for sample and data access.

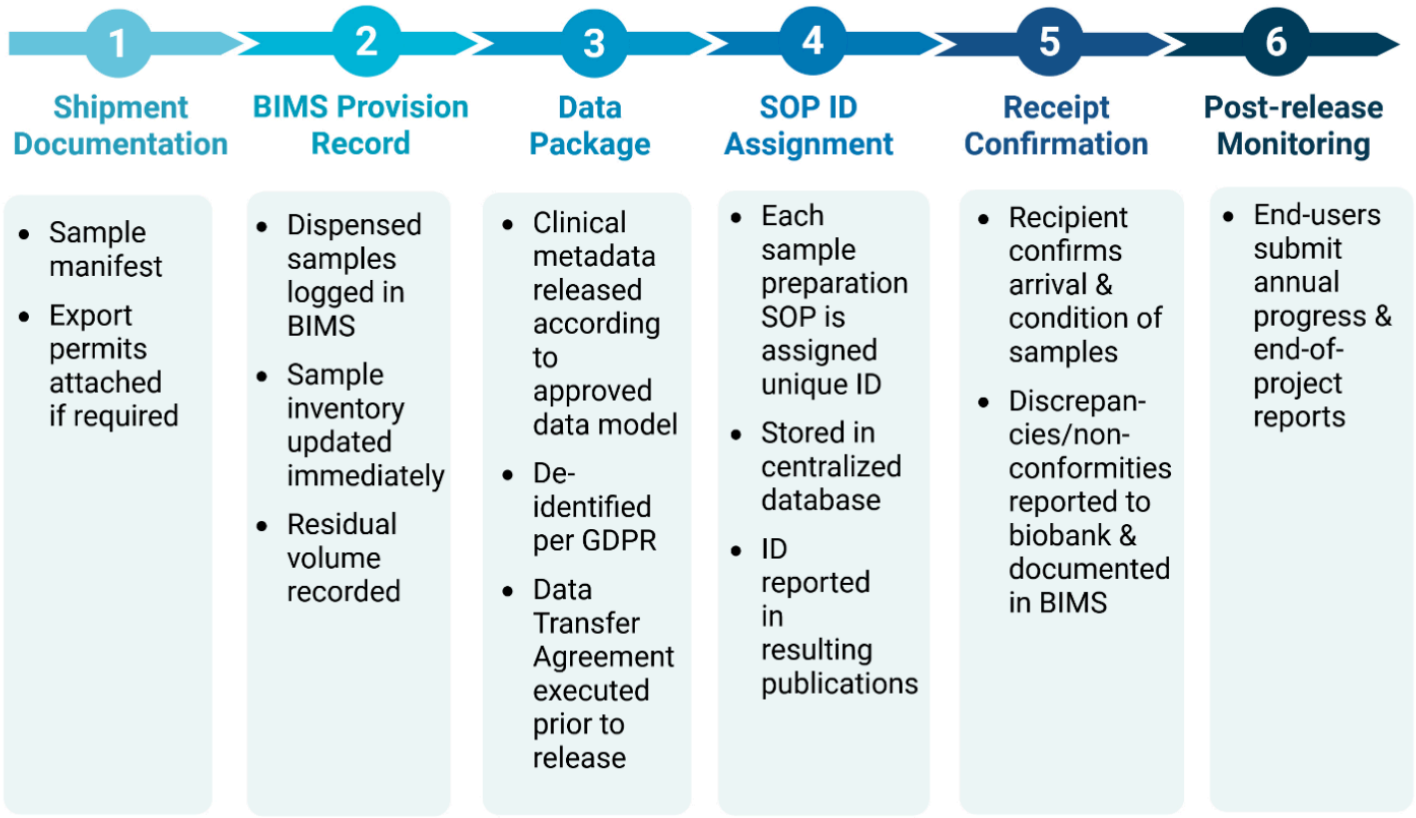

Figure 3

Documentation of sample and data provision. The six-step process by which approved samples and data are released to researchers is shown, from shipment documentation and logging in the Biobank Information Management System (BIMS), through the release of the associated data package and assignment of a standard operating procedure (SOP) identifier, to receipt confirmation and post-release monitoring of the recipient's use of the resources. Created in BioRender. Sassi, M. (2026) https://BioRender.com/ay58699