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Challenges of DAOs in decentralized science: a qualitative analysis of expert interviews

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Introduction: Decentralized autonomous organizations in decentralized science face unique organizational and scientific demands. This study examines core challenges encountered by DeSci DAOs and how these challenges affect governance and research practice.

Methods: Ten semi-structured interviews were conducted with co-founders, working-group leads, and long-term contributors. Transcripts were analyzed using Kuckartz's six-phase qualitative content analysis. Categories were developed and refined to synthesize recurrent themes across interviews.

Results: Nineteen sub-categories clustered into six domains: governance, financials, contribution, onboarding, operations, and science. Findings highlight tensions between token-weighted decision making and domain expertise, labor-intensive hybrid accounting practices, persistent talent shortages, steep Web3 onboarding curves, fragmented project coordination, and science-specific issues that include negotiations with technology transfer offices and the tokenization of research assets. The resulting category system provides a diagnostic baseline for understanding how decentralized governance intersects with scientific rigor.

Discussion: DeSci DAOs progress most effectively when blockchain-enabled transparency is paired with clearly defined coordination roles, structured onboarding pathways, and credible mechanisms for scientific validation. These features help balance organizational experimentation with proven practices and support more reliable scientific workflows.

KEYWORDS

decentralized science (DeSci), decentralized autonomous organization (DAO), challenges, expert interviews, qualitative content analyses

1 Introduction

Decentralized Autonomous Organizations (DAOs) represent an innovative organizational model enabled by blockchain technology, which is characterized by decentralization, automation through smart contracts, and collective governance by members (Bellavitis et al., 2022). Initially conceptualized as “Decentralized Autonomous Companies,” the concept has evolved significantly, encompassing various organizational structures beyond purely capitalist enterprises (Wright, 2021). The core distinction between DAOs and traditional organizations lies in their public, distributed decision-making processes, which replace hierarchical control with community-driven governance mediated transparently by blockchain platforms (Augustin et al., 2023). Central to this model are smart contracts, which are self-executing, autonomous code structures that

enforce predefined rules and interactions among DAO members without centralized authority or managerial hierarchies (Tan et al., 2023).

The first significant practical implementation of a DAO occurred in 2016 with “The DAO,” an ambitious Ethereum-based project aimed at democratizing venture capital funding. Conceived by Christoph and Simon Jentzsch, The DAO utilized token-weighted voting mechanisms to enable decentralized investment decisions, raising approximately USD 168 million through a public crowdfunding campaign (DuPont, 2018; Mehar et al., 2017). However, vulnerabilities within its smart contract permitted exploitation, leading to theft of over USD 50 million worth of Ether. This event, commonly referred to as “The DAO Attack,” sparked intense debates surrounding blockchain immutability, ethical governance, and crisis response, ultimately causing a contentious hard fork of the Ethereum blockchain into Ethereum (ETH) and Ethereum Classic (ETC.) (DuPont, 2018; Mehar et al., 2017). Despite this setback, DAOs have seen a substantial resurgence driven by improvements in the blockchain infrastructure, enhanced smart contract security, and the maturation of governance mechanisms. Contemporary DAOs increasingly incorporate sophisticated voting systems and governance practices such as delegated voting, actively addressing earlier criticisms related to participation rates, concentration of voting power, and accountability (Lustenberger et al., 2025; Weidener et al., 2025). The emergence of platforms such as DAO stack and Aragon has further accelerated DAO adoption, significantly lowering technical barriers and enabling a broader spectrum of users to effectively create and operate decentralized organizations (El Faqir et al., 2020). Between 2019 and 2022, real-world deployments of DAOs surged by approximately 660%, with over 13,000 active DAOs collectively managing assets valued at approximately \$16 billion. Despite their impressive growth and innovation potential, significant challenges persist, including governance centralization, voter apathy, token-based voting inequalities, and uncertainties regarding regulatory environments, necessitating ongoing research and refinement of the DAO frameworks (Lustenberger et al., 2025; Tan et al., 2023).

Recently, DAOs have expanded significantly into diverse domains, becoming notably prevalent within the decentralized science (DeSci) movement, an emerging movement leveraging blockchain technology to transform traditional scientific research practices (Weidener and Spreckelsen, 2024; Wang et al., 2022). DeSci encompasses a decentralized approach designed explicitly to mitigate systemic issues inherent in contemporary science, such as the reproducibility crisis (Ioannidis, 2012; Romero, 2019), oligopolistic structures governing scientific publishing (Larivière et al., 2015), persistent barriers to interdisciplinary collaboration and research funding (Hamburg, 2022; Shilina, 2023), and decline in pharmaceutical innovation efficiency (Scannell et al., 2012). By employing blockchain-enabled governance and smart contract automation, DeSci aims to democratize decision making, enhance funding transparency, and facilitate direct stakeholder engagement in scientific endeavors (Wang et al., 2022).

However, DAOs operating within DeSci are likely to inherit general DAO challenges, such as governance centralization, voter apathy, and disparities arising from token-weighted voting systems (Tan et al., 2023), while simultaneously confronting unique

complexities owing to their intrinsic scientific nature. Unlike DAOs in other sectors, where community involvement might predominantly require generalist knowledge, DeSci initiatives, particularly those in biomedicine or biotechnology, demand substantial scientific expertise, rigorous adherence to methodological standards, and robust mechanisms for quality assurance and peer review (Wang et al., 2022). For instance, biotech technology and research focused DAOs, such as VitaDAO, employ complex funding strategies aimed at bridging commercialization gaps and facilitating early stage biomedical research, reflecting the unique operational complexities of DeSci (Wang et al., 2022). The need for specialized expertise amplifies operational challenges, complicating the coordination of interdisciplinary research efforts within decentralized and often pseudonymous contributor networks. Moreover, maintaining scientific integrity, quality assurance, and credibility becomes substantially more challenging in decentralized contexts, where accountability mechanisms and verification processes must be rigorously restructured to fit blockchain-based organizational paradigms (Shilina, 2023; Wang et al., 2022). As such, governance frameworks and workflows effective in generalist DAOs require substantial adaptation to address the stringent scientific and technical requirements specific to DeSci contexts.

Despite a growing acknowledgment of these multifaceted challenges, empirical research explicitly addressing the operational and governance complexities unique to DeSci DAOs remains limited (Weidener and Spreckelsen, 2024; Shilina, 2023; Wang et al., 2022). The preliminary literature outlines the key aspects of DeSci, such as decentralized infrastructure layers, incentive alignment, and basic governance elements (Hamburg, 2022; Wang et al., 2022). However, detailed qualitative analyses examining the operational bottlenecks, workflow inefficiencies, and technological limitations explicitly encountered by DeSci DAOs remain sparse. Consequently, a notable research gap exists regarding how these domain-specific challenges manifest within DAOs that are focused on scientific innovation. Addressing this gap is crucial not only to explore the broader implications of decentralization for scientific practice, but also to enhance DAO sustainability and operational efficacy within knowledge-intensive environments.

2 Objective and research question

To explore and contextualize the overarching challenges faced by DAOs in DeSci and their subdivisions (e.g., working groups), particularly focusing on operational bottlenecks, workflow inefficiencies, and technological limitations, and to discuss potential organizational responses. The resulting research question guiding this research is the following:

What challenges do DeSci DAOs face according to experts (individuals with leading roles within DAOs)?

The analysis examined challenges across three interrelated domains: operations, technology, and organization. These domains were selected because they capture complementary, yet distinct dimensions of DAO functioning observed in both practice and prior research. Operations refer to day-to-day workflows, coordination, and processes within working groups and

TABLE 1 Expert characteristics.

Expert	Functional role(s)	Founder status	Years of experience in DeSci
E1	Operations lead		4
E2	Communication lead		3
E3	Product lead		2
E4	Community lead		3
E5	Community lead	Yes	<1
E6	Science and dealflow expert		3
E7	Legal lead	Yes	5
E8	Product lead	Yes	3
E9	Science and dealflow lead		2
E10	Operations lead	Yes	4

subdivisions; technology relates to blockchain infrastructure, tools, and onboarding requirements that shape participation; and the organization concerns governance structures, incentive mechanisms, and contributor engagement. While analytically distinguished, the domains are closely interconnected, as technological frictions often manifest in operational inefficiencies and organizational structures mediate how such challenges are addressed.

For this research, a DeSci DAO is defined as token-governed, blockchain technology-based organization, whose primary purpose is to generate, fund or translate scientific knowledge. This definition aligns with recent DAO scholarly discussions (Bellavitis et al., 2022; Augustin et al., 2023) and DeSci analyses (Weidener and Spreckelsen, 2024; Shilina, 2023; Wang et al., 2022).

The qualitative methodology used to address this research question is detailed in Chapter 3.

3 Methodology

The methodological approach for this research comprised expert interviews and qualitative content analysis to systematically examine the operational and structural challenges faced by DAOs operating in DeSci.

3.1 Study design

Expert interviews were conducted in February 2025 to address the objective of this study. Experts were defined for the purpose of this research as individuals who fulfill at least one of the following criteria: (1) founders of a DAO operating within the DeSci ecosystem; (2) holders of leading positions within a DeSci-DAO, such as leaders of working groups or pods; or (3) active contributors with at least 2 years of continuous involvement within a DeSci-DAO. For DAOs to qualify for inclusion, they were required to have an operational governance token that manages a shared treasury, as well as having successfully passed at least one governance proposal.

Additionally, the primary focus of the DAO had to be aligned explicitly with the DeSci objectives. Participants were recruited through direct communication channels, leveraging existing professional relationships, and personal networks. Potential participants meeting the aforementioned expert criteria were approached individually via direct messaging on platforms, such as Discord and Telegram. The expert characteristics, including their roles within their respective DAO and duration of involvement, are detailed in Table 1.

Ten experts agreed to participate and provided explicit consent regarding the recording, transcription, analysis, and use of their data for research purposes. Interviews were conducted using semi-structured guidelines specifically designed to elicit insights relevant to the overarching research question.

Given the emerging state of the DeSci ecosystem, the number of DAOs that currently meet the maturity threshold of operating a governance token is small, less than a dozen at the time of data collection (Weidener and Spreckelsen, 2024). As this constitutes a well-defined but limited population, a sampling strategy targeted fewer highly informed experts (founders, leads, and long-term contributors), which is methodologically preferable to larger yet information-poor samples (Gentles et al., 2015).

3.2 Theory

This section outlines the theoretical basis of the study. In selecting an appropriate analytic framework, several traditions were considered: Mayring's qualitative content analysis, Krippendorff's content analysis, Kracauer's interpretive position on qualitative content analysis, grounded theory coding as an adjacent analytic family, and Kuckartz's qualitative content analysis.

Within the German-speaking tradition, Mayring's approach emphasizes rule-governed procedures for inductive summarizing, explication, and structuring, with the aim of building precise categories closely tied to the text (Mayring and Fenzl, 2019). Deductive categories are possible but not necessary, which suits exploratory mapping when prior theory is limited but aligns less directly with designs that must privilege

TABLE 2 Main categories and subcategories following qualitative content analysis.

Main category	Subcategory	Definition
Governance		Decision-making structures often misalign expertise, engagement, and token incentives, thereby affecting effective collective action
	Representation	Token-weighted voting grants holders influence who lack relevant scientific expertise, risking uninformed funding
	Participation	Community members rarely read or vote on proposals, producing chronically low quorums and stalled governance
	Token Utility	Governance tokens offer little value beyond voting, weakening incentives for long-term engagement and retention
Financials		Managing digital assets and reporting across blockchains and jurisdictions require high financial expertise
	Treasury Management	Lack of professional asset management skills leads to uninformed treasury allocation
	Token Economics	The market valuation of the token frequently diverges from the scientific value that the DAO produces, undermining sustainability
	Accounting and Reporting	Tracking on-chain and off-chain transactions for multi-jurisdictional compliance is time-consuming and error-prone
	Transparency	Members struggle to see who gets paid what, in which asset, and why, eroding trust
Contribution		Attracting, motivating, and disciplining talent in a permissionless environment remains challenging
	Lack of Talent	The scarcity of crypto-native developers and domain experts limits project execution despite abundant ideas
	Engagement	High autonomy without clear ownership leaves many contributors passive, slowing the progress of the DAO.
	Compensation	The absence of robust performance metrics makes fair output-linked payments difficult
	Accountability	Flexible informal work agreements reduce reliability
Onboarding		Newcomers face steep learning curves because of the complexity of science and technology
	Resources and Training	The lack of structured guidance and mentoring impedes newcomers from becoming involved
	Lack of Web3 nativeness	Wallet setup and crypto jargon deter non-crypto scientists from joining or staying
Operations		Day-to-day coordination suffers from fragmented tools, dispersed teams, and weak external messages
	Marketing	Communicating a dual science-plus-crypto mission to diverse audiences exceeds current skill sets
	Project Management	Multiple unintegrated platforms create duplications and slow asynchronous coordination
	Inter-DAO Collaboration	Few formal channels exist for sharing best practices or pooling resources across DAOs
Science		Conducting and commercializing research inside token economies exposes DAOs to novel scientific and legal friction
	Sourcing	Recruiting researchers who fit both scientific aims and the Web3 culture is labor-intensive and slow
	Technology Transfer Office (TTO) Complexities	University Technology Transfer Offices question novel IP and revenue-sharing models, limiting collaboration
	Funding	Blending grants, token sales, and crypto-native mechanisms lacks clear standards, creating uncertainty
	Tokenization	Mis-aligned token designs can erode community trust and impact scientific project sustainability

predefined conceptual domains at the outset and then refine them inductively (Mayring and Fenzl, 2019). Krippendorff's content analysis provides a general methodology across qualitative and quantitative variants, and centers on valid inferences from texts to their contexts of use through explicit attention to unitizing, sampling, coding instructions, and the reliability and validity of interpretations (Krippendorff, 2018). The framework cautions against assuming the stability of meaning without systematic checks, which is germane to traceable coding decisions in organizational research, although it does not prescribe a

specific combination of deductive and inductive category constructions (Krippendorff, 2018).

Kracauer's interpretive statement established the legitimacy of qualitative content analysis by arguing that meaningful content includes latent dimensions that can elude purely numerical summaries and therefore requires theoretically justified categories anchored in persuasive readings of the material (Kracauer, 1952). This perspective underwrites the use of verbatim anchor quotations and thick descriptions to ground analytic abstractions, which directly supports the

reporting standards adopted in this study (Kracauer, 1952). Grounded theory is not a content analysis in the narrow sense, yet its coding procedures have strongly influenced qualitative category work by distinguishing open coding to name concepts, axial coding to relate categories, and selective coding to integrate core categories (Strauss and Corbin, 1990). Debates over the role of prior theory led to the notion of theoretical sensitivity and later constructivist clarifications that recognized the co-construction of meaning and the analyst's standpoint (Glaser and Strauss, 2017; Charmaz, 2006). Grounded theory excels when the aim is maximal emergence with minimal *a priori* structuring, which differs from the present design that intentionally organizes analysis around predefined domains while remaining open to additional themes (Glaser and Strauss, 2017; Strauss and Corbin, 1990; Charmaz, 2006).

Kuckartz's Qualitative Content Analysis formalizes a combined deductive and inductive procedure in a transparent workflow that begins with a small set of concept-driven main categories derived from the research question, interview guide, and prior literature, followed by a retrieval-based inductive elaboration of subcategories (Kuckartz, 2014). The recommendation to retain the main categories preserves the category system and facilitates systematic retrieval and comparison, whereas the use of anchor quotations ensures transparency and intersubjective comprehensibility (Kuckartz, 2014). This sequencing fits organizational studies that require theoretically grounded starting points and empirical sensitivity to unexpected content that emerges during later coding cycles, which matches the present study's need to analyze relevant challenges across DeSci DAOs (Kuckartz, 2014).

3.3 Data analysis

The interviews were recorded and transcribed using fireflies.ai, a solution compliant with the Service Organization Control 2 (SOC 2), the European Union's General Data Protection Regulation (GDPR), and the United States' Health Insurance Portability and Accountability Act (HIPAA) (<https://fireflies.ai/security>). All automated transcripts underwent manual review and revision, adhering to the transcription conventions outlined by Kuckartz (2014). These rules entail transcribing speech verbatim while clearly marking speakers; employing punctuation and minor linguistic smoothing to enhance readability; explicitly indicating significant pauses and interruptions; and appropriately marking unclear or unintelligible passages. Whenever automated transcription was insufficient to fully capture nuances or contexts, segments of the interviews were manually re-transcribed in their entirety.

The qualitative content analysis (QCA) of the interview data followed Kuckartz's systematic six-phase QCA approach (Kuckartz, 2014). The sequence comprised (1) data preparation and intensive first reading; (2) deduction of concept-driven main categories from theory, the research question, and the interview guide; (3) first-cycle coding of the complete corpus with the main categories; (4) retrieval of all passages per category and inductive elaboration of subcategories; (5) category-based analyses; and (6) documentation and reporting of results. Case attributes included founder status

and functional role(s), which were used in role-stratified category-based comparisons.

In line with this process, three main domains (operations, technology, and organization) were defined deductively as the initial analytical categories. These categories reflect the complementary, yet distinct dimensions of DAO functioning identified in prior research, formulated in the research question, and represented in the interview guide. Within each domain, subcategories were inductively elaborated from the interview data during successive coding cycles to ensure that the coding frame remained both theoretically grounded and empirically sensitive.

Guided by Kuckartz's QCA workflow, a provisional, concept-driven set of main categories was derived from the literature and interview guide (Augustin et al., 2023; Weidener et al., 2024; Wright, 2021; Schneider et al., 2022). The initial categories were independently applied and formed by both authors, with passages that did not fit or suggested additional dimensions being noted down. The resulting code assignments were compared during a synchronous consensus meeting; any disagreements served to sharpen category definitions, merge overlaps, and inductively create subcategories. Once consensus was achieved, all transcripts were recoded using the revised categories, and the final coding results were jointly reviewed and approved by both authors.

3.4 Ethical considerations

All the participants consented to the recording, analysis, and use of their data for research purposes. The study involved only adult participants (aged 18 years and older), did not include sensitive topics or vulnerable populations, and all data was anonymized. Given these factors and the independent nature of the research conducted without institutional affiliation, formal ethical approval was not deemed applicable. However, the study adhered to established ethical guidelines for qualitative research, including the European Code of Conduct for Research Integrity, ensuring transparency, voluntary participation, informed consent, and data confidentiality (ALLEA, 2023).

4 Results

The qualitative content analysis of ten expert interviews resulted in the identification of six main categories and 19 subcategories. Each of the defined subcategories is supported by at least one expert quotation. A comprehensive overview of all the identified main categories and their corresponding subcategories is provided in Table 2.

4.1 Main category 1: governance

Effective governance of DAOs in DeSci has emerged as a central challenge. Experts have emphasized the need for clear mechanisms for representation, fostering active participation, and enhancing token utility.

4.1.1 Subcategory 1: representation

Representation was discussed in terms of who should make important decisions within the DAO, specifically questioning the involvement of token holders without relevant expertise.

“But do we need 200 token holders that have no idea what’s going on with the science to be really deciding all of the projects and funding and all of that? Probably not.” — E10

This perspective highlights a recurring dilemma: achieving a balanced representation between expertise-driven and token holder-driven decision-making structures. This suggests the need for governance models that prioritize scientific expertise alongside community interests. Some interviewees proposed specialized committees or working groups to bridge this representation gap, emphasizing that effective governance may require hierarchical elements, despite the decentralized ethos of DAOs.

4.1.2 Subcategory 2: participation

Low engagement and participation in governance processes was identified as an important challenge.

“There’s very low participation in governance. (...) we definitely need some solution to increase participation in governance. (...) People don’t even read the proposals.” — E4

This quote underlines a critical operational bottleneck where the lack of active community involvement negatively impacts DAO functionality, pointing towards the necessity of innovative methods or tools to stimulate meaningful engagement and interest to participate in governance.

4.1.3 Subcategory 3: token utility

The utility and function of governance tokens have surfaced as a common concern, specifically regarding their practical usage and incentive structures within DeSci-DAOs.

“One of the biggest problems I see is the token utility in the DAOs because we know people join their communities and they ask about the token and what they can do with it.” — E4

The experts emphasized that governance tokens must serve functions beyond governance and voting rights. Several experts have highlighted the need for broader applications, such as gated access to research data, or participation in experimental protocols, as mechanisms to incentivize active participation and foster long-term ecosystem engagement.

4.2 Main category 2: financials

Financial management has emerged as a core operational challenge for DAOs in DeSci, particularly in managing treasuries, developing sustainable token economics, handling accounting complexities, and ensuring financial transparency.

4.2.1 Subcategory 1: treasury management

Interviewees highlighted challenges related to managing DAO treasuries effectively, particularly emphasizing the gap

between the necessary financial expertise and current practices within DAOs.

“(...) thinking about how to manage the treasury (...) and doing that while not being a token scientist.” — E5

This statement underscores the complexity of treasury operations in DAOs, illustrating the need for specialized financial expertise to effectively manage treasury assets without losing strategic alignment. Participants emphasized that without professional financial management, DAOs risk inefficiencies and poor strategic decisions, which could undermine their financial sustainability.

4.2.2 Subcategory 2: token economics

Experts highlighted a mismatch between scientific value creation and token price dynamics.

“(...) there’s a big disconnect between the value that we’re producing and then the valuation of the market.” — E8

A founder from another DAO echoed the point, stressing that the underlying economic model still requires refinement:

“I think there’s a lot of work to do on that side of token economics.” — E7

Together these perspectives highlight the need for more rigorous token-economic designs that anchor price dynamics to verifiable research outputs.

4.2.3 Subcategory 3: accounting and reporting

Accounting has emerged repeatedly as an operational bottleneck, mainly due to the complexity of reporting requirements and the friction encountered when bridging crypto transactions with traditional finance systems.

“(...) every transaction that is being made on-chain or off-chain needs to be reported (...) it’s accounting because still everyone needs to be paid and wants to spend money and that needs to be reported.” — E1

As one core contributor put it more bluntly:

“Accounting is annoying. It’s extremely complicated.” — E10

The quotes illustrate the fundamental complexity of accounting in DAOs and highlights the urgent need for streamlined reporting tools and methods. Participants stressed that existing manual and fragmented accounting approaches are time-consuming and error-prone, necessitating comprehensive solutions to efficiently bridge crypto-native and fiat financial systems.

4.2.4 Subcategory 4: transparency

Transparency related to financial operations was identified as essential, yet challenging, particularly in tracking resource allocation, payments, and treasury balances in an accessible manner.

“(...) good to see where the money is going. How much money, who’s getting paid in tokens, who’s getting paid in ETH. How much money do we spend on a monthly basis? Which teams are getting the most?” — E1

A co-founder added that off-chain holdings hide a large part of the picture:

“If most of our money is in a bank account, none of those transactions are on-chain or being logged (...)” — E8

The dual on/off-chain complexity highlight the essence of transparency issues, emphasizing the necessity of clear and accessible financial tracking systems to facilitate accountability and build community trust.

4.3 Main category 3: contribution

Effectively managing contributors is critical to the success of the DAO. The participants described substantial challenges in recruiting the right talent, maintaining contributor engagement, ensuring fair compensation, and fostering accountability.

4.3.1 Subcategory 1: lack of talent

Interviewees frequently emphasized the shortage of qualified personnel, particularly highlighting the difficulties of finding individuals with technical skills or crypto-native expertise.

“(...) we don’t have people to build, you can have millions of ideas and if you have zero developers, who’s going to build this?” — E1

The lack of talent was echoed by another expert, referring to the existing talent available:

“The contributor pool in the DeSci ecosystem is almost useless right now.” — E4

These converging views indicate that talent pipelines, not ideas, are the principal growth constraint. Experts emphasized that the absence of technically proficient and crypto-native contributors severely constrains their ability to execute strategic initiatives.

4.3.2 Subcategory 2: engagement

Sustaining meaningful contributor engagement has emerged as recurring challenge. The experts stressed the importance of motivating contributors to take active roles within the DAO.

“I try to always encourage people to have more agency because a DAO, and I see this across all BioDAOs, is an agent-centric system that doesn’t move forward unless people actually take the agency in their own hands to do things.” — E7

While agency is essential, several interviewees added that contributors still need clear guidance on *how* to translate that agency into concrete action within the DAO.

“The big challenge with the community is showing them how and learning how they can be helpful.” — E5

Effective engagement therefore couples empowerment with concrete entry points and ownership pathways within DAOs.

4.3.3 Subcategory 3: compensation

Fair and effective compensation was highlighted as a central issue, with DAOs facing operational overhead and challenges in assessing the quality of their contributions.

“The friction point we had was compensation for contributors, making sure that we’re compensating fairly. Making sure that people aren’t just booking hours, but not delivering work.” — E3

Another expert highlighted the complexity of assessing contributions as a requirement for compensation:

“There is some operational overhead in assessing whether somebody actually contributed what they say.” — E8

Both quotes illustrate the complexity of managing compensation systems within DAOs, stressing the importance of clear frameworks and mechanisms for accurately evaluating and rewarding contributor efforts.

4.3.4 Subcategory 4: accountability

Limited accountability among contributors was identified as a prominent challenge, often resulting in uncertainty around the reliability and commitment of DAO members.

“(...) agreements are flexible so people treat it flexibly and then that means they sometimes won’t show up.” — E8

This quote highlights the necessity for clearer accountability structures, underscoring how flexibility in agreements, while attractive, can negatively affect project continuity and reliability if not properly managed.

4.4 Main category 4: onboarding

Interviewees consistently described onboarding as a critical factor that influences the success and effectiveness of DAO operations. Effective onboarding processes were linked directly to improved community engagement, while challenges faced by non-Web3-native participants were repeatedly emphasized.

4.4.1 Subcategory 1: resources and training

Effective training and accessible onboarding resources have emerged as important requirements for the DAOs. Experts have described the need for systems that educate new contributors and integrate them seamlessly.

“(...) Onboarding into a DAO will increase engagement and people’s understanding of how they can contribute. And I think that’s the most important thing that a DAO also needs to be super clear about.” — E9

Another expert highlighted the importance of onboarding for the community:

“If you have a good onboarding system, you will probably have a good community base” — E4

Respondents frequently suggested creating standardized onboarding guides, educational materials, and interactive training sessions. These strategies were seen as critical for reducing confusion and enabling contributors to rapidly become productive and engaged members of the community.

4.4.2 Subcategory 2: lack of Web3 nativeness

Onboarding non-Web3-native individuals was particularly challenging, emphasizing the necessity for simplified, user-friendly methods to integrate people unfamiliar with cryptocurrency-related environments.

“A way to onboard non-crypto people into a payment system that’s super easy (...) because even explaining to someone that they need to get like a Metamask and then they need to use an exchange is a far-off concept for those who have never used it before.” — E2

This quote encapsulates the critical barrier of crypto complexity, pointing to an urgent need for intuitive, accessible tools, and processes tailored to newcomers with limited crypto knowledge.

4.5 Main category 5: operations

The operational challenges in DeSci-DAOs have emerged across several critical dimensions, including marketing complexities, inefficient project management systems, and limited collaboration.

4.5.1 Subcategory 1: marketing

Participants underscored the unique difficulty of marketing within scientific and crypto contexts, emphasizing a significant gap in expertise and resources.

“It’s so difficult to get [Marketing] right, especially when it comes to scientific stuff. You need a lot of context. It’s really difficult to get right.” — E10

Other experts highlighted the lack of contributors with marketing expertise in current DAOs:

“We don’t see any marketing people in the teams.” — E4

These insights illustrate the challenge of effectively communicating complex scientific ideas within a decentralized ecosystem, stressing the need for specialized marketing talent. Interviewees noted that effective marketing strategies require extensive contextual knowledge of both science and cryptocurrencies.

4.5.2 Subcategory 2: project management

Project management has emerged as a significant operational burden, with the fragmented use of various tools leading to inefficiency.

“I would say the project management tool is number one, probably the biggest lift.” — E9

Another expert highlighted the current lack of standardization between DAOs:

“Each DAO has their own CRM so that’s also quite time consuming” — E6

These statements emphasize the operational necessity of robust, unified project management solutions tailored specifically to DAO workflows.

4.5.3 Subcategory 3: inter-DAO collaboration

A common concern was the insufficient exchange of knowledge and best practices among the DAOs, highlighting opportunities for structured inter-DAO collaboration.

“Another thing that I have noticed is limited cross-pollination of best practice across DAOs. (...) Some way to share best practices across the DAOs, discussing what’s work, what doesn’t, etc.” — E6

This perspective underscores the potential value of formal collaboration channels and knowledge-sharing platforms to enhance collective operational effectiveness.

4.6 Main category 6: science

The scientific operations of DAOs in DeSci present unique challenges, particularly regarding sourcing qualified researchers, navigating complexities with Technology Transfer Offices (TTOs), funding strategies, and effectively managing tokenization efforts.

4.6.1 Subcategory 1: sourcing

Interviewees indicated that identifying and recruiting qualified researchers was notably resource intensive, presenting a substantial operational barrier.

“It is very time-consuming to look for researchers.” — E6

This emphasizes the need for more efficient tools or platforms specifically designed to streamline the sourcing and engagement of qualified scientific contributors. Participants frequently mentioned that, despite extensive networking, sourcing researchers aligned with specific DAO objectives remains challenging.

4.6.2 Subcategory 2: technology transfer office complexities

Negotiations and interactions with Technology Transfer Offices have been consistently described as significant obstacles, often slowing down project execution.

“Actually, the researchers are always very keen because they understand what’s wrong with the current scientific funding. The issue is mostly with the TTO, the TTOs are unbearable.” — E6

Another expert highlighted the impact of TTO complexities for project velocity:

“Getting the right feedback from the TTOs ... is reducing the velocity of some projects.” — E3

This quote underscores the systemic friction points between DAOs and traditional institutional frameworks, highlighting the necessity for clearer protocols or tools that streamline interactions with TTOs.

4.6.3 Subcategory 3: funding

The interviewees highlighted the ongoing challenges in determining effective strategies for securing funding for scientific projects.

“It has been a challenge understanding the best way to bring funds for projects.” — E3

This reflects a recurring theme around uncertainty and complexity in funding mechanisms, indicating the need for standardized and reliable funding approaches within the DeSci DAO ecosystem.

4.6.4 Subcategory 4: tokenization

Effectively managing tokenization as a core operational strategy has been emphasized as critical, yet currently inadequate, and requires significant improvement.

“The DAOs are not only in the science funding business (...) but also in the tokenization sector. It is very important to get this piece of it right. And we don’t have that yet.” — E7

This insight points to a fundamental gap in current operational practices around tokenization, emphasizing the need for clearer models that integrate scientific project funding with sustainable token economies. Respondents frequently stressed the challenge of aligning token strategies with scientific objectives, noting that poorly structured tokenization could undermine community trust and project sustainability.

4.7 Role specific perspectives

Using the case attributes in [Table 1](#) [founder status and functional role(s)], a category-based, case-oriented comparison indicates where the subcategories were most salient by respondent type. This allows for a contrast of categories in cases of role-specific patterning. Role labels indicate salience, rather than exclusivity.

(Co-) Founder role: In this sample, the founder status denotes the co-founder. It is noteworthy that none of the experts included in this study started a DAO alone. Founders emphasized strategic governance tensions and external positioning. Representation concerns focused on token-weighted decision making without scientific expertise [E10: “do we need 200 token holders ... deciding all of the projects”]. Financial themes centered on tokenomics and tokenization as system-level levers for

sustainability [E8: “disconnect between the value ... and the valuation of the market”] and the need to get tokenization “right” for scientific viability [E7]. Marketing complexity at the science-plus-crypto interface has been highlighted as a persistent challenge [E10]. Founders who also hold community functions stressed practical levers, including clearer guidance for contributors [E5: “The big challenge ... is showing them how they can be helpful”] and treasury discipline under limited in-house token expertise [E5].

Science and dealflow leads: Science-facing roles concentrate on executive frictions. Researcher sourcing was described as time-intensive [E6: “very time-consuming to look for researchers”], and Technology Transfer Offices were cited as recurring bottlenecks [E6: “the TTOs are unbearable”] with measurable velocity impacts [E3: “getting the right feedback from the TTOs ... is reducing the velocity”]. Funding-strategy uncertainty was also prominent [E3: “challenge understanding the best way to bring funds”].

Operations leads: Operation-oriented respondents focus on coordination systems and tooling loads. Project management was named the heaviest lift [E9: “the project management tool is ... the biggest lift”], and fragmentation across customer-relationship and workflow tools was reported as a drag on efficiency [E6: “Each DAO has their own CRM ... time consuming”].

Product and legal leads: Product and legal roles connect financial and scientific categories. Interviewees underscored the misalignment between market and research value [E8] and argued that robust tokenization models are a prerequisite for durable scientific funding [E7]. The selected statements also point to compensation-assessment overhead within contributor management [E8].

Community and communication leads: Community-facing roles emphasize onboarding barriers for non-crypto contributors and participation gaps. Wallet and exchange setups were cited as steep entry hurdles [E2], whereas a shortage of marketing capacity in teams reduced outreach effectiveness [E4]. Low proposal readership and voting participation were noted as governance frictions [E4].

5 Discussion

This study reveals that while DeSci DAOs aim to decentralize and democratize the governance and funding of scientific research, they remain constrained by many of the same operational and structural challenges that plague traditional organizations, often amplified by the absence of formal hierarchies, regulatory clarity, and institutional maturity. Across all six domains analyzed (governance, financials, contribution, onboarding, operations, and science), a recurring tension emerges between the ideological promises of decentralization and the pragmatic demands of coordination, expertise, and accountability. Contrary to the assumption that decentralization inherently solves organizational inefficiencies, the findings demonstrate that DAOs often reproduce or exacerbate these issues under new forms. Notably, the scientific dimension, arguably what distinguishes DeSci DAOs from other DAO forms, reveals the deep structural friction between blockchain-native logic and conventions of institutional science. Thus, instead of displacing legacy systems, DeSci DAOs often operate in hybrid models that recombine traditional organizational practices with the experimental affordances of blockchain technology. Outside this

sample, empirical patterns of DAO governance show both workable designs and recurring pitfalls. Mechanisms such as delegated voting and clearly scoped committee authority can improve proposal quality and participation when aligned with transparent incentives (Weidener et al., 2025; Lustenberger et al., 2025). Conversely, widely discussed failures show how contract vulnerabilities and governance capture can undermine decentralization claims, with crisis responses often reverting to centralized coordination to protect assets or reputation (DuPont, 2018; Mehar et al., 2017). These contrasts situate the interview findings within the broader DAO trajectory and reinforce the need for expertise-sensitive representation, practical participation pathways, and cautious reliance on token-based voting (Wright, 2021; Schneider et al., 2022). This hybrid trajectory resembles earlier phases of Internet development, where democratizing ideals materialized only as common standards, and governance matured through iterative coordination (Berners-Lee and Fischetti, 1999; Shadbolt et al., 2006). When socio-technical alignment is achieved, decentralizing initiatives can measurably widen access and accelerate collaboration, as seen in open-access and networked science projects under clear standards and incentives (Suber, 2012; Nielsen, 2011). Accordingly, a compatibility-first path for DeSci DAOs, which prioritizes interoperable data and process standards, transparent incentive and review mechanisms, and workable interfaces with incumbent institutions, offers a more plausible route to durable change than wholesale displacement attempts (Berners-Lee and Fischetti, 1999; Shadbolt et al., 2006).

5.1 Governance

The governance challenges identified within DeSci DAOs highlight core tensions reminiscent of traditional organizational contexts, reflecting broader theoretical debates on organizational design and decentralized governance. The issue of representation, specifically regarding the decision-making power of token holders lacking relevant scientific expertise, aligns with the distinction between true decentralization and ‘decentralized in name only’ (DINO), where nominal decentralization fails to distribute meaningful decision-making power to qualified stakeholders (Sims, 2024). This echoes Mintzberg’s classical theory of organizational structures, which emphasizes the strategic alignment between authority and expertise to enhance decision-making effectiveness in decentralized contexts (Weidener et al., 2024). Further compounding governance difficulties are the low level of participation, a known challenge of DAOs that often struggle to foster sustained member engagement in governance activities, resulting in ineffective or poorly informed decision-making processes (Schneider et al., 2022). This issue parallels the traditional governance contexts, where clearly defined communication mechanisms and trust building for active stakeholder participation are essential (Aarseth et al., 2013). Additionally, the lack of clear token utility identified in DeSci DAOs poses substantial structural challenges, where tokens without clearly defined roles or utilities fail to incentivize meaningful engagement or long-term member retention. Collectively, these issues suggest that DeSci DAOs could potentially benefit from the governance mechanisms used in traditional organizational

contexts, such as expert-based advisory boards or specialized committees, to balance broad stakeholder engagement with informed, expertise-driven governance (Schneider et al., 2022; Weidener et al., 2025; Tamai and Kasahara, 2024).

Although DAOs are described as automated governance through smart contracts, drafting and parameterizing these contracts typically occurs within core teams and working groups, with wider community ratifying proposals rather than writing rules itself (Wright, 2021; El Faqir et al., 2020). Uneven participation in this upstream stage shifts the influence toward technically skilled early contributors and large token holders, and subsequent codification can entrench initial power asymmetries (Schneider et al., 2022; Tan et al., 2023). Mitigations such as delegated voting, review committees, and iterative upgrades channel expertise into decision-making while retaining community oversight, but they do not fully resolve participation gaps, which qualifies democratization claims by separating the rules from who votes on them (Weidener et al., 2025; Lustenberger et al., 2025; Tan et al., 2023). Realizing a coherent framework for DeSci DAOs faces persistent constraints. Jurisdictional fragmentation and cross-border participation complicate harmonization and consistent enforcement. The unsettled legal status of DAOs sustains compliance uncertainty across securities, commodities, taxation, and consumer protection regimes (Wright, 2021; Schneider et al., 2022). In DeSci, overlapping biomedical oversight and data-protection obligations add further complexity, whereas misalignment with university IP and Technology Transfer Offices can delay translation (Weidener and Spreckelsen, 2024). Given the slow pace of legislative cycles relative to technical change, near-term progress is more plausible through co-regulatory instruments such as voluntary standards, disclosure templates, and sandbox arrangements.

5.2 Financials

Financial management challenges within DeSci DAOs, including treasury management, token economics, accounting complexity, and transparency, reflect both familiar organizational governance issues and the unique complexities introduced by blockchain-based environments. Treasury management within DAOs is hindered by a critical gap in specialized financial expertise, echoing observations of traditional organizations that struggle to match growing operational complexity with internal financial capabilities (Fountain, 2004). Specifically, the management of digital assets, market volatility, and strategic resource allocation requires skills not inherently possessed by typical DAO contributors, which introduces the risk of inefficient resource use or misaligned strategic financial decisions (Santana and Albareda, 2022). Furthermore, the inherent tensions within token economics, notably the persistent disconnect between intrinsic DAO-generated value and external market valuation, mirror established valuation challenges faced by technology-driven start-ups, where speculative markets often fail to accurately reflect the underlying organizational fundamentals (Miles et al., 2010; Caviezel et al., 2024).

The accounting complexity arising from integrating on-chain and off-chain financial activities presents novel

regulatory and technical challenges, substantially extending traditional multijurisdictional reporting complexities (Tan et al., 2023; Galbraith, 2014). DAOs must navigate ambiguous legal and regulatory frameworks across multiple jurisdictions, thus complicating compliance efforts and accountability (Caviezel et al., 2024). Finally, financial transparency is simultaneously a fundamental promise and practical difficulty for DAOs, as public blockchain records facilitate unprecedented openness and create potential risks regarding sensitive financial and strategic information (Schneider et al., 2022). Consequently, the development of DAO-specific financial management systems, including tailored accounting software, decentralized auditing protocols, and sophisticated transparency mechanisms, has become imperative to leverage the advantages of blockchain technology while effectively mitigating traditional financial governance challenges.

5.3 Contribution

The main category “Contributions” encompasses contributor work, engagement, compensation models, and performance assessment. It reflects enduring organizational challenges that are intensified by decentralized structures, token-based incentives, and distributed decision-making, and therefore warrants focused discussion. Particularly evident is the scarcity of specialized talent, notably developers skilled in blockchain technology, highlighting similar recruitment challenges seen in traditional technology-driven sectors that highly value and compete for niche expertise (Galbraith, 2014). However, within DAOs, the implications of talent scarcity are magnified because of the critical role that technical expertise plays in sustaining decentralized infrastructure and maintaining project momentum (Santana and Albareda, 2022). Contributor engagement further complicates DAO effectiveness, as high degrees of autonomy and decentralized workflows must be balanced against a clear role delineation to sustain active participation and motivation. This engagement dilemma resembles broader organizational challenges in global and decentralized projects, emphasizing the need for clearly communicated responsibilities alongside autonomy (Aarseth et al., 2013; Weidener et al., 2024). Additionally, compensation fairness and transparency have emerged as prominent issues within DAOs, exacerbated by flexible, informal work agreements common in decentralized environments. Such arrangements frequently lead to difficulties in objectively assessing contributions and aligning incentives, paralleling traditional organizational difficulties in performance evaluation and reward systems (Miles et al., 2010). Accountability within DAOs is notably challenging because of inherently flexible and informal contributor relationships, leading to uncertainty regarding reliability and continuity in project execution (Tan et al., 2023). These accountability concerns suggest that DAOs would significantly benefit from strategically adapting traditional human resource practices enriched by innovative blockchain-enabled mechanisms that support objective contribution assessment and reinforce reliability and transparency within decentralized work structures (Schneider et al., 2022).

5.4 Onboarding

Effective onboarding has emerged as a pivotal operational concern in DAOs, directly affecting contributor engagement, retention, and overall organizational performance. While its significance is well recognized in the traditional organizational literature, the decentralized and technologically intensive nature of DAOs introduces unique onboarding complexities (Ballandies et al., 2025). In particular, the lack of structured training programs and onboarding resources impedes the ability of new contributors to effectively navigate organizational norms, tools, and governance processes (Fountain, 2004). These challenges mirror the concerns raised in conventional settings regarding the importance of early stage orientation, knowledge transfer, and social integration, which are foundational for role clarity and performance (Ballandies et al., 2025; Miles et al., 2010). However, DAOs face a distinct barrier in integrating individuals unfamiliar with blockchain technologies and Web3 infrastructure. Unlike traditional environments, where onboarding typically assumes baseline digital literacy, DAOs often initiate contributors to entirely unfamiliar technological paradigms. This problem is exacerbated by the lack of standardized tooling and highly fragmented user experiences across DAO platforms (Santana and Albareda, 2022). The interview findings confirm that basic participation, such as navigating token-based compensation or understanding smart contract governance, can be prohibitively complex for newcomers, especially those without a crypto-native background. This complexity not only inhibits inclusivity but also risks creating a core-periphery dynamic in which only highly specialized users remain active contributors (Schneider et al., 2022). To bridge this gap, DAOs could benefit from adapting traditional onboarding practices such as mentoring systems, modular educational content, and stepwise access levels, while leveraging their native blockchain affordances for automation, credentialing, and gamified learning (Caviezel et al., 2024).

5.5 Operations

Operational challenges in DAOs, particularly those involving marketing, project management, and inter-DAO collaboration, closely resemble issues well-documented in traditional organizational contexts, although they manifest heightened complexity due to the absence of centralized coordination and formal hierarchies. In the marketing domain, DAOs face a dual challenge: communicating both the scientific sophistication of their mission and the technical nature of blockchain to a heterogeneous and often disengaged audience. Unlike traditional companies, which benefit from hierarchical brand control and dedicated communication teams, DAOs rely on dispersed actors, which complicates message coherence and weakens outreach effectiveness across channels and stakeholder groups (Ballandies et al., 2025; Miles et al., 2010). Equally, project management in DAOs suffers from inefficiencies owing to the fragmented use of tools and platforms. Without formalized leadership or standard procedures, teams experience coordination bottlenecks and duplicative efforts, particularly when contributors operate asynchronously or across different time zones. These issues align

with the global project coordination challenges described in management literature, where a lack of integrative infrastructure undermines accountability and productivity (Aarseth et al., 2013). Inter-DAO collaboration emerges as both a need and challenge. Although DAOs share overlapping missions, the absence of formal alliance mechanisms and knowledge-sharing protocols limits collective learning and resource pooling. This contrasts with traditional organizations that often institutionalize collaboration through alliances, joint ventures, or consortia supported by shared governance mechanisms (Galbraith, 2014). To overcome these limitations, DAOs should leverage blockchain-native innovations, such as decentralized knowledge graphs, interoperable protocols, and shared coordination layers, while learning from structured forms of interorganizational cooperation.

5.6 Science

The scientific focus represents the defining features of DeSci DAOs and differentiates them most clearly from other DAO typologies. As such, the challenges in this category, researcher sourcing, engagement with Technology Transfer Offices (TTOs), funding mechanisms, and tokenization, require particular scrutiny. The difficulty of sourcing qualified researchers who are both scientifically competent and receptive to decentralized workflows reflects long-standing obstacles in global scientific collaborations, where geographic, institutional, and disciplinary fragmentation hinders the recruitment and retention of top talent (Aarseth et al., 2013). Within DeSci DAOs, these challenges are amplified by the need for contributors to navigate Web3 environments, token-based incentives, and novel governance structures. This results in a persistent bottleneck in the recruitment pipeline, with projects delayed or limited by the scarcity of blockchain-literate researchers willing to operate in a decentralized infrastructure (Santana and Albareda, 2022). Moreover, interactions with Technology Transfer Offices, already considered bureaucratically rigid in traditional academia, have become even more fraught in decentralized contexts, where legal liabilities and contractual norms remain lacking. The lack of clear institutional compatibility between DAOs and university-based IP regimes undermines the transfer of innovation and requires novel frameworks that respect both decentralization and institutional obligations (Caviezel et al., 2024). In the absence of such models, many DeSci initiatives have struggled to advance early stage negotiations. Funding was another critical challenge identified through the interviews. DeSci DAOs operate in a hybrid environment that must reconcile traditional grant-based funding with blockchain-native approaches like token launches and quadratic funding. This hybridity creates operational uncertainty, with few standards for budget forecasting, milestone validation, or risk-sharing between contributors and funders (Santana and Albareda, 2022). The absence of best practices around tokenization, which is often viewed simultaneously as a financial instrument, incentive mechanism, and governance tool, introduces volatility into an already-uncertain ecosystem. As such, the promise of using tokens to democratize science funding remains unrealized without clearer economic design and regulatory stability (Schneider et al., 2022).

6 Conclusion

The exploration of challenges faced by DeSci DAOs reveals a complex interplay between decentralized ideals and the pragmatic requirements of scientific research. Although the ambition to democratize governance and funding strongly resonates with stakeholders, significant operational bottlenecks persist. The reliance on specialized expertise, which must be consistently available and incentivized, presents a challenge that is not easily resolved by token-weighted mechanisms. Limited contributor accountability and difficulties in tracking financial and operational data underscore the necessity for more structured project management practices. Similarly, the often-fragmented nature of scientific collaborations complicates the coordination of interdisciplinary research, increasing the importance of clear onboarding strategies and flexible yet robust oversight models. Moreover, the tension between the dynamic ethos of DAOs and institutional realities, such as technology transfer restrictions or alignment with peer-review standards, further underscores the need for tailored regulatory frameworks and alignment strategies. Rather than wholly supplanting established systems, DeSci DAOs appear to operate most effectively through the careful integration of tried-and-tested organizational principles with technology-enabled decentralized governance structures. These results highlight that genuine innovation in DeSci requires the adoption of both technology and human practices. DAOs can thrive if they adopt robust yet agile coordination protocols, create reliable pathways for scientific validation, and reconcile the promise of distributed decision making with the demands of rigorous research.

This study advances the literature on DeSci DAOs by establishing an empirically grounded typology across operations, technology, and organization, and by showing that their interactions are systematic rather than incidental: coordination bottlenecks intensify where onboarding and tooling fragments and governance choices shape accountability and participation. A role-stratified analysis specifies salience by respondent type: co-founders focus on strategy, representation, token economics, and tokenization; science and dealflow leads to researcher pipelines, Technology Transfer Office interfaces, and funding strategy; operations leads stress tooling and process standardization; product and legal leads foreground valuation alignment and tokenization for scientific sustainability; and community and communications leads prioritize onboarding and participation. The study addresses science-specific frictions missing in general DAO research, especially institutional interfaces, and the translation of scientific value into token-based incentives, compensation, and performance assessment. Methodologically, the analysis operationalizes qualitative content analysis with deductive main categories, inductive subcategories, and case attributes, enabling reproducible role-aware contrasts. These results sharpen debates on expert-sensitive governance, incentive design, and the integration of on-chain mechanisms with off-chain research.

Preprint statement

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical approval was not required for the studies involving humans because all the participants consented to the recording, analysis, and use of their data for research purposes. The study involved only adult participants (aged 18 years and older), did not include sensitive topics or vulnerable populations, and all data was anonymized. Given these factors and the independent nature of the research conducted without institutional affiliation, formal ethical approval was not deemed applicable. However, the study adhered to established ethical guidelines for qualitative research, including the European Code of Conduct for Research Integrity, ensuring transparency, voluntary participation, informed consent, and data confidentiality (ALLEA 2023). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

LW: Writing – review and editing, Methodology, Validation, Writing – original draft, Formal Analysis, Conceptualization, Data curation. LB: Data curation, Formal Analysis, Writing – review and editing, Conceptualization, Writing – original draft.

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Conflict of interest

Authors LW and LB were employed by BIO.XYZ, C/O MJP PARTNERS AG.

Generative AI statement

The author(s) declare that Generative AI was used in the creation of this manuscript. During the preparation of this manuscript, the authors used OpenAI's ChatGPT (versions 4o) to assist with grammar correction, spelling, formatting, and reformulation of selected passages for clarity and style. All content generated through this tool was critically reviewed, edited, and approved by the authors. The authors take full responsibility for the integrity and accuracy of the final manuscript.

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