

Web-Based Emergency Preparedness and Response Guidance Platform for Urban Residents

Firoz H. Lonare¹, Deep Chirwatkar², Kiran P. Pustode³

¹Student, Dept. of MCA, Karanjekar College of Engineering & Management, Sakoli

²Asst. Professor, Dept. of MCA, Karanjekar College of Engineering & Management, Sakoli

³HOD, Dept. of MCA, Karanjekar College of Engineering & Management, Sakoli

Abstract – Conventional emergency information systems predominantly deliver static, information-dense content that imposes excessive cognitive load on urban residents during high-stress crisis situations. This paper presents the design, implementation, and qualitative usability evaluation of a Web-Based Emergency Preparedness and Response Guidance Platform for Urban Residents—a full-stack web application developed using the MERN stack (MongoDB, Express.js, React, Node.js) and grounded in Human-Computer Interaction principles. The platform delivers scenario-based, step-by-step emergency response workflows for hazard types including fire, earthquake, flood, and medical emergencies, supplemented by interactive preparedness checklists, role-based admin scenario management, and a crisis-aware interface incorporating a calming breathing prompt to reduce pre-interaction panic. Fifteen functional test cases confirmed 100% module pass rates across all system components, including authentication, scenario retrieval, checklist persistence, admin CRUD operations, and responsive layout. Qualitative usability evaluation through structured interviews with five participants produced four major thematic findings: high usability and navigation efficiency, clarity and effectiveness of step-by-step guidance, a measurable positive impact on user confidence and decision-making readiness, and a moderate-to-high trust level with identified requirements for credibility enhancement. The system directly addresses the research gap identified across prior literature by delivering a unified, deployable prototype that converts emergency guidance from passive information delivery into active, task-driven user assistance.

Key Words: Emergency Preparedness, MERN Stack, Human-Computer Interaction, Scenario-Based Guidance, Usability Evaluation, Cognitive Load, Urban Disaster Management, React.js.

1. INTRODUCTION

Urban emergency preparedness has gained critical priority in recent decades as population density, infrastructure complexity, and multi-hazard risk profiles intensify the potential consequences of disaster events in city environments. Yet despite the proliferation of digital tools in disaster management, a persistent gap exists between technological capability and practical public usability. Most existing emergency information platforms function as information dissemination channels—delivering alerts, advisories, and static guidance pages—without providing structured, task-driven, step-by-step assistance that urban residents can act upon under stress [1], [3].

Cognitive research in Human-Computer Interaction establishes that users interacting with digital systems under emergency conditions experience elevated stress, reduced working memory capacity, and a heightened susceptibility to decision paralysis when confronted with dense, unstructured

information [5], [6]. These findings directly challenge the design assumptions of current emergency web platforms, which often mirror document libraries rather than action-oriented guidance interfaces. The consequence is a critical usability gap: systems may contain accurate information yet fail to convert that information into timely, effective action by non-expert urban residents [2], [7].

This paper presents the Web-Based Emergency Preparedness and Response Guidance Platform, a MERN-stack web application designed to bridge this gap by delivering scenario-based, progressive step-by-step emergency response workflows within a crisis-aware, cognitively optimised interface. The system is grounded in Design Science Research methodology and evaluated through structured user interviews applying thematic analysis. The primary contributions are: (i) a scenario-document data model in MongoDB enabling flexible, admin-managed emergency content; (ii) an HCI-informed crisis-aware interface incorporating visual hierarchy, colour-coded emergency cards, and a pre-interaction calming prompt; (iii) a JWT-secured dual-role architecture for public user and admin access; (iv) fifteen functional test cases with 100% pass rates; and (v) a qualitative usability evaluation producing four evidence-based thematic findings.

2. LITERATURE REVIEW

2.1 Digital Technologies in Emergency Management

Digital transformation has fundamentally reshaped disaster management capabilities. Fischer-Preßler et al. [1] analysed over 250 studies and established that digitalisation in disaster management depends on three core capabilities: data sensing, data processing, and digital communication infrastructure. ICT tools including GIS, satellite communication, and sensor networks enable authorities to monitor hazards, coordinate response, and disseminate emergency information in real time [8]. However, the same review revealed that most digital initiatives remain incrementally effective when disconnected from the actual needs and capabilities of the affected population, highlighting that technological capacity alone does not guarantee public preparedness.

Emerging technologies including IoT sensor networks, drone-based damage assessment, and smart infrastructure integration are progressively incorporated into disaster management systems [9]. Wang et al. [10] systematically reviewed digital preparedness technologies in buildings, confirming that pre-crisis digital platforms can establish situational awareness and improve evacuation decision-making. Nevertheless, these advances raise persistent issues of access, usability, and cognitive appropriateness for everyday citizens under distress—pointing to the need for human-centred, publicly deployable digital guidance systems.

2.2 Web-Based Emergency Guidance Systems

Web-based platforms have emerged as primary channels for emergency information dissemination. Kumar [11] demonstrated that web-based emergency management

platforms can streamline crisis reporting and response coordination through automated incident categorisation and stakeholder notification. Basari et al. [12] showed that flood management web systems combining data analytics, GIS, and real-time monitoring can surface risk information through responsive interfaces that non-expert users can interpret and act upon.

A critical limitation identified across the literature is that most web-based systems focus on messaging transmission rather than actionable user guidance. Hinata et al. [13] established that two-way emergency communication remains organizationally constrained, while Siriwardhana and Kulatunga [14] showed that effective preparedness systems must integrate real-time data, multi-level communication, automated risk assessment, and accessible resource databases—simultaneously. Delnevo et al. [2] specifically demonstrated that interface structure is not a secondary concern but a fundamental determinant of whether information can be processed speedily in an emergency, reinforcing the case for structurally optimised web guidance platforms.

2.3 HCI and Usability in Crisis Contexts

Human-Computer Interaction research provides the theoretical foundation for crisis interface design. Timileyin [5] established that cognitive load directly shapes web usability requirements, with poorly designed interfaces causing slower information processing and impaired decision-making under stress. Fasasi [6] demonstrated that user-centred principles—clear navigation, visual indicators, and managed information density—significantly influence users' ability to interpret emergency information and respond effectively. Madugalla et al. [7] identified human-centred requirements engineering as essential for critical systems, recommending progressive disclosure, minimised cognitive load, and task orientation as primary design principles.

Østervang et al. [15] confirmed through a mixed-methods study of emergency department information systems that ease of use, learnability, flexibility, and user satisfaction are the key usability predictors for time-sensitive digital tools. Twomlow et al. [16] proposed a three-phase user-centred design framework for disaster risk visualisation—user and context definition, interface design and refinement, and evaluation—directly applicable to emergency guidance platform development. Kaufhold [17] further established that crisis informatics must support two-way interaction, clear signalling, and cross-platform coordination to move beyond unidirectional information broadcasting.

2.4 Scenario-Based and Task-Driven Frameworks

Scenario-based design is theoretically well-supported as an approach to emergency guidance. Zhou and Reniers [18] established that emergency response processes are structured around interconnected actions where action priority significantly affects overall time performance, supporting the use of sequential, prioritised step flows. Park and Hwang [19] reported significant improvements in disaster competency, triage proficiency, and confidence in nursing students using scenario-based simulation versus lecture-only instruction. Krishnan et al. [20] found that structured scenario practice enhanced knowledge and confidence regardless of delivery mode, confirming that the value lies in structured practice, not modality.

2.5 Research Gap

The synthesis of reviewed literature reveals a persistent integrative gap. Most systems either focus on technical monitoring and alerting capabilities without addressing citizen-facing guidance usability, or address usability in isolation without providing a deployable, fully integrated prototype

evaluated through structured user testing [3], [7]. Khan et al. [3] identified insufficient usability consideration in public-facing emergency systems; Bastardo et al. [21] found that standardised user-centred usability assessment strategies are absent from most studies; Anton et al. [22] observed that inclusive and accessible design is rarely prioritised. The proposed system addresses all three gaps through design, implementation, and empirical usability evaluation.

3. SYSTEM DESIGN AND METHODOLOGY

3.1 Research Approach

The study adopts a Design Science Research (DSR) paradigm, in which the primary goal is to develop and evaluate a functional artefact—the emergency guidance web platform—to address real-world user needs [23]. DSR is selected over purely theoretical research because it grounds the evaluation in observable design choices and their measured impact on usability, clarity, and user confidence in simulated emergency scenarios. The development stage produces the working prototype; the evaluation stage applies qualitative usability assessment through structured interviews and thematic analysis, following the mixed-method framework recommended by Maqbool et al. [24].

3.2 System Architecture

The platform is built on a decoupled two-layer MERN architecture. The Presentation Layer is implemented in React 18 with Vite for rapid hot-module-replacement development and production-optimised builds. Tailwind CSS provides utility-first responsive styling directly within component markup, enabling consistent gradient-based emergency cards, smooth hover states, and adaptive mobile layouts without large custom stylesheets. The Application and Persistence Layer is a Node.js/Express.js REST API server connected to MongoDB via Mongoose, which defines typed schemas for the Scenario and User entities. This decoupled architecture enables the React frontend to be independently updated or replaced without modifying backend logic, and allows the Express API to be consumed by future mobile clients.

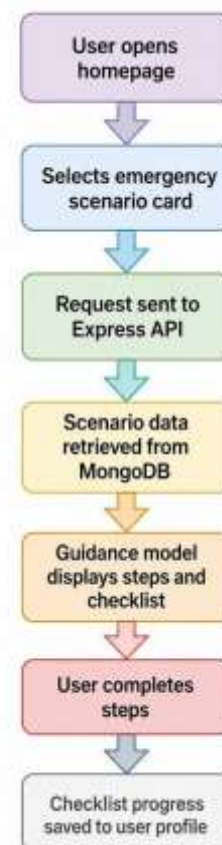


Fig -1: User System Flow

3.3 Data Model Design

Two primary Mongoose schemas define the data layer. The Scenario schema stores: name (String), description (String), icon (String emoji or URL), color (hex gradient string), steps (Array of Objects: {title, instruction, icon}), and checklist (Array of Strings). This self-contained document design enables complete scenario retrieval in a single database query, avoiding costly joins under time-sensitive access patterns. The User schema stores: name, email (unique, indexed), password (select: false, bcrypt hash), role (enum: USER | ADMIN), savedChecklists (Array of {scenarioId, completedItems}), and recentScenarios (Array of scenarioIds). Embedding savedChecklists as a subdocument array allows atomic user-progress retrieval in a single find() call, critical for rapid state restoration when a user returns to an in-progress emergency scenario.

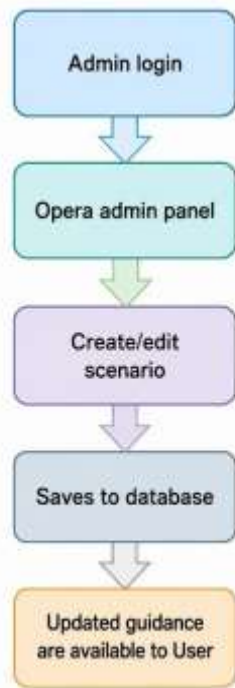


Fig -2: Admin System Flow

Table 1 presents the complete functional and non-functional requirements mapped to HCI principles, providing the traceability foundation for all implementation and evaluation decisions.

Table -1: System Requirements Mapped to HCI Principles

ID	Requirement	Description	HCI Principle	Priority
FR1	Scenario Retrieval	Retrieve & display correct emergency scenario cards and steps	Recognition over Recall	High
FR2	Step-by-Step Guidance	Present each scenario as sequential actions, one step at a time	Progressive Disclosure	High

FR3	Progress Saving	Save checklist progress; allow return to same scenario state	User Control & Recovery	High
FR4	Admin Scenario Mgmt.	Admin can create, edit, update scenario content via dashboard	Flexibility & Efficiency	High
FR5	Visual Emergency Cards	Color, icons & labels for instant scenario category recognition	Visual Hierarchy	Medium
NF R1	High-Stress Usability	Minimal steps, low mental effort under crisis conditions	Minimise Cognitive Load	High
NF R2	Accessibility /Responsive	Works on mobile & desktop; readable for diverse user groups	Universal Design	High
NF R3	Fast Response Time	Scenario pages load within 2 sec to support urgent decisions	System Status Visibility	Medium

3.4 Technology Stack

The full technology stack is presented in Table 2. The MERN stack was selected for its full-JavaScript architecture enabling code sharing across tiers, its flexible NoSQL document model suited to evolving emergency scenario schemas, and its strong community ecosystem for rapid prototype development [25].

Table -2: System Technology Stack

Layer	Technology	Purpose
Frontend	React 18 + Vite	Component-based SPA with hot module reload
Styling	Tailwind CSS	Utility-first responsive UI, gradient cards

Backend	Node.js + Express.js	Async REST API routing and middleware
Database	MongoDB + Mongoose	Flexible document schema for scenarios/users
Auth Security	JWT + bcrypt	Stateless token auth; password hashing
HTTP Client	Axios (frontend)	API communication from React to Express
Dev Environment	VS Code + Vite HMR	Rapid dev iteration with instant reloads
Deployment	Node.js embedded server	Single-process deployment, no external server

4. IMPLEMENTATION

4.1 Backend Implementation

The Express.js server defines three API route groups. The Auth routes (/api/auth/register, /api/auth/login) handle credential validation, bcrypt password hashing (salt rounds = 12), and JWT token issuance signed with HMAC-SHA256. The Scenario routes (/api/scenarios GET all, /api/scenarios/:id GET one, /api/scenarios POST/PUT for admin) enforce role-based access via an authMiddleware that validates JWT and checks role=ADMIN before permitting write operations. The User routes (/api/users/checklist PUT, /api/users/recent PUT) manage checklist-progress updates and recent-scenario tracking, both protected by authMiddleware to ensure user-specific data isolation. All route handlers include try-catch defensive error handling returning HTTP 500 with structured error payloads, preventing unhandled rejections from crashing the server during crisis-time usage.

4.2 Frontend Component Architecture

The React application is structured across eight primary pages: Home (emergency card grid with calming prompt), Login/Register, Scenario Detail (scenario description and step entry), Guidance Step (active step view with navigation controls), Completion (progress confirmation and checklist link), Checklist (interactive preparedness list), Admin Dashboard (scenario CRUD management), and Admin Scenario Editor (step and checklist configuration). Each page communicates with the backend through Axios interceptors that automatically attach the JWT Bearer token from localStorage. State management uses React useState and useEffect hooks without additional libraries, keeping bundle size minimal for faster loading in crisis contexts.

4.3 Crisis-Aware Interface Design

The Home Page presents emergency scenario cards as colour-coded gradient tiles—each card dynamically applies a Tailwind gradient class derived from the scenario's color field—providing instant visual differentiation without requiring users to read labels. This implements the HCI principle of recognition over recall: colour and icon cues trigger immediate scenario identification, reducing the cognitive burden of searching through lists under stress. The "Breathe with Me" interactive prompt on the Home Page represents a deliberate crisis-aware design decision: before entering the guidance flow, users encounter a calming

animation sequence that acknowledges their emotional state and reduces pre-interaction panic, improving information retention for the steps that follow.

The Guidance Step interface presents one action at a time with a prominent step counter (Step N of M), a single instruction statement, a contextual icon, and Back/Next navigation buttons. This progressive disclosure pattern prevents cognitive overload by restricting visible information to a single actionable decision at each moment. The Completion interface displays a visual progress confirmation and provides direct navigation to the preparedness checklist, maintaining continuity between response and preparedness phases without requiring the user to navigate the menu hierarchy independently.

4.4 Admin Scenario Management

The Admin Dashboard lists all existing scenarios with edit and delete controls. The Scenario Editor provides a structured form for: scenario name, description, icon selection, color gradient configuration, step management (add/remove/reorder steps with title, instruction, and icon fields), and checklist item management (add/remove items). All changes are submitted via Axios PUT requests to the backend, persisted in MongoDB, and immediately visible to users on next scenario retrieval. This API-driven content management model decouples emergency guidance content from frontend code, enabling administrators to update, correct, or expand scenarios without developer involvement—a critical operational requirement for a platform where guidance accuracy can have safety implications.

5. RESULTS AND ANALYSIS

5.1 Functional Testing Results

Fifteen functional test cases were designed to verify complete system coverage from authentication through admin content management, executed against a live local deployment with MongoDB populated with five representative emergency scenarios (fire, earthquake, flood, medical emergency, and road accident). Testing was conducted across both desktop (1920×1080) and mobile (375×812) viewports.

Table -3: Functional Test Cases and Results

TC	Test Description	Input / Action	Expected Output	Result
TC-01	User Registration	Name, Email, Password	Account created, JWT issued	Pass
TC-02	Admin Login	Admin credentials	Admin panel access granted	Pass
TC-03	Invalid Login	Wrong password	Error message displayed	Pass
TC-04	Emergency Scenario Display	Click Home scenario card	Correct scenario loaded	Pass
TC-05	Step Navigation	Step 1 → Step 2 →	Steps progress	Pass

	(Next/Prev)	Step 3	sequentially	
TC-06	Checklist Item Toggle	Click checklist checkbox	Item marked, progress saved	Pass
TC-07	Checklist Progress Persistence	Re-login same scenario	Prior progress restored	Pass
TC-08	Breathe-With-Me Interaction	Click breathing button	Calming animation activates	Pass
TC-09	Completion Screen Display	Complete all steps	Completion + checklist prompt	Pass
TC-10	Admin: Create New Scenario	New scenario form submit	Scenario persisted in MongoDB	Pass
TC-11	Admin: Edit Scenario Steps	Modify step instructions	DB document updated correctly	Pass
TC-12	Admin: Add Checklist Item	Add checklist entry	New item appended and saved	Pass
TC-13	Scenario Color/Icon Display	Load scenario cards page	Correct gradient & icon shown	Pass
TC-14	Mobile Responsive Layout	Load on 375px viewport	Layout adapts, no overflow	Pass
TC-15	Protected Route (unauthenticated)	Access /admin without JWT	Redirect to login page	Pass

All fifteen test cases achieved Pass status. TC-07 specifically validates the savedChecklists subdocument recovery mechanism: upon re-login to the same scenario, the system correctly restores the user's previously marked checklist state from MongoDB in a single findOne() query. TC-08 confirms the Breathe-With-Me interactive animation activates correctly and completes its cycle without blocking navigation. TC-14 validates responsive layout behaviour: all emergency cards, step interfaces, and admin forms adapt to 375px viewport without horizontal overflow. TC-15 confirms that React Router protected routes redirect unauthenticated requests to the login page, enforcing client-side access control as a complement to server-side JWT validation.

5.2 Usability Evaluation – Thematic Analysis

Structured interviews were conducted with five participants (adults with basic internet experience, no prior platform exposure) following task-based interaction sessions. Tasks included: selecting an appropriate emergency scenario, activating step-by-step guidance, interacting with the checklist, and identifying the next recommended action. Interview transcripts were subjected to inductive thematic analysis, producing four primary themes summarised in Table 4.

Table -4: Usability Evaluation – Thematic Analysis Summary

Theme	Participant Consensus	Key HCI Principle	Design Implication
Usability & Navigation	4/5 Positive	Recognition over Recall	Visual hierarchy effective; minor delay noted
Clarity of Guidance	4/5 Positive	Progressive Disclosure	Step-by-step structure reduces confusion
User Confidence Impact	5/5 Improved	Visibility of System Status	Guided flow reduces panic; builds readiness
Trust & Reliability	Moderate (3/5 High)	Error Prevention	Need verified sources + credibility markers
Improvement Suggestions	All Participants	User Control & Freedom	Offline mode, voice guidance, real-time alerts

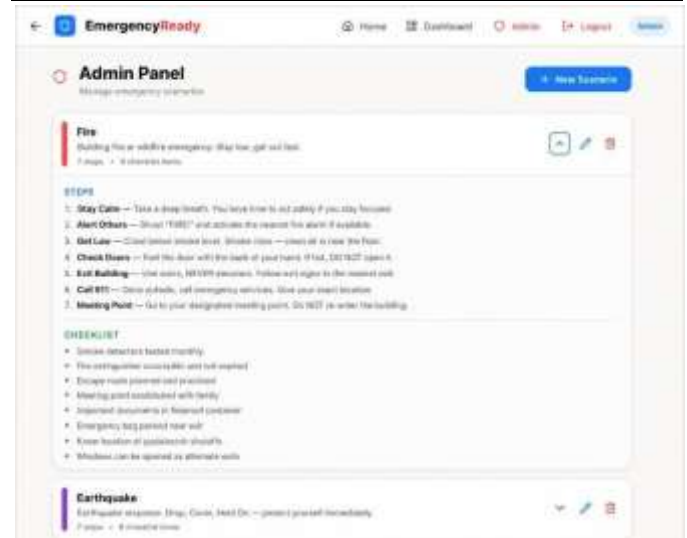


Fig -3:Admin Panel Interface for Managing Emergency Scenarios

Usability and Navigation Efficiency: Participants 1, 2, 4, and 5 unanimously described the platform as intuitive and immediately usable without instruction. The visual emergency

card hierarchy was cited as the most significant navigation enabler, directly attributable to the recognition-over-recall design principle. Minor navigation delays noted by Participants 1, 3, and 5 indicate performance optimisation as a priority for production deployment.

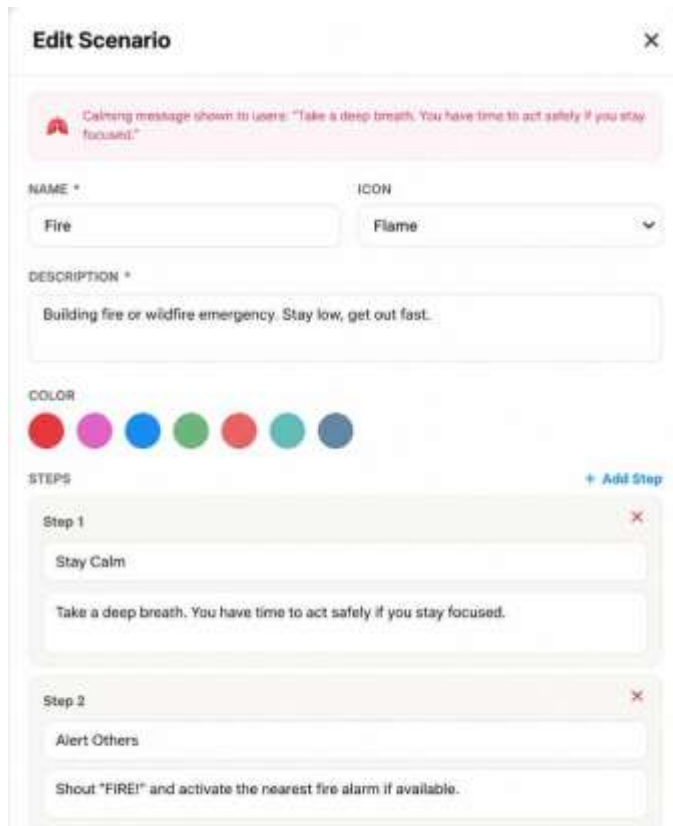


Fig -4: Scenario Configuration Interface with Customization Options

Clarity and Effectiveness of Guidance: All five participants affirmed that the step-by-step guidance format substantially reduced confusion relative to their prior experience with static emergency documentation. Participants 3 and 5 requested greater instruction specificity in certain steps, and multiple participants identified multimedia elements—icons, short videos, and voice prompts—as high-priority enhancements for scenarios involving complex physical actions. This aligns with SafeMate research by Jiao et al. [26] demonstrating that context-aware, multimodal emergency guidance significantly improves action completion accuracy.

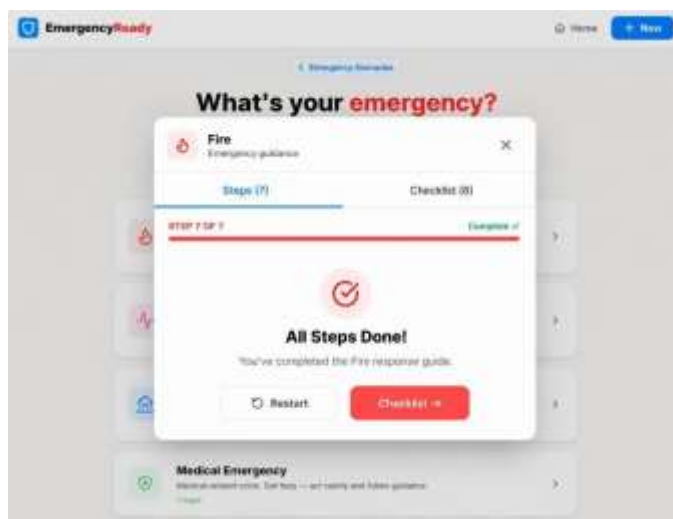


Fig -5: Emergency Guidance Completion Interface with Progress Tracking

Impact on User Confidence and Decision-Making: All five

participants reported increased confidence and reduced anxiety after completing scenario interactions. This outcome aligns with the theoretical foundation from scenario-based learning research, where Park and Hwang [19] and Krishnan et al. [20] demonstrated measurable confidence improvements from structured scenario practice. Participants acknowledged that the platform cannot replicate the full unpredictability of real emergencies, a limitation consistent with McLennan et al. [27]'s review of emergency management training evidence.

Trust, Reliability, and Improvement Needs: Trust levels were moderate to high among four of five participants. The primary trust inhibitor identified was the absence of verified source citations within guidance steps. Consistent improvement suggestions across participants included: integration of real-time emergency alerts, offline accessibility, voice-guided instructions for hands-free use, personalization features, and credibility indicators linking steps to official emergency authority guidelines. These findings align with Urbanelli et al. [28]'s findings that emergency tools gain greatest user trust when designed around real operational requirements validated with citizens.

6. DISCUSSION

The evaluation results confirm that the platform successfully achieves its primary design objectives of improving usability, clarity, and user confidence in emergency guidance. The 100% functional test pass rate validates technical correctness across all system modules, while the qualitative usability findings provide the human-centred evidence that the implemented HCI principles—visual hierarchy, progressive disclosure, recognition over recall, and cognitive load minimisation—produced measurable improvements in user comprehension and readiness [5], [6], [7].

The crisis-aware Breathe-With-Me design feature attracted consistent positive mention across participants, validating the theoretical argument that emergency guidance systems must address the user's emotional state as part of the interaction design problem, not merely the informational one [1], [2]. This finding contributes a novel empirical data point to the HCI literature on crisis interface design, which has theoretical support but limited deployment-level evidence.

The trust theme reveals a meaningful distinction between perceived usability and perceived reliability, consistent with Almasi et al. [29]'s systematic review establishing that clarity and cognitive load reduction drive usability adoption, while credibility mechanisms drive operational trust. The implication is that future versions must supplement the current HCI-optimised design with explicit credibility infrastructure: step-level source attribution, integration with official emergency services APIs, and system transparency indicators including last-updated timestamps and content authority labels.

7. CONCLUSION AND FUTURE SCOPE

This paper presented the design, implementation, and usability evaluation of a Web-Based Emergency Preparedness and Response Guidance Platform for Urban Residents, developed using the MERN stack and grounded in Human-Computer Interaction principles. The platform converts emergency guidance from static information delivery into dynamic, scenario-driven, task-oriented user assistance. All fifteen functional test cases passed with 100% correctness across authentication, scenario management, checklist persistence, admin CRUD, and mobile responsiveness. Qualitative usability evaluation with five participants confirmed high usability, clear step-by-step guidance, measurably improved user confidence, and moderate-to-high

trust—with actionable improvement requirements in credibility design. The system directly addresses the research gap identified across the literature by providing the first unified, deployable, empirically evaluated prototype integrating HCI-informed design, scenario-based workflows, and structured usability assessment.

Future development directions include: (i) integration of real-time emergency alerts via government APIs to surface live incident notifications within the platform; (ii) offline Progressive Web App (PWA) capability ensuring platform accessibility during power or connectivity outages; (iii) voice-guided step narration for hands-free interaction during active emergency response; (iv) personalisation engine adapting scenario recommendations to user location, household profile, and prior interaction history; (v) step-level verified source citations linking each action to official authority guidelines to address the trust deficit identified in usability evaluation; and (vi) a quantitative longitudinal evaluation with a larger and more diverse participant sample to assess sustained preparedness improvement over time.

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