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Digital Health Record Management System for Migrant Workers in Kerala: A MERN Stack Approach for Portable Healthcare Identity and Public Health Surveillance

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Abstract: *Kerala hosts an estimated 25 to 35 lakh migrant workers drawn from Bihar, West Bengal, Odisha, Jharkhand, Assam, and Uttar Pradesh — a demographic that contributes substantially to the state's construction, manufacturing, and service sectors yet remains almost entirely absent from its formal healthcare documentation infrastructure. Paper-based clinic registers stay behind when workers relocate to a new district, language differences obstruct accurate medical history-taking, and no mechanism exists to detect infectious disease clusters forming within migrant settlements. This paper presents the Digital Health Record Management System (DHRMS), a centralised cloud-based web application built on the MERN stack (MongoDB, Express.js, React.js with TypeScript, Node.js) that directly addresses these gaps. Every registered worker receives a unique Health ID encoded as a QR code, functioning as a portable healthcare passport across any participating facility in Kerala. A three-role architecture — Worker, Doctor, and Admin — is enforced through Role-Based Access Control (RBAC) and JSON Web Token (JWT) authentication. Doctors retrieve a patient's complete medical history by scanning a QR code via a browser-based optical scanner, then log diagnoses, prescriptions, vaccinations, and upload reports in real time. Workers access their own records and download a PDF health card through an interface supporting English, Hindi, and Malayalam via i18next internationalisation. Administrators monitor a live analytics dashboard powered by Recharts and receive automated outbreak alerts when three or more cases of the same disease type appear within a 30-day rolling window. The system places the entire technology burden on the clinic rather than the patient, making it accessible regardless of a worker's digital literacy. This approach directly supports UN Sustainable Development Goal 3: Good Health and Well-Being by integrating a marginalised transient population into Kerala's mainstream healthcare ecosystem.*

Keywords: Digital Health Records, Migrant Worker Healthcare, QR Code Health ID, MERN Stack, Role-Based Access Control, Disease Outbreak Detection, Multilingual Healthcare Interface, Public Health Analytics, Kerala, SDG Goal 3.

I. INTRODUCTION

Kerala's economy is sustained in significant measure by migrant labour. Workers from Odisha, Assam, West Bengal, Bihar, Jharkhand, and Uttar Pradesh arrive in substantial numbers each year to fill positions in construction, manufacturing, and the informal service sector. State government estimates place the total migrant worker population at 25 to 35 lakh, making this one of the most numerically significant demographic groups in Kerala today.

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Despite this, migrant workers remain almost entirely outside the state's formal healthcare documentation infrastructure. When a worker visits a government hospital or primary health centre for the first time, their medical history exists, if at all, as handwritten entries in a register at that specific facility. When the same individual moves to a different district or returns the following season, that record stays behind. No mechanism connects these scattered entries, and no doctor treating the patient a second time has any reliable access to what occurred during the first treatment.

The consequences extend well beyond administrative inconvenience. A treating physician without knowledge of a patient's allergy to a common antibiotic, or unaware that the patient completed only half a tuberculosis medication course, is operating with a clinically meaningful information deficit. For workers who cannot communicate in Malayalam and whose medical vocabulary in any language may be limited, this risk is compounded further.

At the public health level, the situation carries equally serious implications. Migrant workers frequently live in densely shared accommodation near construction sites, conditions in which communicable diseases spread rapidly. Because no unified health record system captures diagnoses across this population, the Health Service Department lacks any mechanism to detect a disease cluster forming within migrant settlements before it has escalated into a localised outbreak.

This paper presents the Digital Health Record Management System (DHRMS), a centralised cloud-based web application designed to address these problems systematically. The system provides every registered migrant worker with a permanent, portable digital health identity accessible via QR code at any participating facility in Kerala. It enables doctors to retrieve a patient's complete medical history within seconds of arrival, and it provides public health administrators with a live analytical view of disease patterns across the migrant population.

II. RELATED WORK

Several existing systems address portions of the problem space, but none resolves the specific combination of portability, accessibility, multilingual usability, and population-level surveillance required for migrant worker healthcare in Kerala.

The Ayushman Bharat Digital Mission (ABDM) introduced the ABHA (Ayushman Bharat Health Account) identifier, a 14-digit unique health identity number intended as a backbone for federated electronic health records across India [1]. However, ABDM onboarding requires stable Aadhaar or mobile number linkage, and adoption among informal migrant workers remains limited [2]. Workers who frequently change phones and lack consistent address documentation face structural barriers to enrolment that the ABDM architecture does not adequately address.

eSanjeevani, the national telemedicine platform launched by the Ministry of Health and Family Welfare, enables video-based teleconsultation between patients and doctors [3]. The platform assumes that patients possess smartphones and reliable internet connectivity — conditions that cannot be guaranteed for migrant labour populations. Furthermore, eSanjeevani focuses primarily on consultation delivery and does not maintain portable longitudinal health records that remain accessible across facilities.

Blockchain-based electronic health record proposals, such as the framework examined by Christian Esposito and colleagues [4], offer theoretical advantages in data immutability and decentralisation. However, practical deployments face transaction latency, infrastructure complexity, and operational costs that make them unsuitable for widespread deployment in primary health centres and low-resource clinical environments across Kerala. Conventional Hospital Management Information Systems (HMIS) operated by the National Informatics Centre and private vendors digitise internal hospital workflows effectively but continue to create institution-specific data silos where records do not follow patients across facility boundaries [5].

The LEMS (Labour Employment and Management System) portal operated by the Kerala government captures demographic and employment data for registered migrant workers but contains no clinical history, health records, or disease-monitoring capability [6]. The healthcare vulnerability of migrant populations has also been recognised internationally by the World Health Organization, particularly regarding continuity of care and access inequity among

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transient populations [8]. Studies on temporary and seasonal migration in India further highlight how frequent mobility disrupts continuity in healthcare delivery and documentation [9].

Technological components used in the proposed system are based on established open-source and cloud platforms. QR-based identification and browser-native scanning are implemented using the html5-qrcode library [10]. Administrative analytical dashboards are developed using Recharts [11], while multilingual support across English, Hindi, and Malayalam is implemented using i18next [12]. Cloud-hosted document storage and aggregation queries are supported through MongoDB Atlas Documentation [13], and authentication is implemented using JSON Web Tokens based on the Auth0 JWT model [14]. Data handling considerations are aligned with the provisions of the Digital Personal Data Protection Act, 2023 [15].

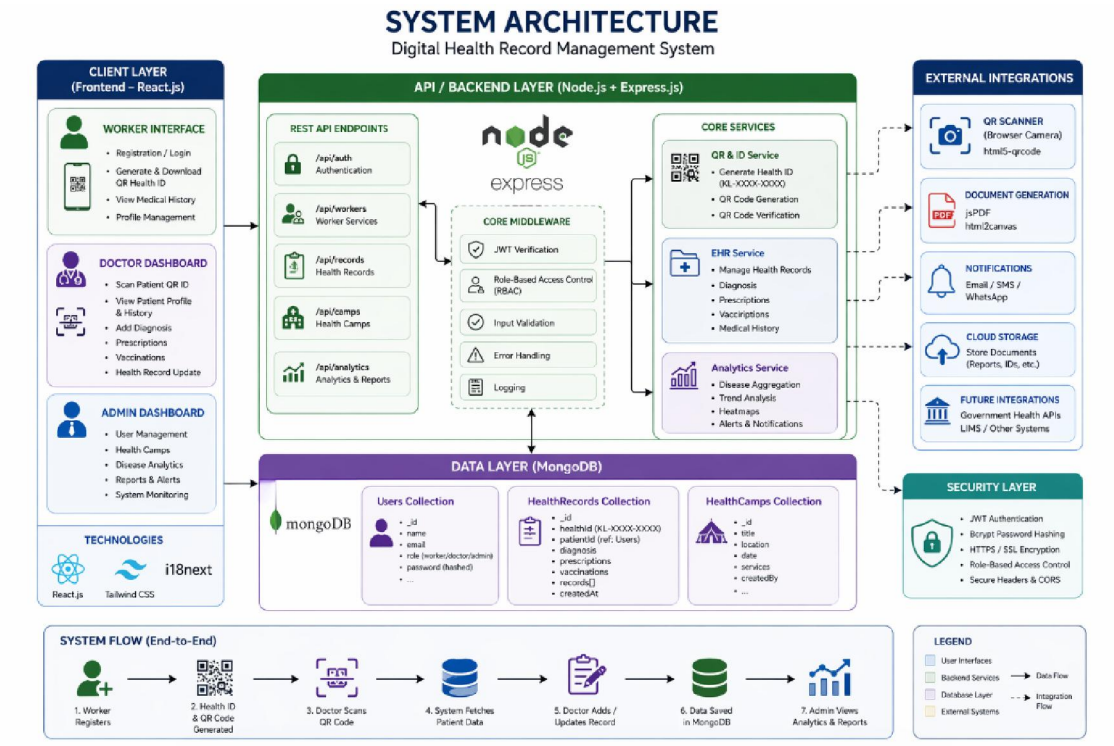
Existing systems therefore address digital identity management, telemedicine, institutional healthcare digitisation, or migrant welfare individually, but no identified solution combines portable QR-based healthcare identity, multilingual accessibility, clinic-centric operation, and disease surveillance specifically for migrant workers in Kerala.

The DHRMS proposed in this paper addresses this gap through a state-wide unified health record architecture in which the patient carries only a printed QR-enabled health card while the technological burden remains entirely on healthcare providers.

III. SYSTEM ARCHITECTURE

A. Overview

The DHRMS follows a three-tier client-server architecture. The presentation layer is a React TypeScript Single-Page Application (SPA) built with Tailwind CSS and bundled using Vite. The application layer is a Node.js Express REST API server. The data layer is a MongoDB Atlas cloud database accessed through the Mongoose ODM. Communication between tiers is exclusively through JSON over HTTPS, with JWT tokens carrying authentication context on every request.



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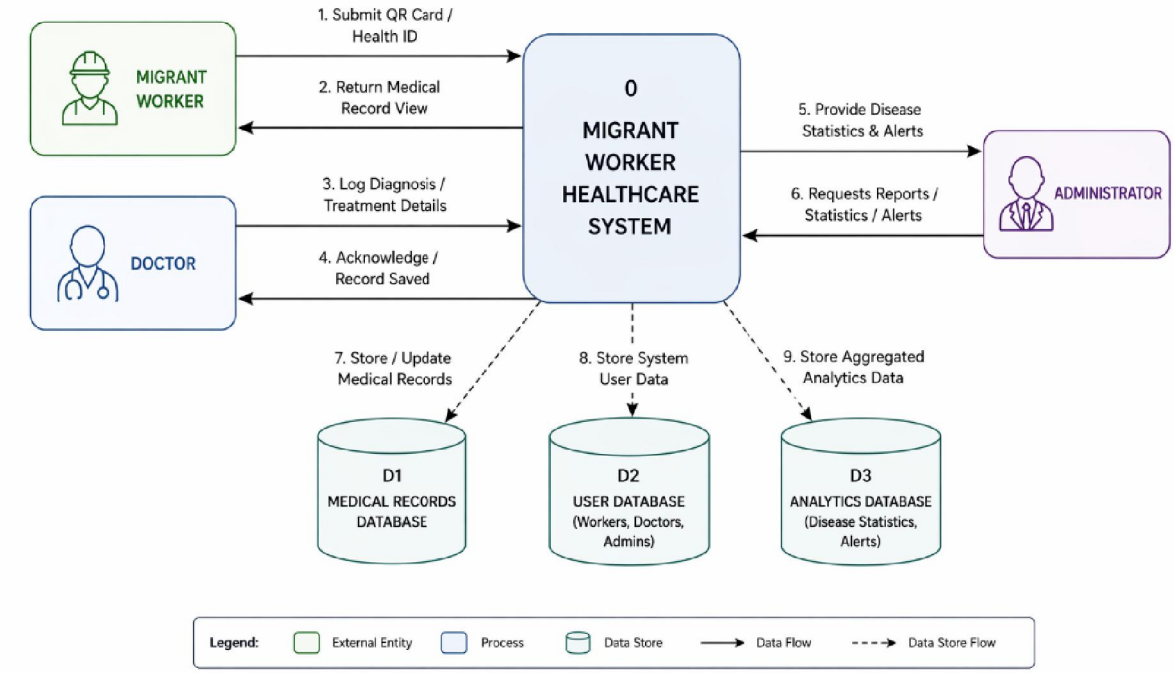
B. User Role Architecture

The system supports three distinct user roles, each with dedicated dashboard components and strictly enforced access boundaries:

- Worker: Registers on the platform, receives a unique Health ID, views personal health records, downloads a PDF health card, uploads medical documents, and selects the interface language.
- Doctor: Searches for workers by name, scans QR codes to retrieve patient records, logs diagnoses and prescriptions, records vaccinations, and uploads medical reports. Doctors cannot access administrative statistics.
- Administrator: Views live disease distribution charts, manages automated outbreak alerts, creates and manages health camp events with volunteer assignments, and can access individual worker records for investigation.

Figure 6.3: Level 0 DFD – Migrant Worker Healthcare System



C. Health ID and QR Code System

Each registered migrant worker is assigned a unique Health ID in the format KL-XXXX-XXXX, where each X is a random decimal digit. The KL prefix anchors the identifier to Kerala's deployment context. The identifier is generated server-side, stored as a unique indexed field in the MongoDB users collection, and encoded into a QR code rendered client-side using qrcode.react.

At the point of care, doctors activate a browser-based camera scanner using the html5-qrcode library. The scanner decodes the QR code at up to 10 frames per second, extracts the Health ID from the payload, and issues an authenticated API call to retrieve the complete patient profile. The entire process from card presentation to record display takes under 2 seconds on a stable connection.

D. Security Design

Authentication is handled through JSON Web Tokens signed with a server secret. Stateless tokens are attached to every API request via an Axios request interceptor on the frontend. Passwords are stored as bcrypt hashes with a minimum

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salt round of 10. RBAC middleware on the Express server validates both token authenticity and role permissions before any data operation executes. Cross-origin requests are controlled through explicit CORS configuration, and the camera API requires HTTPS deployment enforced by browser security policy.

IV. DATABASE DESIGN

The system manages five primary MongoDB collections. Each worker's User document includes a unique healthId field and demographic data including origin state, blood group, and language preference. HealthRecord documents store individual clinical visits with references to both the worker (workerId) and attending doctor (doctorId), ensuring full traceability of every diagnosis. Vaccination documents record immunisation events with the administering doctor's identity for audit purposes. MedicalReport documents store metadata and file paths for uploaded clinical documents, with physical files held in the backend server's uploads directory. HealthCamp documents manage outreach events with embedded volunteer subdocument arrays.

MongoDB's document model was selected over a relational alternative because the nested structure of health records — a worker has many visits, each visit has multiple prescriptions and notes — maps more naturally to embedded documents than to normalised tables. MongoDB Atlas provides managed cloud hosting with built-in replication and an aggregation pipeline framework that supports the analytical queries required by the administrator dashboard without requiring separate analytics infrastructure.

TABLE I: PRIMARY MONGODB COLLECTIONS AND KEY FIELDS

Collection	Key Fields	Purpose
users	email, password (bcrypt), fullName, healthId, role, bloodGroup, originState	Central user store for workers, doctors, and admins
healthrecords	workerId, doctorId, diagnosis, diseaseType, prescription, visitDate	One document per clinical visit with full traceability
vaccinations	workerId, doctorId, name, date, administeredBy, notes	Vaccination history with audit trail
medicalreports	workerId, title, fileUrl, fileType, uploadedBy, uploadedAt	Metadata for uploaded clinical documents
healthcamps	name, district, location, date, volunteers[]	Health camp events with embedded volunteer records

V. KEY ALGORITHMS

A. Health ID Generation

The Health ID generation function produces a formatted identifier in the format KL-XXXX-XXXX where each segment is a random four-digit integer between 1000 and 9999. The identifier is stored as a unique indexed field. In the event of a collision, which has a probability below 0.003% for a database of under 10,000 workers, the Mongoose unique constraint causes the save operation to fail and the registration function retries. The collision probability decreases further as the identifier space covers 81 million distinct combinations.

B. Outbreak Detection Algorithm

The outbreak detection mechanism executes as part of the administrative alerts endpoint via a MongoDB aggregation pipeline. The pipeline first matches all health records with a visit date within the preceding 30 days, excluding general-category diagnoses. It then groups the matched records by disease type and counts occurrences per group. Any disease type where the count reaches three or more triggers an alert. Alert severity is classified as High when the count exceeds five cases and Medium for counts between three and five. The aggregation executes in under 200 milliseconds on test

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datasets of 1,000 records, comfortably within acceptable response time targets for a dashboard that refreshes on page load.

VI. IMPLEMENTATION

A. Frontend Stack

The React frontend is structured around a central AuthContext that manages session state. Dashboard components for each role — WorkerDashboard, DoctorDashboard, and AdminDashboard — are self-contained pages that fetch their own data on mount. TypeScript type annotations enforce interface contracts across all API calls. Tailwind CSS utility classes handle responsive layout. The i18next internationalisation library provides full UI translation across English, Hindi, and Malayalam with runtime language switching and browser-language detection.

QR code generation in the Worker Dashboard uses qrcode.react to render the Health ID as an SVG element. Health card PDF export uses html2canvas to render the health card component to a canvas at double resolution, which jsPDF then encodes into a downloadable landscape-oriented PDF. The doctor-facing QR scanner uses html5-qrcode to access the device camera through the browser Web API and decode the presented card within a visible detection box.

Administrative analytics use Recharts to render a PieChart showing disease distribution and a BarChart showing origin-state demographics. All chart data is fetched from the backend aggregation endpoint on each page load, providing live rather than cached statistics.

B. Backend Stack

The Node.js Express server implements a RESTful API with route-level role guards that verify both JWT authenticity and user role before any database operation. File uploads are handled by Multer with disk storage configured to the server uploads directory, returning a relative file URL stored in the MedicalReport document. The MongoDB connection string and JWT secret are managed through environment variables loaded by dotenv, ensuring no credentials appear in source code.

TABLE II: TECHNOLOGY STACK SUMMARY

Layer	Technology	Purpose
Frontend	React 18, TypeScript, Tailwind CSS, Vite	Role-specific SPA dashboards
QR Scanning	html5-qrcode 2.3.8	Browser-native camera-based QR decoding
Internationalisation	i18next, react-i18next	English, Hindi, Malayalam UI translation
Analytics	Recharts 3.8	Disease distribution and demographic charts
PDF Export	jsPDF 4.2, html2canvas 1.4	Downloadable health card generation
Backend	Node.js 18, Express.js 5.2, Mongoose 9.3	REST API with JWT and RBAC middleware
Authentication	jsonwebtoken 9.0, bcryptjs 3.0	Stateless auth and secure password storage
Database	MongoDB Atlas	Cloud-hosted NoSQL document store
File Upload	Multer 2.1	Medical document upload handling
Deployment	Vercel (frontend), Render (backend)	Cloud hosting with HTTPS certificates

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VII. TESTING AND RESULTS

System testing was carried out across unit, integration, and system testing levels. Unit tests verified the Health ID generation format, bcrypt password hashing and verification, JWT token generation and payload recovery, Mongoose model validation constraints, and i18next translation key resolution across all three language locales.

Integration testing validated the complete registration-to-login flow, health record creation and retrieval across doctor and worker roles, QR-scan-based patient lookup, admin statistics aggregation accuracy when seeded with controlled record counts, and file upload and report retrieval. System-level tests covered the complete worker journey from registration through record access, cross-role access enforcement confirming 403 responses on unauthorised routes, outbreak alert triggering at the defined threshold, language preference persistence across login sessions, and PDF health card generation with a correctly encoded QR code.

Security testing confirmed that RBAC guards prevent cross-role data access, that malformed or expired JWT tokens are rejected at the middleware layer, and that bcrypt password verification behaves correctly on both valid and incorrect credentials. Performance testing measured QR-scan record retrieval time at under 2 seconds under normal network conditions and the outbreak aggregation query response at under 200 milliseconds on a dataset of 1,000 records, both within the targets specified in the Software Requirements Specification.

The live deployment is accessible at https://labou-r.onrender.com. Screenshots of the system in operation confirmed that the Worker Dashboard correctly displays the health card with QR code, the Doctor Dashboard retrieves full worker profiles on QR scan, and the Admin Dashboard displays disease trend charts and health camp management tools.

VIII. SDG ALIGNMENT AND SOCIETAL IMPACT

The DHRMS was conceived with explicit reference to the United Nations 2030 Agenda for Sustainable Development. Its primary alignment is with SDG 3: Good Health and Well-Being, specifically Target 3.8 — achieving universal health coverage, including financial risk protection and access to quality essential healthcare services. By making a worker's health record available to any authorised provider anywhere in Kerala, the system supports healthcare continuity for a demographic that by definition does not stay in one place long enough for location-specific records to be clinically useful.

The connection to SDG 10: Reduced Inequalities is equally central. Migrant workers rank among the most economically and socially marginalised groups in India's urban informal economy. A system built specifically around their circumstances — requiring only a printed card from the patient, operating in their languages, and placing all technology requirements on the clinic — is a practical expression of health equity rather than a rhetorical one. SDG 8: Decent Work and Economic Growth is served by the occupational health documentation that emerges naturally from the record-keeping workflow. SDG 17: Partnerships for the Goals is reflected in the system's design for integration with national infrastructure including ABDM and state-level platforms including LEMS.

In concrete terms, the system transforms individual medical records into collective intelligence. The public health surveillance capability that was previously unavailable for the migrant worker demographic becomes automatic as doctors log records in their day-to-day clinical workflow. Outbreak containment shifts from reactive to proactive, reducing the risk of communicable disease spreading from migrant settlements into the general population of Kerala.

IX. LIMITATIONS AND FUTURE SCOPE

The current architecture has three principal limitations. First, the system is cloud-dependent: clinics in areas with unreliable internet connectivity cannot perform real-time QR scanning or record retrieval. A fallback to manual Health ID text entry partially mitigates this, but full offline functionality requires a service worker and IndexedDB-based local cache with sync-on-reconnect logic. Second, the clinical utility of the system depends on doctors consistently logging records after every consultation. The architecture logs the attending doctor's identity against every record to support audit trails, but mandatory data entry is a policy enforcement matter beyond the system's direct control. Third, the

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current registration requires at least one physical clinic visit per worker, which may not be achievable for newly arrived workers before they require medical attention.

Future development directions include offline mode implementation, integration with the Ayushman Bharat Digital Mission through the ABHA Health ID API, mobile native application development for field use in labour settlements, automated disease prediction through machine learning models trained on the system's aggregated data, biometric authentication as a fallback for lost QR cards, voice interface support in Hindi and Malayalam, and telemedicine consultation integration with notes appended automatically to the worker's health record.

X. CONCLUSION

This paper has described the design, implementation, and testing of the Digital Health Record Management System for migrant workers in Kerala — a centralised, cloud-based, multilingual web application built on the MERN stack. The system assigns every registered worker a portable digital health identity accessible via printed QR card at any participating facility in the state, enables doctors to retrieve complete patient records within seconds of arrival, and provides public health administrators with real-time disease surveillance across a demographic that was previously entirely absent from Kerala's health data infrastructure.

All six primary objectives of the system — unique digital health identity assignment, QR-based record access, structured clinical logging, administrative analytics with automated outbreak detection, full UI internationalisation, and strict RBAC enforcement — have been implemented and verified through unit, integration, and system testing. The live deployment demonstrates the system functioning as specified across all three user roles.

The infrastructure required for this level of healthcare inclusion is neither expensive nor technically exotic. A modern web stack, a cloud database, and a device with a camera are sufficient to build a system that any registered clinic in Kerala can operate from its first day of connection. The printed QR card that a worker carries costs nothing to produce. What this project demonstrates is that the gap between the healthcare access that migrant workers currently have and what they deserve is not a gap that requires cutting-edge technology to close — it requires applying existing technology with deliberate attention to the specific circumstances of the people who need it most.

XI. ACKNOWLEDGMENT

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