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BloodMap: A geolocation-based mobile application prototype to support blood donor location at the Uíge General Hospital, Angola

BloodMap: protótipo de aplicação móvel baseado em geolocalização para apoiar a localização de doadores de sangue no Hospital Geral do Uíge, Angola

BloodMap: prototipo de aplicación móvil basada en geolocalización para ayudar a localizar donantes de sangre en el Hospital General de Uíge, Angola

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Abstract:
The response to transfusion needs depends on the ability to locate compatible donors in a timely manner. This task is particularly challenging in hospital settings where manual processes prevail and information about donors is scattered across various records, phone calls, and informal networks. This study aimed to develop and conduct a preliminary evaluation of "BloodMap," a geolocation-based mobile application prototype designed to support the identification of and contact with potential blood donors at the Uíge General Hospital in Angola. This applied, exploratory-descriptive study involved requirements gathering, UML modeling, and iterative development following the Rational Unified Process, utilizing React Native/Expo, Firebase, and Google Maps. Between June 5 and June 11, 2026, a structured interview questionnaire was administered to 127 participants, selected via convenience sampling. Data were analyzed using descriptive statistics. The prototype includes features for registration, availability management, location tracking (subject to consent), urgent requests, and notifications. Regarding acceptance, 80.3% of participants believed the application could encourage voluntary blood donation, and 68.5% expressed a willingness to use it. However, 48.8% reported only moderate confidence in the protection of their personal data, and connectivity issues were identified as a recurring limitation. It is concluded that BloodMap serves as a technically coherent and promising proof of concept. The results reflect self-reported perceptions and do not allow for generalization, nor do they demonstrate operational efficacy. The efficacy, safety, and impact of the application should be evaluated in a hospital-based pilot study.

Keywords:
Mobile application. Blood donation. Geolocation. Digital health. Angola.

Resumo:
A resposta transfusional depende da capacidade de localizar, atempadamente, doadores compatíveis. Esta tarefa é particularmente difícil em contextos hospitalares onde predominam processos manuais e a informação sobre doadores se encontra dispersa entre registos, chamadas telefónicas e redes informais. O estudo teve como objetivo desenvolver e avaliar preliminarmente o BloodMap, um protótipo de aplicação móvel baseado em geolocalização para apoiar a identificação e o contacto de potenciais de doadores de sangue no Hospital Geral do Uíge, Angola. Trata-se de um estudo aplicado, exploratório-descritivo, que incluiu levantamento de requisitos, modelação UML e desenvolvimento iterativo segundo o Rational Unified Process, usando React Native/Expo, Firebase e Google Maps. Entre 5 e 11 de junho de 2026, aplicou-se uma ficha de entrevista estruturada a 127 Participantes, selecionados por conveniência. Os

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dados foram analisadas por estatística descritiva. O protótipo integra funcionalidades de registo, gestão da disponibilidade, localização mediante consentimento, pedidos urgentes e notificações. Quanto à aceitação, 80,3% dos participantes consideraram que a aplicação poderá favorecer a doação voluntária, e 68,5% manifestaram disponibilidade para a utilizar. Contudo, 48,8% revelaram confiança apenas moderada na proteção dos dados pessoais, e a conectividade foi identificada como limitação recorrente. Conclui-se que o BloodMap constitui uma prova de conceito tecnicamente coerente e promissora. Os resultados refletem percepções declaradas e não permitem generalização nem demonstram eficácia operacional. A eficácia, segurança e impacto da aplicação deverão ser avaliados estudo piloto hospitalar.

Palavras-chave:
Aplicação Móvel. Doação de sangue. Geolocalização. Saúde digital. Angola.

Resumen:
La respuesta a las necesidades de transfusión depende de la capacidad de localizar oportunamente a donantes compatibles. Esta tarea resulta especialmente difícil en hospitales donde predominan los procesos manuales y la información sobre los donantes se encuentra dispersa en registros, llamadas telefónicas y redes informales. El objetivo fue desarrollar y evaluar de forma preliminar BloodMap, un prototipo móvil basado en geolocalización que ayuda a identificar y contactar con posibles donantes en el Hospital General de Uíge, Angola. El estudio aplicado y exploratorio-descriptivo incluyó el levantamiento de requisitos, el modelado UML y el desarrollo iterativo conforme al Rational Unified Process, con React Native/Expo, Firebase y Google Maps. Entre el 5 y el 11 de junio de 2026 se aplicó una entrevista estructurada a 127 participantes seleccionados por conveniencia. Los datos se analizaron con estadística descriptiva. El prototipo incluye registro, gestión de disponibilidad, localización con consentimiento, solicitudes urgentes y notificaciones. El 80,3 % consideró que la aplicación podría favorecer la donación voluntaria y el 68,5 % manifestó disposición a usarla. El 48,8 % declaró una confianza moderada en la protección de datos personales y la conectividad fue una limitación recurrente. BloodMap constituye una prueba de concepto técnicamente coherente y prometedora. Los resultados reflejan percepciones declaradas, no permiten generalizar ni demuestran eficacia operativa. La eficacia, la seguridad y el impacto requieren evaluación en un estudio piloto hospitalario.

Palabras clave:
Aplicación móvil. Donación de sangre. Geolocalización. Salud digital. Angola.

1. Introduction

Timely access to safe blood is essential to hospital care, especially in emergencies, surgery, obstetric complications, trauma and transfusion-dependent treatment. World Health Organization reports (WORLD HEALTH ORGANIZATION, 2022) document substantial differences in blood availability among countries and emphasize systems based on regular, voluntary, unpaid donation.

Beyond having donors, transfusion response depends on identifying eligible people, communicating a need and arranging contact promptly. Where manual processes predominate,

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information can be scattered across records, telephone contacts and informal networks, limiting coordination and request traceability.

Digital health can support this process. Mobile apps can organize donor data, send notifications, provide location services and facilitate communication between donors and institutions. In the systematic review by Li et al. (2023), most studies on blood donation apps (44.1%) concerned finding donors and collection centers, followed by encouraging donation (26.4%), recruitment (14.7%), retention (8.8%) and scheduling (5.8%). Effectiveness depends on user adoption and the implementation context, and evidence from resource-constrained settings such as Angola is limited.

Uíge General Hospital, the setting for this study, lacks an integrated digital system for volunteer donor registration, declared availability, authorized location and hospital requests. The authors make no assumption about the presence of similar solutions elsewhere in Angola. The study concerns the need observed and modeled at this hospital. Fragmentation may delay identifying and contacting donors, leave availability and blood type information outdated, increase reliance on informal contacts in emergencies and reduce the traceability of requests and replies.

The overall objective was to develop a geolocation-based mobile system to help find compatible donors at Uíge General Hospital. The study asked four questions:

(a) how can a mobile system organize communication between health professionals and volunteers;
(b) how can geolocation with consent help identify available donors near the hospital;
(c) is a functional prototype using mobile technologies, cloud services and notifications technically feasible;
(d) what usability, security and operational aspects require validation before full-scale hospital deployment?

The article presents the design and implementation of BloodMap and an exploratory assessment of acceptance among 127 participants.

2. Theoretical background

2.1 Blood donation and donor communication

Transfusion depends on a chain that includes recruitment, collection, testing, processing, storage and appropriate use. WHO emphasizes that a stable base of voluntary,

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unpaid donors is essential to a safe and sufficient supply (WORLD HEALTH ORGANIZATION, 2022). For Angola, its Regional Office for Africa (2014) stresses the need to mobilize volunteers. An application such as BloodMap can support communication and information organization, but cannot by itself resolve capacity, screening, storage or blood management constraints. Digital interventions do not replace functioning health services, policies, personnel or sound clinical processes (WORLD HEALTH ORGANIZATION, 2019).

2.2 Geolocation in donation apps

Geolocation obtains or estimates a device's position using GPS, mobile networks or Wi-Fi. In blood donation apps it can connect needs with potential donors when there is consent, access control and data minimization. Prior work explored mobile computing, cloud services and geolocation to support communication among blood donors (MOSTAFA et al., 2014). Location combined with blood type is sensitive information, so only necessary location data should be exposed and access should be restricted to authorized roles.

2.3 Existing digital solutions

Existing solutions include apps focused on scheduling and donor retention and apps that use location to bring people who need blood together with potential donors. Table 1 compares three examples with BloodMap based on observable features, avoiding subjective rankings unsupported by comparative tests. The American Red Cross Blood Donor App (n.d.) locates drives and centers, manages appointments and displays history, but is not designed to expose donor locations to hospitals. NHS Give Blood (NHS BLOOD AND TRANSPLANT, n.d.) serves the UK national health service ecosystem. BloodConnect (n.d.) is an open-source platform that connects blood needs with nearby donors, but its governance and operational context differ from those at the study hospital.

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Table 1 – Functional comparison of digital solutions for blood donation

Platform	**Setting**	**Use of location**	**Main function**	**Limitation for this study**	**Open source**
Blood Donor App	American Red Cross (USA)	Finds drives and centers	Appointments, history and follow-up	No real-time hospital–donor matching	Not identified
NHS Give Blood	United Kingdom (UK)	Helps locate venues and appointments	Booking and donor profile management	Designed for the NHS ecosystem	Not identified
BloodConnect	Community platform	Finds nearby donors	Connects needs and donors	Different context, governance and operation	Yes
BloodMap (prototype)	Uíge, Angola	Locates available donors	Requests, filtering and notifications	No full-scale hospital validation	Academic prototype

Source: Prepared by the authors based on American Red Cross (n.d.), NHS Blood and Transplant (n.d.) and BloodConnect (n.d.).

Note: “Not identified” means the information was absent from the sources consulted.

3. Method

3.1 Study design and development process

The study was applied and exploratory-descriptive. It combined literature and document reviews, requirements gathering, modeling, iterative development and preliminary prototype assessment. Rational Unified Process (RUP) principles guided inception, elaboration, construction and transition (KRUCHTEN, 2004), along with prototyping to build functional versions, understand requirements and obtain feedback (SOMMERVILLE, 2016). The waterfall and spiral models were considered but not selected. Waterfall is less flexible when changes occur late (PRESSMAN; MAXIM, 2020), and technical uncertainty did not justify formal risk analysis in every spiral cycle (BOEHM, 1988). RUP served as a process reference. Quality depends on implementing requirements, testing and user validation.

During inception the problem was defined, actors and constraints identified and requirements gathered from healthcare staff at Uíge General Hospital. During elaboration the team produced UML use case, class and activity models (OBJECT MANAGEMENT GROUP, 2017), defined the data structure and planned map service integration. Construction incrementally implemented the mobile app and backend, including notifications and blood compatibility filters. Transition comprised a controlled demonstration and preliminary user evaluation.

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3.2 Requirements

Requirements were organized by system actor (donor, hospital and administrator), yielding 12 functional and 10 nonfunctional requirements. Table 2 summarizes them by actor or category and indicates which were implemented and which still need validation under real conditions.

Table 2 – Summary and status of BloodMap requirements

Actor or category (requirements)	**Summary**	**Status**
Donor (FR01–FR06)	Registration with minimum details and blood type; activate availability and authorize location; view history; receive compatible notifications; answer requests; record donation confirmation	Implemented
Hospital (FR07–FR10)	Create requests with blood type and radius; filter donors by blood type and location; display a map; send push notifications	Implemented
Administrator (FR11–FR12)	Track requests and statuses; suspend or block accounts	Implemented
Security and privacy (NFR03–NFR06)	HTTPS/TLS; authentication delegated to Firebase Authentication; Firestore role-based access rules; location processed while availability is active	Implemented; no independent audit
Performance (NFR01–NFR02)	Push notification in under 5 s; location update in under 2 s	Criteria defined; validation pending
Portability and usability (NFR07–NFR08)	Android 6.0+ and iOS 13.4+; 5–7 inch screens	To be validated
Reliability and scalability (NFR09–NFR10)	Production availability target; concurrent user capacity assessed by load testing	Not validated

Source: Prepared by the authors.
Note: FR = functional requirement, NFR = nonfunctional requirement.

3.3 Architecture and technologies

BloodMap uses a cloud client-service architecture with three layers (Figure 1): presentation, services and data. The interface uses React Native and Expo (EXPO, n.d.) from a shared codebase. Firebase Authentication, Cloud Firestore and Firebase Cloud Messaging serve authentication, persistence and notifications (FIREBASE, n.d.). Google Maps Platform supports map rendering and proximity calculations (GOOGLE MAPS PLATAFORM, n.d.). In Firestore, the document-oriented NoSQL data model uses native types (String, Boolean, Timestamp and Geopoint) and unique identifiers to link entities. The public, donor and institutional areas show sensitive options only to authorized roles.

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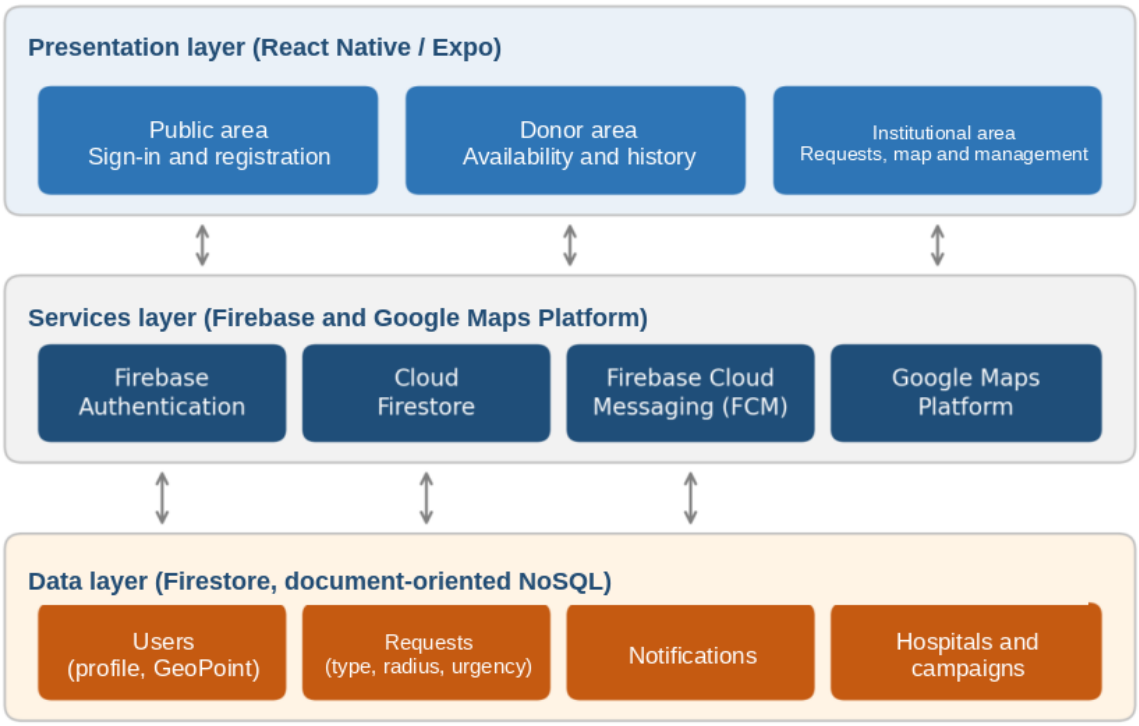
Figure 1 – BloodMap's three-layer architecture



Source: Prepared by the authors.
Note: Arrows show bidirectional communication between layers.

3.4 Privacy and security by design

Because the system connects identity, contact details, blood type and location, security was a central requirement. The principles were

(a) sharing location only when a donor expressly activates availability;
(b) limiting institutional access to necessary data;
(c) delegating credentials to Firebase Authentication without storing passwords in Firestore;
(d) using Firestore rules to distinguish ordinary users, hospitals and administrators;
(e) providing account correction and deletion mechanisms.

The app's compatibility indication is informational and does not replace clinical and laboratory confirmation.

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3.5 Exploratory user evaluation

Instrument and procedure

A structured interview form contained an identification block and 20 closed-ended questions in five sections: respondent information, current blood donation context, perceptions of mobile technology, assessment of BloodMap and overall assessment. Between June 5 and 11, 2006, 127 forms were collected from healthcare staff, hospital managers, volunteer donors, transfusion recipients and other respondents. The convenience sample makes the study exploratory.

Data analysis

The forms were consolidated into a data matrix. Absolute frequencies (n) and percentages were calculated for closed-ended questions using valid responses as denominators, shown with each result. For multiple-choice questions, percentages refer to the respondents who answered, so the total can exceed 100%. Given sample size and nonprobability sampling, no inferential tests or confidence intervals were applied.

Simulated test scenarios

Ten functional test scenarios and nine security verification scenarios were specified for validation. Their success rates, times and ratings were academic simulations rather than experimental measurements, so they were not presented or used as evidence of system performance or security.

4. Results

4.1 Prototype developed

The prototype combines donor and institutional registration and authentication, availability and location updates, urgent requests, and notifications to compatible donors (Figure 2). Donors can switch availability on or off. Once location is authorized, the app records coordinates for proximity search. The overview shows a map of donors, requests and hospitals,

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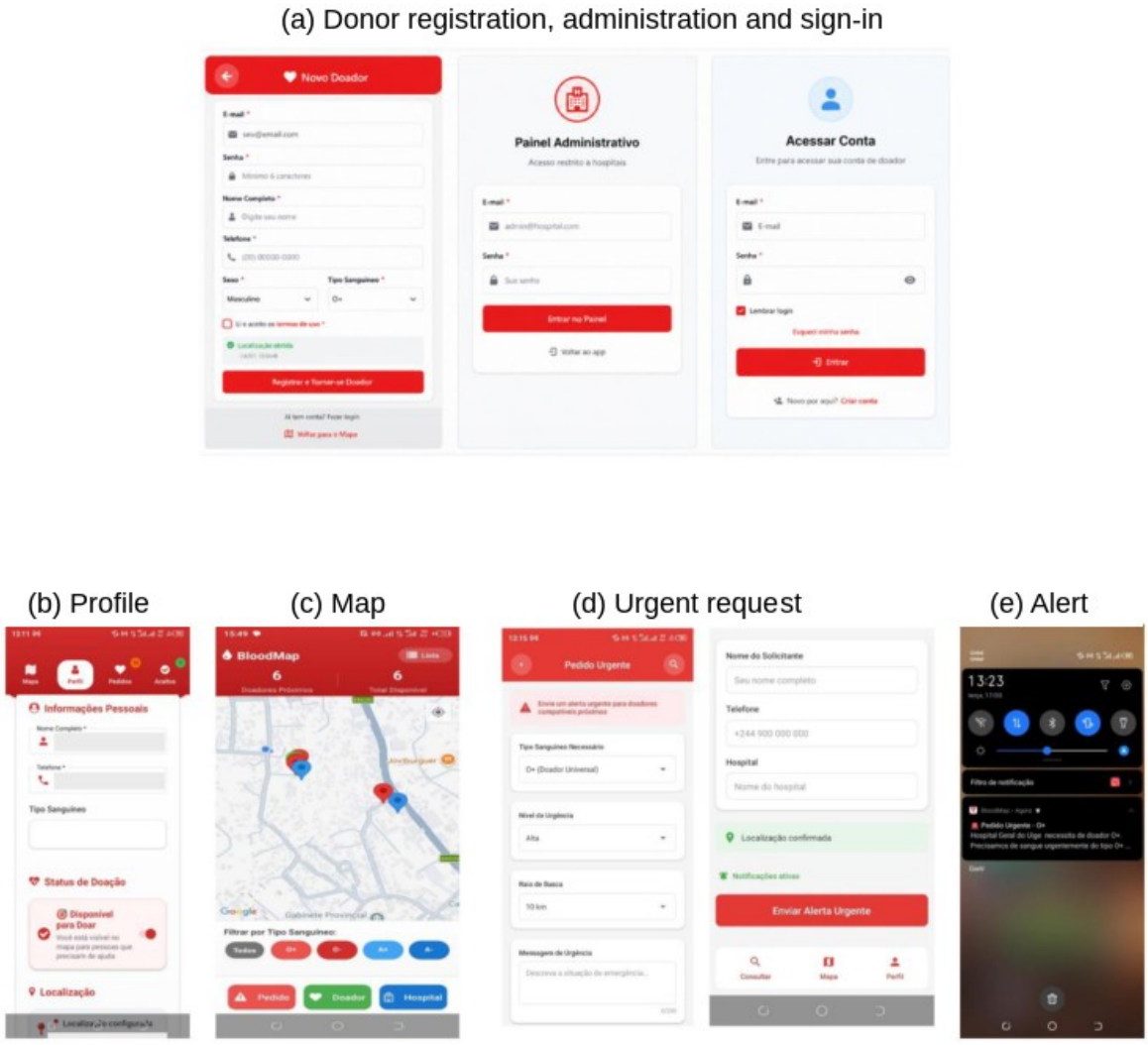
a count of available nearby donors, blood type filters and a map or list toggle. Authorized institutional users create requests with blood type, urgency and search radius. The system prepares notifications for eligible donors in range. Firebase Cloud Messaging can deliver alerts while the app is in the background, but delivery depends on connectivity, operating system permissions and device settings, so alerts should not be the sole channel for clinical emergencies. Offline access is partial: cached data can be read, but writing and sending new events requires internet access.

Figure 2 – BloodMap prototype screens



Source: Prepared by the authors.

Note: Prototype screenshots. (a) Registration, administration panel and sign-in; (b) donor profile and availability; (c) donor map; (d) creation of urgent requests; (e) notification received. Personal data hidden.

Interface labels: (a) New donor, email, password, full name, phone, gender, blood type, terms of use, location enabled, register as a donor, return to map, administration panel, access restricted to hospitals, enter panel, return to app, sign in, remember me, forgot password, create an account. (b) Personal information, donation status, available to donate, location confirmed. (c) List, nearby donors, available donors, filter by blood type, all, request, donor, hospital. (d) Urgent request, blood type required, urgency level, search radius, urgent message,

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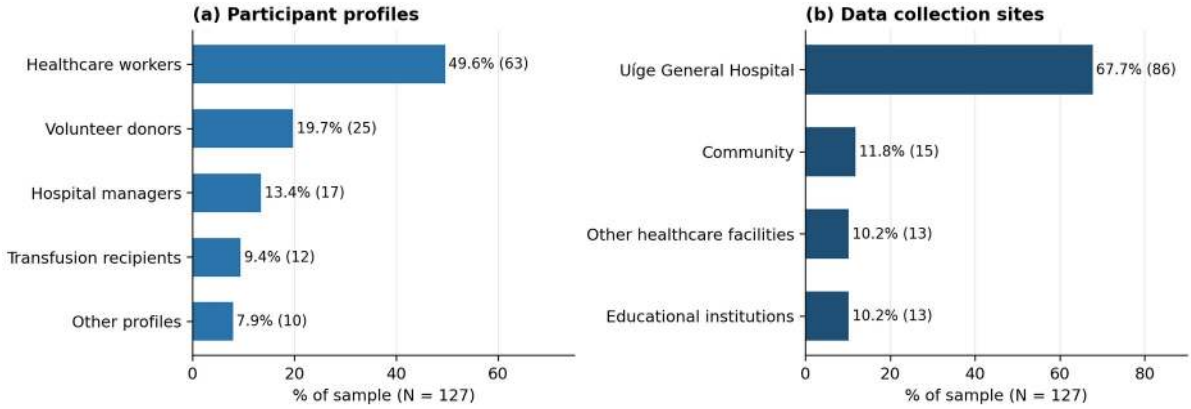
requester name, phone, hospital, location confirmed, active notifications, send urgent alert, consult, map, profile. (e) Notification panel, urgent request, blood needed at Uíge General Hospital.

4.2 Sample characteristics

There were 127 participants. Most responses came from Uíge General Hospital (86; 67.7%), followed by the community (15; 11.8%), other health facilities (13; 10.2%) and educational institutions (13; 10.2%). The profiles were healthcare workers (63; 49.6%), volunteer donors (25; 19.7%), hospital managers or administrators (17; 13.4%), transfusion recipients (12; 9.4%) and others, including relatives, researchers and students (10; 7.9%) (Figure 3).

Figure 3 – Participant profiles and data collection sites



Source: Prepared by the authors.

Note: N = 127. Values report percentages and participant counts in parentheses.

4.3 Perceptions of BloodMap

The findings indicate favorable initial reception (Figure 4). Some 80.3% (102/127) believed the app could increase voluntary donation, and 68.8% (87/127) were willing to use it. Delays in the current process had already compromised care according to 69.3% (88/127), and 68.3% (84/123 valid responses) expected a high or very high impact on blood bank management. Prior experience was rare: 93.7% (119/127) had never used a health or blood donation app. The study received an overall rating of “very good” or “excellent” from 53.6% (67/125).

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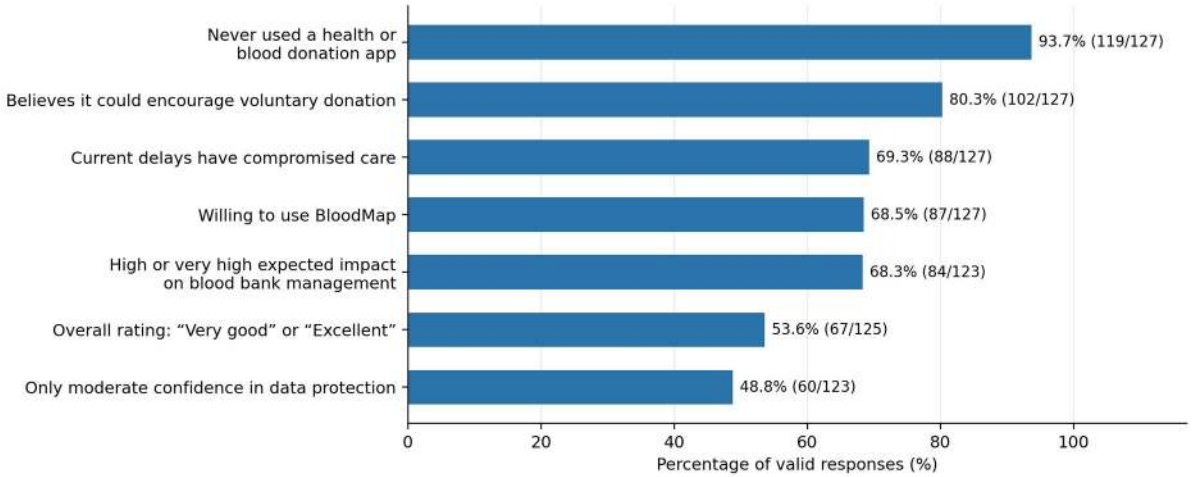
Figure 4 – Main exploratory assessment indicators



Source: Prepared by the authors.

Note: Percentages are based on valid responses. Denominators are given in parentheses.

Priority features (multiple choice; 124 valid respondents) had similar support (Figure 5a): automatic emergency notifications (51; 41.1%), donation campaigns and alerts (49; 39.5%), locating the nearest donor and donor registration/profile (48 each; 38.7%), and integration with hospital records and donation history (46 each; 37.1%). No one feature stood out clearly.

Among barriers to adoption (121 valid respondents; Figure 5b), data privacy and protection was cited most (46; 38.8%), followed by lack of staff training, lack of donor mobile devices and cultural resistance to donation (38 each; 31.4%), and lack of stable internet (35; 28.9%). Forty participants (33.1%) reported no significant barrier. Data protection confidence was mainly moderate (60 of 123 valid respondents; 48.8%), and 26 (21.1%) reported little or no confidence.

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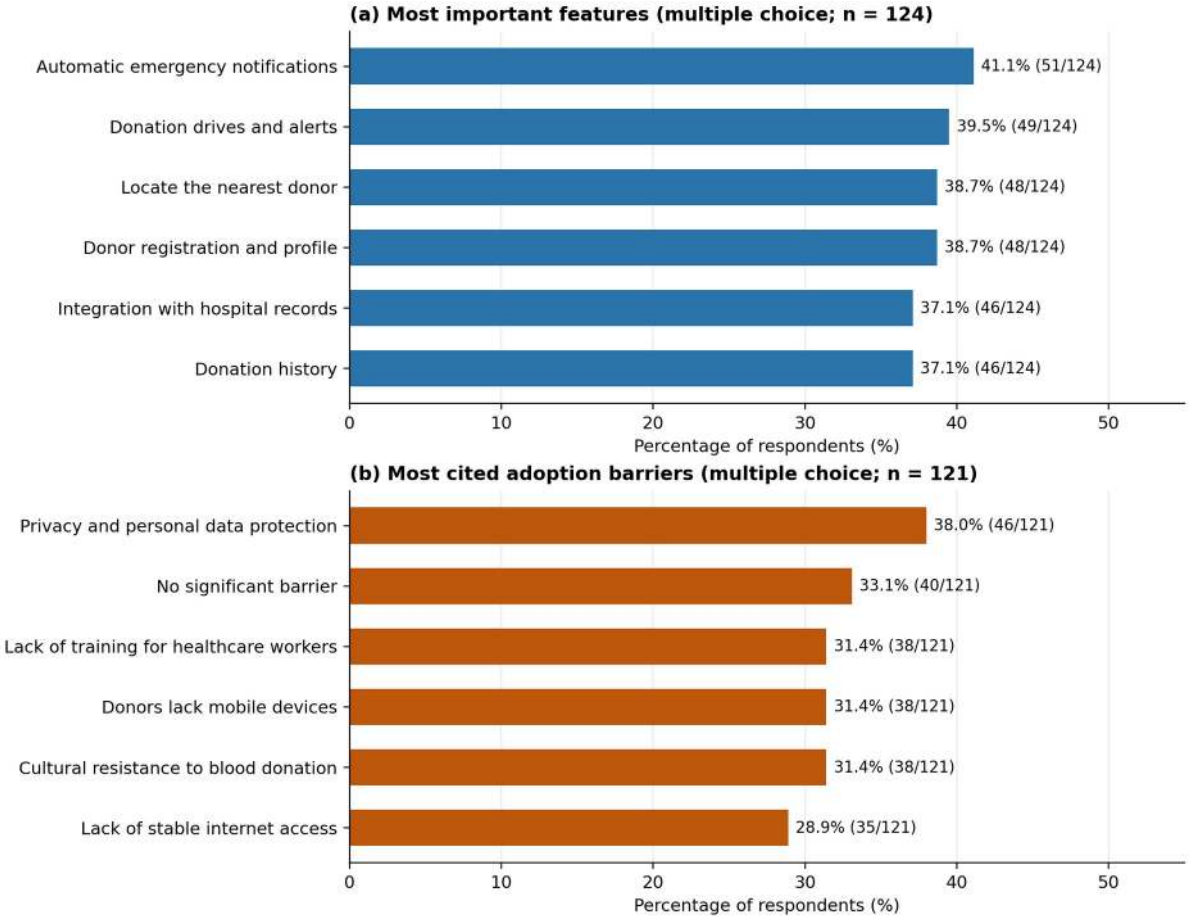
Figure 5 – Most valued features and barriers to BloodMap adoption



Source: Prepared by the authors.

Note: Multiple-choice questions. Percentages may total more than 100%. (a) n = 124; (b) n = 121.

5. Discussion

This study described the development of a mobile prototype to help locate blood donors and an initial assessment of acceptance at an Angolan provincial hospital. The prototype demonstrates that common cross-platform mobile technologies and cloud services can integrate donor registration, consent-based availability, proximity search, urgent requests and notifications. Feasibility was demonstrated at implementation level. Latency and scalability still require validation by performance measurements (Table 2).

The declared willingness to use the app (68.5%) and belief it could encourage voluntary donation (80.3%) suggest that participants recognize the problem. Nearly seven in ten reported that delays had compromised care. The direction agrees with Li et al. (2023), whose pilot of 952 participants aged 18–39 found favorable perceptions of a donation app in 73% of cases. The studies differ in population, setting and instrument, making comparison indicative only.

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Most participants (93.7%) had never used such apps, so acceptance concerned a technology unfamiliar to them and was based on expectations rather than prolonged use.

Privacy was the most relevant finding for system design. Data protection was the most cited barrier and nearly half reported only moderate confidence. This reflects the sensitivity of combining blood type and location and makes explicit consent, clear disclosure of location use, data minimization and retention rules conditions for adoption. Unstable connectivity, lack of devices and staff training needs likewise mean that adoption cannot rely on ideal access and requires both organizational and technological measures.

The hypotheses—improving efficiency and donor engagement (H1), reducing the time and effort to identify eligible donors (H2), feasibility of timely notifications (H3) and usefulness of operational records (H4)—remain unconfirmed. These are self-reported perceptions without a comparison group, pre/post measurements, actual donor mobilization times or longitudinal follow-up. H1 and H2 remain plausible from the architecture, while H3 and H4 require observation of actual system and donor behavior over time.

5.1 Limitations

The findings are limited by a heterogeneous convenience sample (N = 127), mainly from Uíge General Hospital (67.7%), which precludes statistical generalization. Manual and BloodMap-supported processes were not compared in real emergencies. Functional and security scenarios were simulated and do not show performance or constitute a security audit. Offline access is partial, and notifications depend on networks and devices. No load testing, cost analysis, independent security audit or legal compliance assessment was performed. Self-reports are susceptible to social desirability bias, especially among staff where the prototype was demonstrated.

6. Concluding remarks

BloodMap integrates actors, data and services into a coherent flow of availability, search, requests and notifications, providing a technically feasible proof of concept for donor location at Uíge General Hospital. The exploratory assessment with 127 people suggests good acceptance and perceived utility but shows moderate confidence in data protection, with connectivity, device access and training still to address. There is no evidence at this stage for shorter response times, more donations, scalability or validated production security.

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Future work should

(a) conduct a hospital pilot with an approved protocol, a methodologically defined sample and comparison with current practice;
(b) replace simulated criteria with reproducible measurements of response time, notification delivery, network failures and satisfaction;
(c) develop a stronger offline mode with delayed synchronization;
(d) strengthen authorization, validate institutional roles, minimize data and commission an independent audit before deployment;
(e) study interoperability with health systems and blood banks, observing data governance law;
(f) evaluate backend costs, scalability and sustainability through load testing.

Declarations

Ethics and consent. The study was conducted at Uíge General Hospital under institutional authorization (Credential No. 173/26, March 24, 2026). Data were collected June 5–11, 2026 from 127 participants by structured interview with twenty closed-ended questions. Participants were informed verbally about the objectives and gave oral consent, with confidentiality and optional identification guaranteed. The study was not submitted to an ethics committee and proceeded under the institutional authorization cited.

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