VitaCollab: A Privacy-First Personal Health Record Platform with Consent-Driven Workflows and a Longitudinal Health Timeline

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***Abstract*—The fragmentation of medical records across disconnected hospital systems remains one of the most persistent structural problems in modern healthcare. Patients routinely lose control of their own clinical data, creating barriers to continuity of care, emergency access, and informed self-management. While Electronic Health Record (EHR) systems have digitised individual institutions, they have not resolved the fundamental asymmetry in which providers, rather than patients, hold authority over personal health information.**

This paper presents VitaCollab, a privacy-first, patient-centric Personal Health Record (PHR) platform that reframes data ownership as a first-class architectural concern. Built on a fullstack web architecture using Next.js, Node.js with Express, and MongoDB, VitaCollab introduces two principal contributions: (1) a *consent-driven approval workflow* that requires explicit patient authorisation before any hospital-uploaded record becomes part of the canonical health history, and (2) a *longitudinal Health Timeline* interface that presents medical events in a chronologically ordered, visually coherent feed inspired by social media interaction patterns. Security is realised through JSON Web Token (JWT) authentication with refresh-token rotation, RoleBased Access Control (RBAC), and layered AES-256 encryption at the application, file, and database levels. The platform is deployed at https://vitacollab.in and its architecture is evaluated against the requirements of India's Ayushman Bharat Digital Mission (ABDM), demonstrating structural readiness for national PHR certification.

***Index Terms*—Personal Health Record, Patient Data Ownership, Consent-Driven Workflow, Health Timeline, Next.js, JWT Authentication, RBAC, AES-256 Encryption, ABDM, Digital Health, Healthcare Interoperability**

I. INTRODUCTION

Healthcare data management has undergone a fundamental shift over the past three decades, moving from paper-based filing systems to digitised records maintained within hospital information systems. Despite this transition, the structural problem of *patient data ownership* has remained largely unresolved. Medical records continue to be siloed within the institutions that generated them. A patient who has consulted multiple hospitals, diagnostic centres, or specialists over a period of years typically has no single, verified, and complete account of their own health history [1], [4].

This arrangement creates a condition of involuntary *institutional dependency*. Accessing historical records for a second opinion, presenting a coherent clinical summary in an emergency, or understanding one's longitudinal health trajectory all require negotiating with institutions that hold data but have no structural incentive to share it efficiently [6], [15]. The problem is compounded by the proliferation of additional data sources — wearable sensors, point-of-care devices, and patient-reported outcome instruments — that generate clinically relevant information outside any institutional system [2].

Electronic Health Record (EHR) systems, despite decades of investment, have delivered outcomes below early projections. A comprehensive review spanning twenty-five years of deployment concluded that barriers including inconsistent data standards, poor interoperability, and high cognitive burden on end users have persistently limited EHR utility relative to their original promise [4], [5]. Patient-facing extensions of these systems, commonly referred to as *tethered* PHRs or patient portals, mitigate this only partially: they grant read access to a subset of data held by a single institution but do not support patient-initiated data entry, cross-institutional aggregation, or patient control over what is retained [17], [18].

The Indian government's response to this structural deficit is the Ayushman Bharat Digital Mission (ABDM), a national framework designed to enable a federated, consent-based digital health ecosystem [2], [12]. ABDM establishes the architectural infrastructure but its success depends on the availability of highquality PHR applications through which citizens can exercise the rights the framework grants them.

This paper presents VitaCollab (https://vitacollab.in), a PHR platform designed to occupy precisely this space. The platform's public landing page, shown in Figure 1, communicates its three core guarantees — Secure, Patient Controlled, and Encrypted — and previews the three-step data flow: Hospital Upload → Patient Approval → Shared with Specialist. The paper's specific contributions are:

1) Architectural: A consent-driven record approval workflow implementing patient data ownership as a finite state machine with PENDING, APPROVED, and DISPUTED record states and an immutable audit trail.
2) Interface: A longitudinal Health Timeline that organises medical events in chronological order within an interaction paradigm familiar from social media feeds.
3) Strategic: A detailed architectural mapping of VitaCollab's design to the structural requirements of ABDM, with a concrete roadmap for national certification.
4) Engineering: A production deployment at vitacollab.in using Next.js (App Router), Node.js with Express, and MongoDB with a modular service-repository architecture.

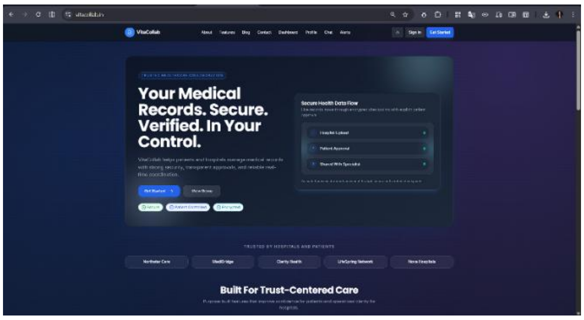


Fig. 1. VitaCollab public landing page (vitacollab.in). The hero panel presents the platform's core value proposition and shows a live preview of the consent data flow: Hospital Upload, Patient Approval, and Shared with Specialist. Trust badges — Secure, Patient Controlled, Encrypted — and hospital partner logos reinforce institutional credibility.

II. RELATED WORK

A. The EMR–EHR–PHR Conceptual Hierarchy

Three categories of digital health record must be distinguished to situate VitaCollab correctly within the literature.

An *Electronic Medical Record* (EMR) is an institutionscoped digital record replicating the clinical chart of a single healthcare provider [3], [13]. It serves internal administrative and clinical functions effectively but provides no mechanism for cross-institutional data portability and grants patients no control over the data it contains [6], [15].

An *Electronic Health Record* (EHR) extends the EMR concept with interoperability as an explicit design goal [2], [4]. In practice, realisation of this goal has been constrained by inconsistent terminological standards, competing vendor interests, and the absence of patient consent as a governing principle [5], [12].

A *Personal Health Record* (PHR) places the patient at the centre by defining the health record as an artefact managed, curated, and controlled by the individual [7], [8]. The PHR literature distinguishes three sub-types: *standalone* systems that operate independently; *tethered* systems that are patient-facing extensions of a single institution's EHR; and *interconnected* systems that aggregate data from multiple sources under patient authority [17], [19]. VitaCollab is designed as an interconnected PHR.

B. The Usability Crisis in Digital Health Interfaces

The academic literature on EHR usability identifies a persistent and severe problem. Interfaces characterised by deep menu hierarchies, excessive navigational steps, and fragmented presentation impose a high cognitive load that contributes to clinician burnout and reduces system adoption [9], [10]. These findings extend to patient-facing applications: engagement with tethered PHRs has historically been low [7], [11].

The visualisation of clinical events as a *timeline* has been proposed as a structural response to this fragmentation [20]. VitaCollab extends this insight by embedding the timeline within an interaction paradigm already internalised by most adult users: the social media feed. This decision is grounded in evidence that patients with chronic conditions are disproportionately active on visual, feed-based social platforms and that leveraging existing mental models reduces onboarding friction and increases sustained engagement [11], [17].

C. National Strategic Context: ABDM

The Ayushman Bharat Digital Mission (ABDM) constitutes the most significant structural intervention in Indian healthcare data management [2]. Its governing principles are a federated data architecture, an open ecosystem of interoperable building blocks, and patient consent as the sole gateway to any data exchange [12]. VitaCollab's internal approval workflow is structurally equivalent to the HIE-CM consent lifecycle, as analysed in Section VI.

D. Research Gap

The literature identifies a gap that current systems do not fill: a PHR platform that simultaneously (a) implements patient data ownership as a primary architectural constraint, (b) delivers a usable interface exploiting patterns already embedded in users' daily digital behaviour, and (c) is technically structured to participate in India's national consent-based interoperability framework. VitaCollab is designed to address this threefold gap.

III. COMPARATIVE ANALYSIS

Table I summarises VitaCollab's positioning relative to conventional digital health platforms.

TABLE I
COMPARATIVE ANALYSIS: CONVENTIONAL PLATFORMS VS. VITACOLLAB

Dimension	Conventional Platforms	VitaCollab
Data Owner-ship	Records held by institutions; patients have readonly access with no dispute authority.	Every upload requires explicit patient approval before entering the canonical timeline.
Record Porta-bility	History fragmented across institutional silos; transfer requires manual requests.	Unified timeline aggregates records from all connected hospitals; ABDM integration extends portability nationally.
Audit Transparency	Audit logs maintained by platform; not visible to the patient.	Patient-facing timeline is the audit log; disputed records create an immutable non-repudiation record.
Interface	Folder/table navigation with high cognitive overhead.	Chronological feed modelled on social media; low cognitive overhead and high scanability.
Architecture	Centralised within a single institution or vendor ecosystem.	Federated by design; structured for ABDM compliance.
Security	Security responsibility concentrated in the platform operator.	Layered AES-256 encryption; RBAC enforces leastprivilege access.

IV. VITACOLLAB SYSTEM ARCHITECTURE

A. Architectural Principles

VitaCollab is designed around three non-negotiable principles.

Consent precedence. No clinical record may enter a patient's permanent health history without an explicit affirmative action by the patient, enforced at the data layer.

Role isolation. Every system actor operates within a strictly bounded permission space enforced by middlewarelevel RBAC.

Auditability. Every consequential state transition is logged with an immutable timestamp and attributed actor identity.

B. Technology Stack

Table II details the technology choices.

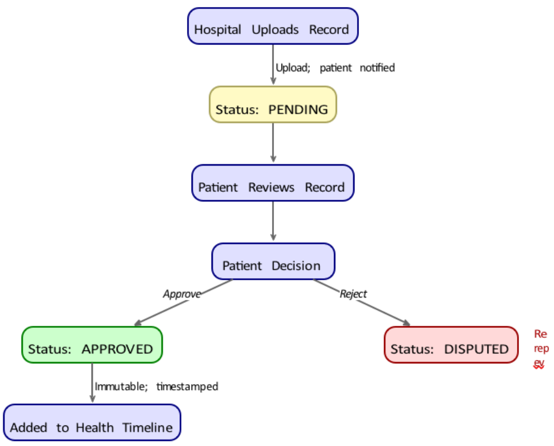
TABLE II
VITACOLLAB TECHNOLOGY STACK AND DEPLOYMENT ARCHITECTURE

Component	Technology

Frontend Client	Next.js (App Router), React.js, Tailwind CSS
Backend Server	Node.js, Express.js (REST API)
Database	MongoDB (primary), PostgreSQL (reporting)
Authentication	JWT with refresh-token rotation
Access Control	Role-Based Access Control (RBAC)
File Storage	S3-compatible cloud object storage
Realtime Events	WebSocket channel with polling fallback
Deployment	Vercel (frontend), Render/Railway (backend)
Domain	vitacollab.in

C. User Role Model

Patient. The data owner and primary beneficiary. Patients review pending uploads, approve or dispute records, and interact with the Health Timeline. Ownership is enforced by matching the JWT sub claim to the patient_id field on every timeline event.
Hospital. Healthcare providers who upload clinical records on behalf of a named patient. Hospital users may view status of submitted records but cannot modify a record once the patient has acted upon it.



Administrator. Platform operators responsible for verifying hospital credentials and managing system-wide configuration, with no access to patient record content.

D. The Consent-Driven Approval Workflow

The central innovation of VitaCollab is its consent-driven approval workflow, which implements patient data ownership as a finite state machine (FSM) governing every clinical record. Figure 2 illustrates the state transitions, and Figure 3 shows the hospital-facing upload interface that initiates the workflow.

Pending state. When a hospital user uploads a clinical document the system creates a timeline_event with status pending and notifies the target patient. As shown in Figure 3, the hospital interface at vitacollab.in/upload-record presents five record types (Report, Prescription, Bill, Lab, Imaging), a Fig. 2. Consent-driven approval workflow modelled as a finite state machine. The DISPUTED state preserves the record as an immutable audit artefact without admitting it to the canonical Health Timeline.

patient identifier field, and a right-panel submission checklist to minimise errors before the patient review stage. A realtime "Record Status Tracking" panel at the bottom displays Pending/Approved/Rejected states of all submitted records, with a "Cross-network sync active" indicator confirming that the WebSocket event channel is operational.

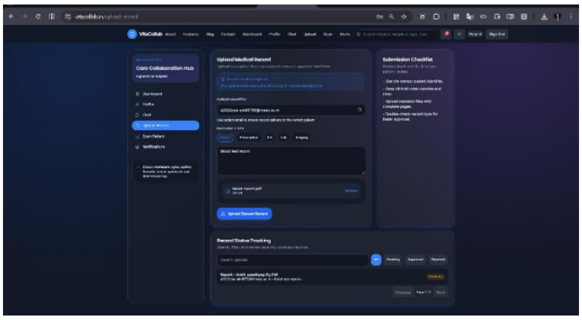


Fig. 3. Hospital-facing *Upload Medical Record* interface (vitacollab.in/ upload-record). The form supports five record types and identifies the target patient by email. A submission checklist on the right reduces errors before patient review. The lower panel shows real-time record status tracking with Pending/Approved/Rejected filter controls.

Approved state. If the patient confirms the record's accuracy, the system transitions the status to approved, renders the event immutable, and adds it to the chronological Health Timeline with a timestamp and the patient's authenticated identity.
Disputed state. If the patient identifies an error — factual inaccuracy, incorrect treatment record, or fraudulent billing — the record status transitions to disputed and is retained as an immutable non-repudiation record. This provides patients with a structured basis for challenging incorrect medical billing and supporting insurance dispute processes.

E. The Health Timeline Interface

Figure 4 shows the patient-facing Health Timeline at vitacollab.in/timeline. The interface presents clinical records as a chronologically ordered feed, with each event card displaying the record type, uploading institution, file reference, audit trail link, approval attribution, and status badge (Pending in amber, Approved in green). Filter controls (All, Pending, Approved, Rejected) and a full-text search bar allow navigation of large medical histories without folder hierarchies. Records awaiting action display prominent Approve and Reject controls, minimising the interaction cost of the consent decision.

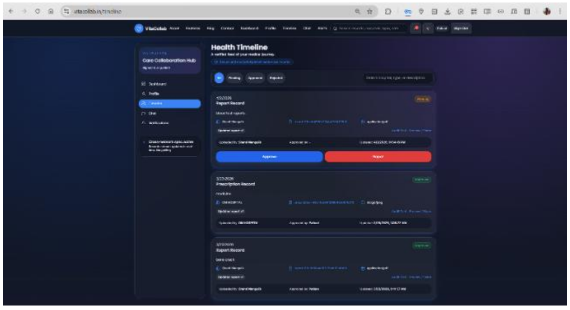


Fig. 4. Patient-facing *Health Timeline* (vitacollab.in/timeline). Records are displayed as a chronological feed with colour-coded status badges. Each card exposes the uploading institution, file reference, approval attribution, timestamp, and an Audit Trail link. Pending records display prominent Approve and Reject controls to minimise consent friction. The "Cross-network sync active" status confirms real-time event delivery.

The social-media feed metaphor is a deliberate UX decision grounded in evidence that patients with chronic conditions are disproportionately active on visual, feed-based platforms and that leveraging established interaction patterns reduces onboarding friction and increases sustained engagement [11], [17].

F. Database Schema

The timeline_events collection is the operational core of the data layer. Documents are stored independently of the user record to avoid the *growing document anti-pattern*, in which embedding an unbounded array within a parent document degrades read performance as medical history accumulates.

```
{
  "_id":           "ObjectId",
  "patient_id":    "ObjectId",
  "hospital_id":   "ObjectId",
  "event_type":    "String",
  "event_title":   "String",
  "event_date":    "Date",
  "status":        "pending | approved | disputed",
  "file_url":      "String",
  "metadata":      "Object",
  "uploaded_by":   "ObjectId",
  "actioned_by":   "ObjectId",
  "created_at":    "Date",
  "last_updated":  "Date"
}
```

The actioned_by field records the patient identifier at the time of approval or dispute, creating an immutable attribution chain from upload to final disposition. The metadata object is schema-flexible, accommodating document-type-specific fields without requiring a separate collection per document type.

G. Authentication Flow

VitaCollab implements a dual-token JWT architecture aligned with OAuth 2.0 and OpenID Connect (OIDC) conventions. On successful authentication the server issues a shortlived *access token* and a longer-lived *refresh token* whose hash fingerprint is persisted server-side. Refresh token rotation limits the replay window for compromised tokens to the access token's short lifetime.

V. SECURITY AND PRIVACY FRAMEWORK

VitaCollab treats security not as a supplementary layer but as a structural design constraint from which no component is exempt.

A. Layered Encryption Strategy

Encryption in transit. All communication between the Next.js frontend, the Node.js backend, and all hosted services is enforced over TLS/HTTPS [15].

File-level encryption at rest. All uploaded binary files are stored in cloud object storage with server-side AES-256 encryption. Access requires a valid pre-signed URL generated by the backend after RBAC validation.

Application-level encryption. Sensitive fields within the metadata object are encrypted using aes-256-cbc via the Node.js native crypto module before database transmission, with a unique Initialisation Vector (IV) per operation. This ensures PHI remains unreadable even in a database-level breach [19].

Database-level encryption. The MongoDB managed service provides AES-256 encryption of all collections, indices, and operational logs at rest by default.

B. Access Control Implementation

RBAC is implemented as Express.js middleware performing three sequential checks per request: token signature verification, claims extraction and role identification, and route-level permission evaluation. A request that fails any check is rejected before any business logic executes. Ownership enforcement is a distinct additional constraint: a patient's JWT sub claim must match the patient_id field in any timeline event they attempt to approve or dispute, preventing horizontal privilege escalation.

C. Compliance Mapping

Table III maps VitaCollab's security controls to HIPAA Technical Safeguard categories, which represent internationally recognised best practice for PHI protection [7], [15].

TABLE III
VITACOLLAB SECURITY CONTROLS VS. HIPAA TECHNICAL SAFEGUARDS

Safeguard	VitaCollab Implementation
Access Control	JWT authentication enforces identity; RBAC enforces role and ownership-level authorisation per route and per record.
Audit Controls	Every upload, approval, and dispute generates a timestamped, attributed log entry. The DISPUTED state functions as a non-repudiation audit artefact.
Integrity	Application-level AES-256 prevents silent modification of stored PHI. The immutable APPROVED state prevents retroactive alteration of canonical records.
Transmission Security	End-to-end TLS/HTTPS across all channels; pre-signed object URLs prevent unauthorised direct file access.

VI. ALIGNMENT WITH ABDM

A. VitaCollab as a PHR Application

In ABDM terminology, VitaCollab fulfils the role of a *PHR application*: a citizen-facing platform through which individuals manage health records linked to an Ayushman Bharat Health Account (ABHA) number — a unique 14-digit identifier serving as the cross-institutional key enabling longitudinal health data to be associated with a single individual [2].

B. HIU and HIP Roles

ABDM requires interoperating applications to implement one or both of two roles: Health Information User (HIU) and Health Information Provider (HIP). VitaCollab is designed to function as both.

VitaCollab as HIU. When a clinician needs to access a patient's records held by an external institution, VitaCollab initiates a consent request through the HIE-CM gateway. On patient approval, the HIE-CM returns a digitally signed consent artefact, which VitaCollab presents to the source HIP to retrieve the authorised data [12].

VitaCollab as HIP. When an external clinician (HIU) requests records held within VitaCollab, the Node.js backend validates the consent artefact, queries MongoDB for status: approved records, and transmits encrypted data to the HIU [19].

C. Congruence with HIE-CM Consent Logic

VitaCollab's internal approval workflow is the functional equivalent of the HIE-CM's consent lifecycle. Both systems implement the same sequence: a provider raises a data transfer request, the patient reviews and acts, and data is made available or withheld accordingly. VitaCollab's pending→approved state transition directly mirrors the HIE-CM consent acceptance event. Extending VitaCollab to support ABDM external consent flows therefore requires wrapping, not redesigning, the existing approval workflow.

D. Certification Roadmap

Table IV presents a structured pathway for achieving formal ABDM certification through sandbox integration, security audit
(WASA), and formal assessment by the Quality Council of India (QCI) and the National Accreditation Board for Hospitals and Healthcare Providers (NABH).

TABLE IV
PROPOSED ABDM INTEGRATION ROADMAP FOR VITACOLLAB

Component	Role	Integration Action
ABHA	Unique patient ID	Node.js backend calls ABDM ABHA APIs via OAuth 2.0; ABHA ID linked to the users collection.
HIE-CM (HIU)	Inbound consent	React frontend triggers Node.js API to submit consent request to HIE-CM; on approval, data fetched from source HIP.
HIE-CM (HIP)	Outbound consent	Node.js endpoint receives HIE-CM request; validates consent artefact; pushes encrypted approved records to HIU.
HFR/HPR	Facility registry	HFR/HPR APIs called during hospital registration to auto-verify institutional credentials.
UHI	Service discovery	UHI open protocol integration to enable patients to discover and book UHI-compliant health services.

VII. INTELLIGENT FEATURES: ROADMAP

The following features are proposed as future extensions, made possible by the longitudinal structured data accumulated by the Health Timeline.

AI-assisted medication adherence. A predictive model trained on the VitaCollab timeline — using prescription events, follow-up records, and patient-reported outcomes — could identify non-compliance risk before it manifests clinically [11].

Predictive analytics. The timeline dataset supports machine learning models for no-show prediction, scheduling optimisation, and at-risk patient identification.

NLP-based timeline curation. Named Entity Recognition
(NER) and temporal information extraction applied to discharge summaries and clinical notes could automatically populate the Health Timeline with structured events derived from unstructured text [20]. Anomaly detection algorithms could further flag significant deviations from a patient's baseline for clinical review.

VIII. PROPOSED EVALUATION FRAMEWORK

A. Usability Evaluation

A within-subjects comparative study exposing representative users to both VitaCollab's timeline interface and a conventional folder-based health record system, measured using the System Usability Scale (SUS) [10]. A mean SUS score of 68 is the accepted threshold; the evaluation target for VitaCollab significantly exceeds this. Supplementary instruments including the mHealth App Usability Questionnaire (MAUQ) and Technology Acceptance Model (TAM) will capture adoption intention.

B. Security Evaluation

Formal penetration testing conducted in accordance with the OWASP Web Security Testing Guide (WSTG), targeting authentication and session management (WSTG-ATHN, WSTGSESS), authorisation and RBAC (WSTG-ATHZ), and input validation including NoSQL injection (WSTG-INPV).

C. Performance Evaluation

API load testing using Artillery or Apache JMeter, simulating ramp loads of 100, 500, and 1000 concurrent users. Targets: API response latency ≤300ms at p95 under 500 concurrent users; error rate <1% at 500 concurrent users.

D. Patient Engagement Evaluation

A longitudinal pilot study with real patients and at least one partner hospital over a minimum of six months. Metrics: patient activation rate (proportion approving or disputing at least one record in month one); curation ratio (approved vs. disputed records); six-month retention; and patient-reported outcomes via structured interviews.

IX. DISCUSSION AND CONCLUSION

A. Summary of Contributions

This paper has presented VitaCollab, a privacy-first PHR platform advancing the state of the art along three dimensions.

The *consent-driven approval workflow*, illustrated in Figure 2, operationalises patient data ownership as a concrete engineering mechanism. The tripartite

PENDING/APPROVED/DISPUTED FSM ensures patients have meaningful control at the moment clinical claims are introduced into their health history. The DISPUTED state transforms the platform into a non-repudiation instrument patients can use to contest institutional claims — a capability absent from all current tethered PHR systems.

The *Health Timeline* interface, shown in Figure 4, resolves the usability crisis of conventional EHR navigation by applying a design paradigm that patients already understand from daily digital interaction.

The *ABDM alignment* analysis demonstrates that VitaCollab's internal consent architecture is a functional analogue of the HIE-CM consent lifecycle, significantly reducing the engineering effort required for national certification.

B. Limitations

VitaCollab is a functional prototype deployed at vitacollab.in. The evaluation framework proposed in Section VIII has not yet been executed; all performance, usability, and security claims therefore remain theoretical pending empirical validation. ABDM integration requires formal sandbox testing and thirdparty security audit. AI-assisted features require data collection at scale, model training, and clinical validation.

C. Conclusion

VitaCollab demonstrates that placing the patient at the centre of health data architecture is not merely an ethical imperative but a tractable engineering challenge addressable with commercially available open-source technologies. By combining a consent-first approval workflow, a social-context Health Timeline (Figures 1–4), and a layered security framework aligned with international best practice and India's ABDM strategy, VitaCollab provides a coherent blueprint for nextgeneration patient-centric health record platforms.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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This research received no external funding.

DATA AVAILABILITY

The live system described in this paper is publicly accessible at https://vitacollab.in. No additional datasets were generated or analysed during this study.

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