Resilience by Design

Technical Whitepaper for the Pain Tracker Project

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Abstract

Chronic pain documentation remains fragmented, privacy-compromising, and inaccessible in unstable or low-connectivity environments. This paper introduces Pain Tracker, a privacy-first, offline-capable Progressive Web App developed under the CrisisCore design framework to support longitudinal symptom documentation without reliance on centralized data storage. The system integrates trauma-informed user-experience principles, client-side encryption, and clinically aligned assessment structures, including fibromyalgia-relevant scoring frameworks, while explicitly avoiding diagnostic or treatment functionality. A local-first security architecture mitigates risks associated with data breaches, subpoenas, and broker aggregation, though device-level compromise remains outside software control. Current implementation demonstrates complete offline clinical assessment capability and structured export pathways for clinical or occupational documentation. This work proposes a resilience-oriented baseline for ethical digital health tooling in contexts where privacy, autonomy, and infrastructure instability intersect.

Problem Definition

Chronic pain affects approximately 1 in 4 Canadians, yet clinical documentation remains fragmented and inconsistent. Patients are asked to compress weeks of lived experience into 0–10 ratings during 15-minute appointments, losing critical data on sleep disruption, medication efficacy, and functional limitation. Privacy concerns further reduce disclosure—individuals withhold information when records exist beyond their control. Cloud-dependent tools fail during infrastructure instability, excluding those in housing transition, rural areas, or disaster contexts. No widely available local-first clinical journaling tool exists that combines trauma-informed design with diagnostic-grade assessment standards. This gap produces systematic underdocumentation, delayed diagnosis, and reduced access to appropriate care.

1 Executive Summary

The Pain Tracker project is an institutional-grade, privacy-first Progressive Web App (PWA) engineered to bridge the profound data gap between patient lived experience and clinical requirements. Developed by CrisisCore Systems, this application is not a traditional "wellness" tool but a localized sanctuary designed for individuals navigating chronic pain, medical trauma, and systemic instability.

Reliability is not viewed as a feature, but as a clinical requirement. The architecture is built upon four non-negotiable pillars:

- **Privacy as Architecture:** Security is a constraint enforced at the data layer through local-only persistence and AES-GCM client-side encryption.
- **Offline Resilience:** The system maintains 100% functionality during network collapse, ensuring the application "forgets" the internet exists until the user chooses to engage it.
- **Non-Exploitative Simulation:** Crisis scenarios are validated through the lived chaos of authentic survival contexts rather than treating human suffering as a commodified data point.
- **Lived Experience Integration:** Design standards are dictated by the physical and cognitive realities of medical trauma, prioritizing the "user in crisis" over corporate metrics.

2 Clinical Boundary Statement & Literature Alignment

Chronic pain is a structural public health crisis, affecting approximately 1 in 4 Canadians according to the Health Canada Canadian Pain Task Force [1]. Traditional clinical assessments often fail because they rely on "snapshots"—subjective 0–10 ratings provided during 15-minute appointments. This compression results in the loss of critical longitudinal data regarding sleep, medication effectiveness, and activity limits.

DISCLAIMER

Pain Tracker is not a medical device, does not provide diagnosis or treatment recommendations, and is intended solely for personal documentation and communication support within existing clinical relationships.

2.1 Literature Alignment and Standards

Pain Tracker formalizes the systematic tracking seen in models like the University of Washington's PainTracker [2], which monitors pain, mood, and function over time. The project integrates evidence-based scales, specifically:

- **The Widespread Pain Index (WPI):** Regional scoring support for fibromyalgia assessment.
- **The Symptom Severity Scale (SSS):** Mandated tracking for fatigue, sleep quality, and cognitive "fog" [3].

2.2 Diagnostic Thresholds & Validation

The UI provides real-time validation cues. When scores meet American College of Rheumatology (ACR)-informed severity thresholds, the system provides immediate visual feedback. This is a clinical intervention designed to empower the user to speak the "language of the system" without being consumed by its coldness, ensuring their lived experience commands medical respect.

3 Trauma-Informed UX: The "Energy Envelope" Framework

From a systems-engineering perspective, the User Experience (UX) is treated as a clinical intervention. The architecture is designed to protect the user's "Energy Envelope"—the finite cognitive and physical capacity of a person experiencing chronic pain or dissociation. Poor UX acts as a "cognitive tax" that can trigger Post-Exertional Malaise (PEM).

3.1 The 7-Step Assessment Workflow

To manage fatigue and ensure data integrity, clinical entry follows a mandatory, isolated workflow:

1. **Intensity:** A single scalar input for the immediate baseline.
2. **Anatomical Location:** Non-interactive visual mapping. *Technical Constraint:* Interactive "hotspots" are strictly forbidden to prevent the motor-control frustration common during acute flares.
3. **Symptom Complexity:** Identification of sensations (e.g., burning, stabbing).
4. **Work Impact:** Assessment of missed days and functional limitations (e.g., lifting constraints).
5. **Medication/Treatment:** Logging of interventions and activity pacing effectiveness.
6. **Quality of Life:** Correlation of the Energy Envelope with sleep and mood.
7. **Summary:** A final review to validate entries before local persistence to the encrypted vault.

3.2 Language Standards

The system replaces cold, clinical terminology with empathetic prompts to reduce psychological friction:

Clinical/Cold Language	Empathetic/Context-Sensitive Standard
Input Pain Severity	"How are you feeling right now?"
Data Submission Failed	"We couldn't save that entry locally. Let's try again."
Analyze Symptoms	"Let's look at your patterns together."
User Crisis Detected	"It looks like things are difficult. Let's use a grounding tool."

3.3 Sensory Anchors

The technical implementation requires `AccessiblePainSlider` components featuring mandatory haptic feedback "clicks" to serve as physical anchors during dissociation. `FocusTraps` are hard-coded into all modals to lock cognitive focus and prevent accidental navigation during high-stress states.

4 Adaptive Crisis Response: The Panic Mode Protocol

The architecture recognizes the "Two People, Same Body" philosophy: the user in a stable state is functionally a different user than the one experiencing a level-10 pain flare.

4.1 The Empathy Intelligence Engine

Crisis detection is handled by a local heuristic engine that analyzes pain frequency, duration, and intensity without server-side surveillance. The software remains hyper-aware of user needs locally while "forgetting" the user exists to any third party.

4.2 Visual Regression

During high-stress thresholds, the UI undergoes a "Visual Regression." Complex data entry is forbidden. The interface transforms into a high-contrast state prioritizing:

- Guided breathing exercises and sensory grounding prompts.
- Immediate access to safety resources.

4.3 Predictable Predictability

To serve as sensory anchors, all safety resources remain in fixed, identical locations. This ensures that a user experiencing dissociation can find support through muscle memory rather than cognitive processing.

5 Technical Architecture & The "Offline Guardian"

The system utilizes a hardened stack designed for reliability under environmental pressure. This architecture was developed under conditions of housing instability and infrastructure constraint, validated in non-traditional environments.

- **The Stack:** Node 20, Vite, React 18, TypeScript, and Zustand.
- **The Hardened Data Path:** User Device → Client-Side Encryption (AES-GCM) → Local Persistence (IndexedDB) → User-Controlled Export.

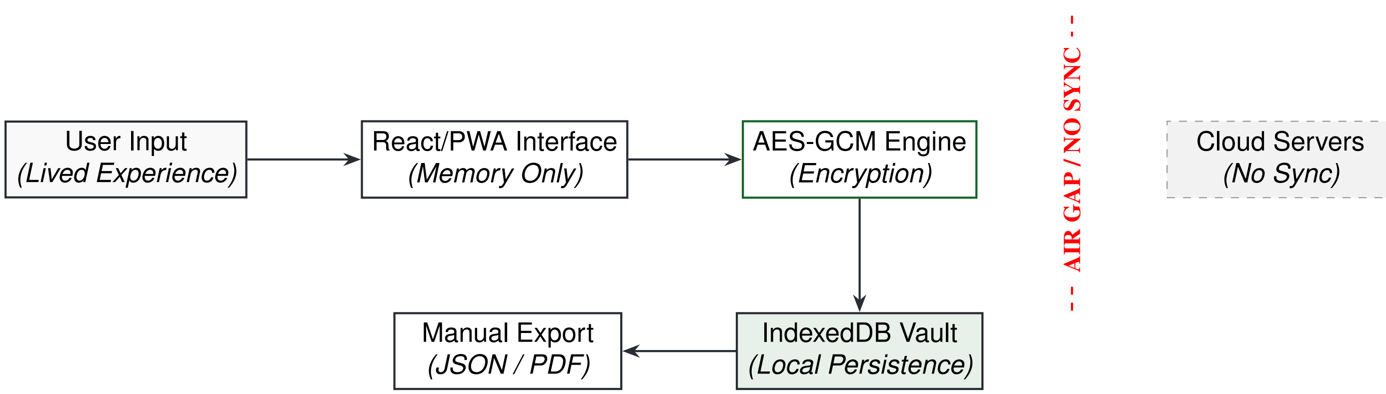

Figure 1: Local-First Encrypted Data Path. Data flows strictly from the user to the local encrypted vault. The system maintains no persistent connection to external servers.

5.1 Service Worker Logic

The "Offline Guardian" utilizes a Cache-First strategy to eliminate the "element of surprise." Transitions between online and offline states are invisible.

1. **Intercept:** Service Worker catches the resource request.

2. **Deterministic Check:** It looks into the local cache. Panic Mode logic is hard-coded into the Service Worker's deterministic manifest to ensure core stabilization tools never "disappear."
3. **Instant Serve:** Resource is served from the device instantly.
4. **Invisible Update:** Background fetches update the cache without interrupting user flow.

5.2 Persistence

The architecture enforces automatic persistence. If a user abandons a form to enter Panic Mode, their effort is preserved, honoring their limited energy.

6 Security Threat Model & Data Sovereignty

The user's device is the single "Source of Truth." This model prioritizes sovereignty over the convenience of the developer.

6.1 Adversarial Assumptions

The threat model assumes active attempts to access user data without consent. The architecture protects against remote breach, subpoena, and data broker aggregation. It further assumes that device-level compromise (malware, physical theft) cannot be fully mitigated by software alone—users are advised to employ standard device encryption.

6.2 Comparison of Storage Models

Dimension	**Traditional Cloud Storage**	**CrisisCore Local-First Architecture**
Privacy	Vulnerable to breach/subpoena	Data stays on-device; developer "forgets" user
Availability	Fails during instability	"Always-On"; 100% functional offline
User Autonomy	Provider controls data	User is the sole Source of Truth

6.3 Encryption & Logging

All data in IndexedDB is protected via AES-GCM. The system enforces Non-Reconstructive Logging: we log for system health, but the collection of temporal data (location, activity history) that could allow a third party to reconstruct a user's identity is strictly prohibited.

6.4 Honest Limits

This model accepts specific trade-offs: there is no automatic cross-device sync, and the developer cannot perform remote backups. The user is the sole owner of their data, making manual exports a prerequisite for data longevity.

7 Institutional Governance & Compliance

- **Versioning:** The project follows Semantic Versioning (SemVer), currently verified at v1.3.0.
- **Open Source:** Licensed under the MIT License, prioritizing "Inspectability." Open-source code is a prerequisite for health privacy, allowing audit of all data flows.
- **Responsible Disclosure:** Security issues may be reported via a public vulnerability reporting channel in the project repository.
- **Regional Alignment:** The system includes WorkSafe BC-oriented export capabilities, generating Form 6/7 previews and functional limitation logs (e.g., "cannot lift >5lbs") to support legal claims.

8 Current Implementation Status

1. **Empathy Intelligence Engine:** Fully implemented heuristic-based pattern analysis for struggle detection without spying.
2. **7-Step Clinical Assessment:** Fully implemented multi-dimensional tracking; interactive hotspots forbidden by design.
3. **Security Architecture:** Hardened with AES-GCM helpers and strict CSP primitives for a local-first environment.
4. **WorkSafe BC Reporting:** Integrated CSV, JSON, and PDF export utilities for insurance and clinical claims.
5. **PWA Infrastructure:** Verified service worker registration and deterministic cache-first utilities for total offline autonomy.
6. **Offline completion rate:** 100% of core assessment functions verified without network connectivity.
7. **Advanced Visualizations:** Phase 2 (Q1–Q2 2026) is currently in progress, focusing on advanced temporal progression and enhanced body heatmap visualizations.

Future Validation Pathways

The project seeks to establish formal validation through:

- Structured usability studies with chronic pain populations
- Clinician pilot feedback sessions
- Comprehensive accessibility compliance auditing (WCAG 2.1 AA)
- Privacy threat-model peer review

9 Conclusion: Towards a New Baseline

This work challenges prevailing surveillance-based assumptions in digital health. It demonstrates that high-resolution clinical utility does not require the extraction of personal data. By treating bioethics as engineering constraints rather than marketing slogans, we have built a localized sanctuary that survives when infrastructure fails. We call upon regulators and funders to adopt these standards as the new baseline for digital health, ensuring technology serves user dignity above all else.

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