Instant Plasma donor Recipient Connector

1) *Background/ Problem Statement*

Although the government is carrying out Covid vaccination campaigns on a large scale, the number of vaccines produced is not enough for all the population to get vaccinated at present. And with the corona positive cases rising every day, saving lives has become the prime matter of concern. As per the data provided by WHO more than 3 million people have died due to the coronavirus (https://covid19.who.int/). However, apart from vaccination, there is another scientific method by which a covid infected person can be treated and the death risk can be reduced. This plasma therapy is an experimental approach to treat corona-positive patients and help them recover. This plasma therapy is considered to be safe & promising. A person who has recovered from Covid can donate his/her plasma to a person who is infected with the coronavirus.

This system proposed here aims at connecting the donors & the patients by an online application. By using this application, the users can either raise a request for plasma donation or requirement.

2) Working of the Project

This system is used if anyone needs a Plasma Donor. This system comprises of Admin and User where both can request for a Plasma. In this system there is something called an active user, which means the user is an Active member of the App and has recovered from Covid 19, only such people are recommended here for Plasma Donation. Both parties can Accept or Reject the request. User has to Upload a Covid Negative report to be able to Donate Plasma.

3) Advantages

- App already filters the Active Members.

- Here a User can be a giver as well as a borrower.

4) *System Description*

The system comprises of 2 major modules with their sub-modules as follows:

1. ### Admin

   - **Login:** Admin can login into his account using id and password.
   - **Active User:** Admin can view all active users.
   - **Plasma Request:** Admin can raise request for plasma donation to an Active User.
   - **User Request:** Admin can accept or reject donor requests on basis of user report.

2. ### User

   - **Register:** User can register using personal details.
   - **Login:** User can login into his account using email id and password.
   - **Request for Plasma:** User can raise request for plasma donation.
   - **Report:** User need to upload their report of been successfully recovered from COVID19.
   - **Emergency Request:** User can raise request for plasma in emergencies.

NEVON SOLUTIONS

5) *Project Life Cycle*

The waterfall model is a classical model used in system development life cycle to create a system with a linear and sequential approach. It is termed as waterfall because the model develops systematically from one phase to another in downward fashion. The waterfall approach does not define the process to go back to the previous phase to handle changes in requirement. The waterfall approach is the earliest approach that was used for software development
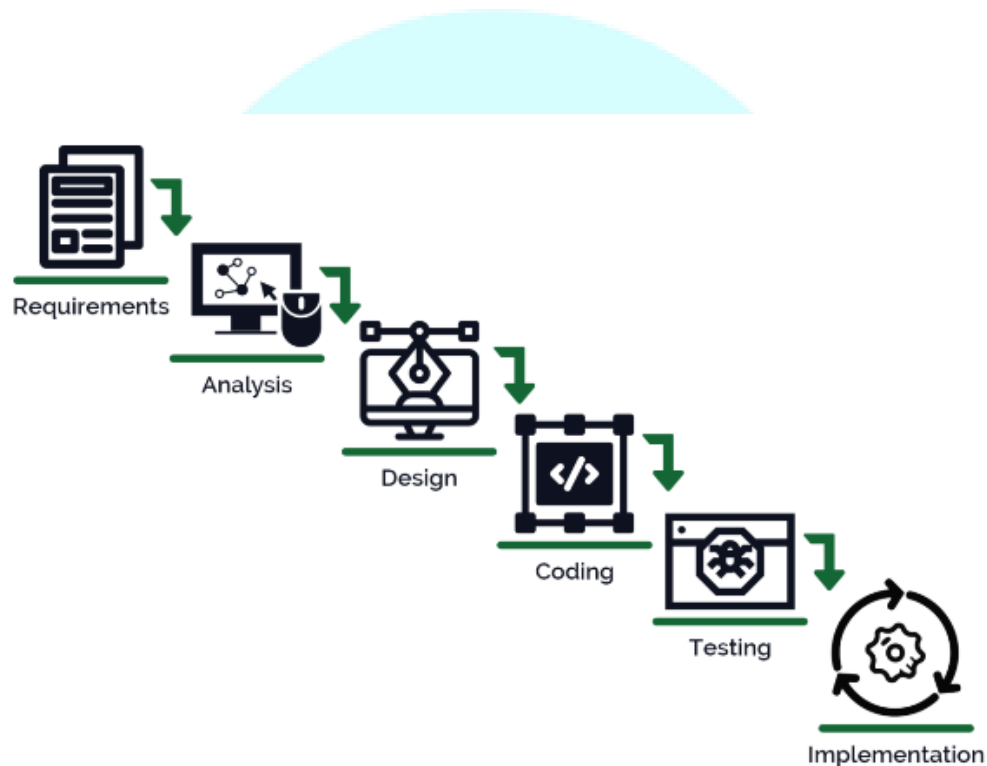
6) System Requirement

I. Hardware Requirement

i. Laptop or PC
- I3 processor system or higher
- 4 GB RAM or higher
- 100 GB ROM or higher

ii. Android Phone (6.0 and above)

II. Software Requirement

iii. Laptop or PC
- Windows 7 or higher
- Android Studio

7) *<u>Limitation/Disadvantages</u>*

- Wrong inputs will affect the project outputs.
- Internet Connection is mandatory.
- Reports are not Verified

8) *<u>Application</u>* – This system can be used by any User who wants to donate or find a donor for Plasma.

9) *<u>Reference</u>*

- https://ccpp19.org/donors/index.html

Free Blood Donation Mobile Applications

Some of the authors of this publication are also working on these related projects:

Mohammed VI Polytechnic University View project

Connected Health Applications for Mental Health in the UAE View project

MOBILE SYSTEMS

Free Blood Donation Mobile Applications

**Sofia Ouhbi · José Luis Fernández-Alemán ·
Ambrosio Toval · Ali Idri · José Rivera Pozo**

Abstract Blood donation (BD) is a noble act and mobile applications (apps) can help increase awareness about it. This paper analyzes and assesses the characteristics of free apps for BD as regards features and functionality. A search in Google Play, Apple Apps store, Blackberry App World and Windows Mobile App store was carried out to select 169 free BD apps from the 188 apps identified. The results presented in this paper show that the majority of the apps selected have been developed for the Android operating system. Moreover, most of the apps selected are available to help users search for donors. Few of the apps could not be installed and/or accessed. Of those that could be installed: half of them do not require any kind of authentication; a few of them are available in more than one language; half of them have a geographical restriction; around 60 % of them do not notify the user of BD events and requests; one, which is available for Android and iOS, can connect with a laboratory; around 45 % of them allow users to share information via social networks, and the majority of them do not provide BD recommendations. These results are used as a basis to provide app developers with certain recommendations. There is a need for better BD apps with more features in order to increase the number of volunteer donors.

Keywords Blood donation · Mobile application · Review · Functionality · Characteristics · M-health

Introduction

Providing health care via electronic means (e-health) is a new perspective as regards global health [1] which aims to improve health care service delivery to people [2]. Various e-health solutions currently offer different contents regarding health, such as: personal health records (PHRs) [3], home nursing [4], emergency health care information [5], electronic medical records (EMR) [6], electronic health records (EHR) [7] and health monitoring systems [8]. Computer literacy is therefore becoming increasingly important, and a requirement for citizenship [9].

One of the e-health components is m-health which is defined as medical and public health practice supported by mobile devices [10]. The transition of care beyond the traditional hospital setting to the homes of patients has been facilitated thanks to m-health technology [11]. The development of smartphones and tablets has had an impact on the rapid growth in the field of m-health. Moreover, mobile applications (apps) have undergone rapid growth with the release of affordable smartphones [12]. Many people currently use apps that collect or deliver health care information and data. These apps potentially provide the dynamic

S. Ouhbi (✉) · J. L. Fernández-Alemán · A. Toval
Department of Informatics and Systems, Faculty of Computer
Science, University of Murcia, Murcia, Spain
e-mail: sofia.ouhbi1@um.es

J. L. Fernández-Alemán
e-mail: aleman@um.es

A. Toval
e-mail: atoval@um.es

A. Idri
Software Project Management research team, ENSIAS,
Mohammed V University, Souissi Rabat, Morocco
e-mail: idri@ensias.ma

J. Rivera Pozo
Department of Internal Medicine, Faculty of Medicine,
University of Murcia, Murcia, Spain
e-mail: jrp@um.es

engagement of patients and health care providers and a new means to improve health outcomes [13]. Access to the m-health apps is becoming easier thanks to the distribution model of apps repositories. Major stakeholders in mobile apps include Apple, Blackberry, Google, and Microsoft. Each company owns an independent apps store for software in their operating system (OS).

Blood donation (BD) is seen as a noble act as it helps save precious human lives. According to the World Health Organization (WHO), 108 million BDs take place every year from all types of blood donors (voluntary unpaid, family/replacement and paid) and 65% of blood transfusions in low-income countries are given to children under five years of age [14]. Note that around 50% of blood donations are collected in high-income countries, home to 15% of the world's population [15]. The year 2020 is WHO's target year for all countries to obtain 100% of blood supplies from voluntary unpaid donors. BD apps are very useful for people in need, particularly in the case of emergencies when it is necessary to identify eligible blood donors. BD apps can help save lives or help volunteers keep records of their BD activities. BD apps can provide an insight into and useful information about BD types and process. Information on blood donation has been identified as a popular service in smart cities [16]. The aim of our paper is to identify, study and assess free BD apps. The search for free BD apps performed in this study has been addressed through the use of a systematic review to answer four research questions. A total of 169 free BD apps were selected and assessed. This study shows the types, functionality and characteristics of the BD apps selected. To the best of our knowledge, no previous studies have identified and presented the characteristics of BD apps, free or otherwise.

This paper is structured as follows. "Background and significance" provides an overview of related work concerning BD and m-health apps and addresses the motivations behind this study. Section "Methodology" describes the research method and protocol that were employed to select the free BD apps. The main results of the research questions of this study are presented in "Results"and "Discussion"

discusses the principle findings, presents hints to BD app developers and lists some limitations of this study. Finally, section "Conclusion and future work" outlines some conclusions based on the results and outlines the work that will be carried out in the future.

Background and significance

This section presents the guidelines of WHO as regards BD and discusses the current state-of-the-art of m-health apps.

Blood donation guidelines

According to WHO [17], "the term blood donors includes donors of whole blood, red cells, platelets, plasma and other blood components, donated as whole blood and/or through Apheresis." Blood transfusion services (BTS) are responsible for collecting blood only from those donors who are at low risk as regards any infection that could be transmitted through transfusion and who are unlikely to jeopardize their own health by BD. In order to protect the safety and sufficiency of the blood supply, a rigorous process to assess the suitability of donors is essential. This protocol is also needed to safeguard the health of the recipients of transfusions and blood donors themselves, while ensuring that suitable donors are not eliminated unnecessarily. BD apps can help blood donors to find out how, when and where to donate blood, which will save them time and protect them from any frustration and injury that may be caused during the BD process.

WHO presents guidelines for blood donor selection [17]. Guidelines on assessing donor suitability for BD have been designed for use in national blood programs in health ministries and national advisory bodies such as BTS. The availability of blood and blood products for transfusion requires the recruitment and selection of voluntary non-remunerated blood donors. Table 1 presents WHO's recommendations for blood safety and availability. The assessment of donor suitability should be undertaken in accordance with national

Table 1 WHO's Recommendations for blood safety and availability

1. Establishment of well-organized blood transfusion services that are coordinated at national level and that can provide sufficient and timely supplies of safe blood to meet the transfusion needs of the patient population.

2. Collection of blood from voluntary non-remunerated blood donors at low-risk of infections that can be transmitted through blood and blood products, the phasing out of family/replacement blood donation and the elimination of paid donation.

3. Quality-assured screening of all donated blood for transfusion-transmissible infections, including HIV, hepatitis B, hepatitis C and syphilis, blood grouping and compatibility testing, and preparation of blood components.

4. Rational use of blood to reduce unnecessary transfusions and minimize the risks associated with transfusion, the use of alternatives to transfusion, where possible, and safe clinical transfusion procedures.

5. Implementation of effective quality systems, including quality management, documentation, training of all staff and assessment.

criteria for blood donor selection. These criteria should be applied in every BD setting on each occasion of donation to all blood donors, including voluntary non-remunerated donors and even family donors and paid donors [17].

M-health applications

M-health technology could have a profound application in the prevention of cardiovascular disease [18] or in the treatment of patients with chronic diseases such as diabetes and congestive heart failure [19]. Owing to the increasing number of smartphones and m-health apps, the US Food and Drug Administration [20] recently issued guidance that will apply a risk-based approach to ensure the safety and effectiveness of m-health apps, as occurs with other medical devices [13]. While mobile devices previously existed in the form of Personal Digital Assistants, their role was relegated to functioning solely as a mobile reference containing locally stored static resources because of their limited functionality and connectivity options. What is more, the software distribution model for these devices was limited to the expansion of apps onto the market. The advent of recent smart devices and a more robust software distribution model through app stores has therefore led to a large increase in the development and implementation of apps into daily use [12]. Previous research has provided insights into how the different app markets have grown, the variation in prices, the sizes of apps, ratings, number of downloads, description lengths, and top app vendors [21]. Many researchers have carried out studies on different m-health apps [22]. The mobile PHRs [13] and m-health app tools [23] have been evaluated. The patchwork of legal and liability issues of m-health apps has been discussed [11]. The features of mobile apps in specific domains such as: diabetes [24], health promotion [25], emergency decision making [26, 27] and older adults [28] have been reviewed. The quality of experience of the different m-health app features could be assessed using a tool which has been developed with the help of psychologists [29].

Note that with the exception of one thesis [30], no study about BD apps has been identified. The aim of this study is to identify the existing types of free BD apps and also to review and evaluate the functionality and characteristics of free BD apps for Android, Blackberry, iOS, and Windows. Those apps that are complaint with BD guidelines are also identified as a consequence of this evaluation.

Methodology

This section describes the method used to search for, select and assess the free BD apps.

Review protocol

A systematic review has been used to address the search for free BD apps. This paper follows the quality reporting guidelines set out by the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) group [31]. The objective of the PRISMA Statement is to help authors improve the reporting of systematic reviews and meta-analyses. A review protocol was adopted in which each step of the systematic review, including eligibility criteria, was described before beginning the search for apps and the data extraction.

Research questions

The objective of this study is to answer the four RQs presented in Table 2.

Eligibility criteria and sources

To find BD apps that are relevant to the objective of this study. Each application identified has been evaluated to decide whether or not it should be included. The following inclusion criteria (IC) were used in order to perform the selection process:

IC1   BD apps
IC2   Apps that have a free version
IC3   Apps for human BD

Table 2 Research questions

ID	Research Question	Motivation
RQ1	Which BD apps are currently available in app repositories?	To identify the BD apps that are available in repositories, and which app store offers most mobile BD apps
RQ2	What types of BD apps have been selected?	To classify the different types of BD apps that exist in each mobile app store
RQ3	Can the BD apps be installed with no problems?	To list the possible problems that can occur while installing BD apps
RQ4	What are the characteristics of the installed BD apps?	To analyze which features are presented in BD apps

IC4   Apps which focus only on BD

IC1 selects those BD apps which were classified by their developers as pertaining to health category. **IC2** selects free BD apps because they are available to anyone. **IC3** is necessary to ensure that the BD apps to be selected are for human in order to eliminate apps for pets, such as cat and dog BD. **IC4** selects only those apps which were developed for BD and discards those that focus on general health but include BD as functionality.

The following apps repositories were selected to perform the research: Apple App store, Blackberry App World, Google Play, and Windows Mobile store. The PICO (population, intervention, comparison and outcome) [32] criteria were used to define the search string. The population considered is that of blood donors; our intervention was free apps for BD; and all existing outcomes regarding BD apps are of interest in this study. As the aim of this study is not to find evidence about BD free apps, the "Comparison" part of the PICO criteria was excluded. The search string is defined as follows:

Blood **AND** (*donat** **OR** give **OR** type* **OR** bank* **OR** network* **OR** center* **OR** help **OR** need*)

BD app selection

The selection of BD apps was organized as follows:

1. The search string was used to search for apps in the repositories in order to identify candidate apps for this study.
2. Eligibility criteria **IC1**, **IC2**, **IC3** and **IC4** were applied to the candidate apps.

3. The BD apps which did not meet **IC** were not selected.

The activities above were carried out in May 2014 by one author and reviewed by another author. Apps that were judged differently were discussed by the two authors who carried out the evaluation until an agreement had been reached. The remaining authors reviewed the final selection. Figure 1 presents the result of the selection process in each app repository. A total of 169 BD apps were selected from the 188 apps identified. Nineteen candidate apps were discarded from our study: 6 apps are not free, 2 apps are dedicated to animal BD and 11 apps do not focus solely on BD and include other health aspects.

Data extraction strategy

The characteristics were chosen by conducting a preliminary evaluation of the BD apps and identifying common elements that could form the basis for a comparison. Furthermore, there is little consensus as to what information should be included in m-health apps in general and in BD apps in particular. Comparative frameworks of previous studies on m-health [23, 24] and web-based health [3] were therefore explored to elaborate a catalogue of relevant features. The data extraction was carried out on the 18th of May 2014 using the questionnaire shown in Table 3. A template was designed containing the data that should be extracted. Two authors and two experts in new technologies evaluated the BD apps. Each person has a different OS installed in her/his smartphone:

–   Android version 4.3
–   Blackberry 10.2.1.2102

Fig. 1 Selection process

After Applying	IC1	IC2	IC3	IC4 Final selection
App Store	32	30	30	28
BlackBerry App World	9	9	9	9
Google play	114	111	109	106
Windows Mobile	33	32	32	26
Total	**188**	182	180	**169**

Table 3　Characteristics questionnaire

ID	Question	Motivation
Q1	What types of authentication are used in BD apps?	Privacy. To identify the authentication types used before accessing the data in the BD apps
Q2	Are the BD apps available in more than one language?	Internationalization. To identify the languages used in BD apps
Q3	Are the BD apps dedicated to universal use?	Internationalization. To analyze the potential population of BD apps
Q4	Is notification one of the features of the BD apps?	User communication. To discover whether the user receives notification from the BD apps and to identify the types of notification used in these apps
Q5	Do the BD apps use maps to show localization?	Localization. To examine whether it is easy to localize centers or donors in the BD apps
Q6	Do the BD apps connect to laboratories, hospitals or third party information systems?	User communication. To investigate whether the user can receive BD data from laboratory, hospital information systems or PHR directly on his/her smartphone
Q7	Is it possible to use the BD apps to connect to a social network?	Social media. To inspect whether the app can share BD information via a social network and also to identify the main social networks that the user can access
Q8	Do the BD apps include a set of recommendation about the BD process?	Recommendations. To identify whether the user can access information, advice and tips regarding the BD process in the BD apps

– 　iOS 7.0.4
– 　Microsoft Windows* Phone 7.8

BD apps characteristics

A list of 8 characteristics of the free BD apps were extracted and evaluated: authentication methods, languages in which the apps are provided, geographical limitations, notifications, geolocation, connection with laboratories, hospitals or third parties, connection to social networks, and BD recommendations. The motivations for using these characteristics are also presented in Table 3.

Results

This section describes the results related to the data extraction process performed. Table 4 presents an overview of the final result of this study. This table also shows the date of the last update of each app. Note that in the rest of the paper, only the IDs of the BD apps will be used. In order to match the ID with the name and the website of the app, the reader should refer to Appendix A. The following subsections present the result of this study per RQ.

RQ1. The final BD app selection list

A total of 169 free BD apps were selected from the 188 apps identified. The final list of the selected BD apps are presented in Appendix A. Around 63 % of the BD apps selected are available in Google Play, 17 % are available in Apple App store, 15 % in Windows Mobile store and only 5 % in Blackberry App World.

RQ2. Types of BD apps selected

The following types were identified from the description in the repository of each of the BD apps selected:

Find donors.　Apps which help the user find donors
Find centers.　Apps which help the user to find centers/hospitals where she/he can donate blood
Records.　Apps which record the donation history of the user
Blood types.　Apps which explain information about blood types to the user
Blood calculation.　Apps which estimate the blood type of a user by using the blood types of relatives
Related to a center.　Apps which provide the user with information related to a center or centers such as BTS, hospitals, or laboratories
BD eligibility.　Apps which calculate the date on which the user may donate blood based on the date of her/his last BD
General.　Apps which provide general information about the BD process

The BD apps categorized in each type are presented in Fig. 2. This figure also shows the BD apps selected that can be classified in more than one type such as the G56 app

Table 4 Results

RQ1	RQ2	RQ3	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Latest update
G1	FD	No	Yes	No	No	Yes	No	No	Yes	No	9/19/13
G2	FD	No	No	No	Yes	No	No	No	No	No	9/20/13
G3	FD	No	No	No	Yes	No	No	No	No	No	9/19/13
G4	FD	No	Yes	No	No	Yes	No	No	Yes	No	2/21/14
G5	FD	No	Yes	No	Yes	No	Yes	No	No	No	8/24/13
G6	FD, E	No	No	No	No	Yes	Yes	No	Yes	Yes	3/13/12
G7	FD	No	Yes	No	Yes	No	Yes	No	No	No	1/20/14
G8	RC	No	No	No	No	No	Yes	No	Yes	No	4/29/14
G9	FD	No	Yes	No	No	Yes	No	No	No	No	10/18/13
W1	FD	No	Yes	No	No	Yes	Yes	No	No	No	8/30/12
G10	FD	No	Yes	No	No	Yes	No	No	No	No	5/1/14
W2	BT	Yes	-	-	No*	-	-	-	-	-	2/10/14
A1	FC	No	Yes	No	Yes	No	Yes	No	No	No	8/14/13
W3	GI	No	Yes	Yes	Yes	No	No	No	Yes	Yes	12/17/13
A2	E	No	Yes	No	Yes	No	No	No	Yes	Yes	4/3/14
G11	BC	No	No	No	Yes	No	No	No	No	No	6/9/13
G12	FD	No	Yes	No	Yes	No	No	No	Yes	Yes	2/5/13
G13	FD	No	No	No	No	No	No	No	No	Yes	8/16/12
G14	FD	No	No	No	Yes	No	Yes	No	Yes	Yes	3/6/14
G15	FC	No	No	No	Yes	No	No	No	No	Yes	11/28/12
A3	FD	No	No	No	Yes	Yes	No	No	No	Yes	11/28/12
G16	E	No	No	Yes	Yes	No	No	No	No	Yes	12/27/12
B1	E	Yes	-	-	-	-	-	-	-	-	1/27/13
G17	FD	No	Yes	No	No	No	No	No	Yes	No	4/26/14
B2	E	Yes	No	Yes	No	No	No	No	No	-	3/13/12
G18	E	No	-	-	-	-	-	-	-	No	3/31/14
G19	FD	No	Yes	No	Yes	Yes	No	No	No	No	5/10/11
G20	FD	No	No	No	Yes	No	No	No	Yes	No	10/4/11
G21	FD	No	Yes	No	No	No	No	No	No	Yes	2/21/13
G22	FD	No	No	No	No	Yes	No	No	Yes	Yes	3/22/12
G23	R	No	No	No	No	No	No	No	Yes	Yes	12/16/12
W4	BT	No	No	Yes	Yes	No	No	No	No	Yes	6/1/12
W5	FD	Yes	-	-	-	-	-	-	-	-	9/25/13
G55	E	No	No	No	Yes	No	No	No	No	Yes	12/11/13
B7	E	No	No	No	Yes	Yes	No	No	No	No	3/6/12
W18	FD	Yes	-	-	-	-	-	-	-	-	11/13/13
B8	GI	No	No	No	Yes	No	No	No	No	Yes	7/12/13
G56	R, FD, FC, E	No	Yes	No	Yes	No	Yes	No	Yes	No	4/21/14
A8	E	No	No	No	Yes	No	No	No	No	Yes	3/5/13
W19	FD	No	Yes	No	No	No	No	No	No	No	7/12/13
G57	GI	Yes	-	-	No*	-	-	-	-	-	4/24/14
G58	R	No	No	No	No	No	No	No	Yes	Yes	5/31/13
A9	FD	No	No	No	No	Yes	No	No	Yes	Yes	10/31/12
G59	FC	Yes	-	-	No*	-	-	-	-	-	1/18/11
G60	FC	No	No	No	Yes	No	No	No	No	Yes	10/3/13
G61	FC	No	No	No	No	No	Yes	No	No	No	5/14/12
G62	FC	No	No	No	No	No	No	No	Yes	Yes	10/28/13
W20	FD	No	No	No	No	No	No	No	Yes	No	4/29/13
G63	FD	No	No	No	No	No	No	No	Yes	No	11/3/13
A10	FD	No	No	No	No	No	No	No	Yes	No	5/10/13
W21	FC, E	Yes	-	-	No*	-	-	-	-	-	10/31/13
G64	FC	No	No	No	No	No	Yes	No	No	Yes	7/2/12
A11	RC	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	1/20/14
W22	FD	No	-	-	No*	-	-	-	-	-	6/20/13
A12	FC	Yes	Yes	No	Yes	No	Yes	No	Yes	Yes	4/20/14
G65	FD	No	Yes	No	Yes	No	Yes	No	Yes	No	1/30/14
A13	FD	No	Yes	No	Yes	Yes	Yes	No	Yes	No	6/6/13
A14	FD	No	Yes	Yes	Yes	No	Yes	No	Yes	No	4/13/14
G66	FC	Yes	-	-	No*	-	-	-	-	-	4/30/14
G67	FC	No	Yes	No	No	Yes	No	No	Yes	No	5/2/14
G68	FC	Yes	-	-	-	-	-	-	-	-	1/30/14
G69	FC	No	No	No	No	No	No	No	No	No	8/12/13
G70	FC, R	No	Yes	No	No	Yes	Yes	No	No	No	3/29/13
A15	FC	No	Yes	No	No	Yes	No	No	No	No	3/27/13
G71	FC	No	No	No	No	No	Yes	No	Yes	No	1/20/14
W23	FD	No	No	No	No	Yes	No	No	Yes	No	11/30/13

Table 4 (continued)

RQ1	RQ2	RQ3	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Latest update
G24	FC	Yes	-	-	No*	-	-	-	-	-	12/24/13
W6	GI	No	No	No	Yes	No	No	No	No	Yes	8/29/12
G25	FC	No	No	No	Yes	No	Yes	No	No	No	6/15/12
W7	BT	Yes	-	-	-	-	-	-	-	-	1/21/14
B3	BT	Yes	-	-	-	-	-	-	-	-	8/19/13
G26	FD	No	Yes	No	Yes	Yes	Yes	No	No	No	8/7/13
G27	FD	No	No	No	Yes	No	No	No	No	No	10/13/13
W8	FD	No	No	No	No	No	No	No	No	No	10/11/12
G28	FD	No	Yes	No	Yes	Yes	No	No	No	No	4/11/14
G29	FD	No	No	No	No	Yes	Yes	No	Yes	No	9/25/13
A4	FD	No	No	No	No	Yes	Yes	No	Yes	No	4/1/14
A5	FD	No	No	Yes	No	Yes	No	No	Yes	No	4/29/14
G30	FD	No	No	No	Yes	No	No	No	Yes	No	3/4/14
W9	FD	Yes	-	-	-	-	-	-	-	-	12/14/11
G31	FD, FC	No	Yes	No	No	Yes	Yes	No	Yes	No	10/17/13
G32	FD	No	Yes	No	Yes	No	No	No	Yes	No	3/21/14
W10	BT	Yes	-	-	-	-	-	-	-	-	1/10/14
W11	E	No	No	No	Yes	No	No	No	No	No	7/2/13
W12	BT	Yes	-	-	-	-	-	-	-	-	11/20/13
G33	FD	No	No	No	No	No	No	No	Yes	No	2/24/14
G34	FD	No	Yes	No	No	No	No	No	No	No	5/4/14
G35	FD	No	No	No	Yes	Yes	Yes	No	Yes	No	10/11/12
B4	FD	Yes	-	-	-	-	-	-	-	-	10/11/12
G36	FD	No	Yes	No	No	No	Yes	No	No	No	1/10/14
W13	GI	No	No	No	Yes	No	No	No	No	Yes	8/31/12
W14	FD	No	Yes	No	No	Yes	No	No	Yes	Yes	3/31/12
W15	BT	Yes	-	-	-	Yes	-	No	Yes	-	1/3/14
W16	FD	Yes	-	-	Yes	-	-	-	-	-	12/22/13
G37	BT	No	No	No	Yes	No	No	No	No	No	2/16/13
G38	FD	No	No	No	No	No	No	No	No	No	11/8/12
G39	FD, FC	Yes	-	-	-	-	-	-	-	-	10/19/12
G40	FD, FC	No	Yes	No	Yes	Yes	No	No	Yes	No	5/7/14
B5	FD, FC	Yes	-	-	No*	-	-	-	-	-	10/22/13
B6	FD	Yes	-	-	No*	-	-	-	-	-	3/19/14
G41	FD	Yes	-	-	-	-	-	-	-	-	8/31/13
G72	FD	No	No	No	No	Yes	No	No	No	Yes	No	10/20/13
G73	FD	No	No	No	No	No	No	No	Yes	Yes	No	2/8/12
G74	FD	No	No	No	No	No	No	No	No	No	No	2/10/12
A16	FC, E	Yes	-	-	-	-	-	-	-	-	.	9/19/13
G75	FD	No	Yes	No	No	No	Yes	Yes	No	Yes	No	1/14/14
G76	FD	No	Yes	No	No	Yes	Yes	No	No	Yes	No	5/31/13
W24	BT	No	No	No	No	Yes	No	No	No	No	No	3/16/12
G77	FD, FC	No	Yes	No	Yes	No	Yes	No	No	No	No	5/28/13
G78	FD, FC	No	No	No	Yes	Yes	Yes	Yes	No	No	No	12/6/13
G79	FD	No	Yes	No	No	No	No	No	No	Yes	Yes	1/7/14
W25	FD	Yes	-	-	-	No*	-	-	-	-	.	10/11/13
W26	E	No	Yes	Yes	No	Yes	Yes	No	No	Yes	No	12/3/13
A17	E	No	Yes	No	No	Yes	No	No	No	Yes	No	3/28/14
G80	FD	No	No	No	No	No	No	No	No	No	No	10/8/13
G81	FC	No	No	No	No	Yes	Yes	No	No	No	Yes	1/6/14
G82	GI	Yes	-	-	-	No*	-	-	-	-	.	9/30/13
A18	GI	No	No	Yes	No	No	No	Yes	No	Yes	Yes	10/6/13
G83	FD, FC	No	Yes	No	Yes	Yes	Yes	Yes	No	No	No	12/3/12
A19	R	No	Yes	No	No	No	No	No	No	No	No	2/19/14
G84	FD	No	No	No	No	Yes	No	No	No	No	No	10/27/13
B9	FD	No	No	No	No	No	No	No	No	No	No	9/26/13
G85	FD	No	Yes	No	No	Yes	Yes	No	No	No	No	10/6/13
G86	BT	No	No	No	No	No	Yes	No	No	No	No	2/25/14
G87	BT	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	No	11/5/13
G88	R	No	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	5/28/13
A20	FC	No	Yes	No	Yes	Yes	No	Yes	No	No	No	9/10/13
A21	FD	Yes	-	-	No*	-	-	-	-	-	.	8/13/12
G89	RC	No	Yes	No	No	No	No	No	Yes	Yes	Yes	5/8/13
G90	E	Yes	-	-	-	-	-	-	-	-	.	4/23/14
A22	R	No	Yes	No	No	Yes	Yes	Yes	No	No	No	7/29/12
G91	FD	No	No	Yes	Yes	Yes	No	No	No	No	Yes	4/19/14
G92	FD	Yes	-	-	-	-	-	-	-	-	.	11/22/13
A23	FD	No	Yes	No	Yes	Yes	No	No	Yes	Yes	No	11/19/13
G93	BT	No	No	No	No	No	No	No	No	No	No	1/31/14
A24	FD, FC	No	Yes	No	No	No	Yes	No	No	Yes	No	7/12/13

Table 4 (continued)

RQ1	RQ2	RQ3	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Latest update
G42	FD	No	Yes	No	Yes	Yes	Yes	No	Yes	Yes	5/20/13
A6	FD	No	Yes	No	Yes	No	No	No	Yes	No	5/22/13
G43	FD	No	Yes	No	Yes	No	No	No	Yes	No	3/19/14
A7	FD	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	5/15/14
G44	R	No	Yes	No	Yes	Yes	No	No	No	No	4/6/14
G45	FD	No	No	No	Yes	No	No	No	Yes	No	2/27/14
G46	R	No	Yes	No	No	Yes	Yes	No	No	Yes	11/15/13
W17	E	Yes	-	-	-	-	-	-	-	-	5/5/14
G47	FD	Yes	-	-	-	-	-	-	-	-	2/12/14
G48	FD, FC	No	No	No	No	Yes	No	No	Yes	No	2/1/14
G49	FC	No	No	No	No	No	Yes	No	No	Yes	7/31/12
G51	R	No	No	No	No	Yes	Yes	No	No	Yes	1/12/14
G50	GI	No	No	No	No	No	No	No	Yes	No	1/12/14
G52	FC	No	No	No	No	No	Yes	No	No	No	4/8/13
G53	FD, FC, E	No	No	No	Yes	Yes	Yes	No	Yes	Yes	3/17/13
G54	E	No	No	No	No	No	No	No	No	No	5/27/13
A25	FC, E	No	No	No	No	Yes	Yes	No	No	Yes	9/18/10
G94	FD	No	No	No	Yes	No	No	No	No	No	8/7/13
G95	FD	No	Yes	No	Yes	Yes	Yes	No	Yes	No	4/19/14
G96	FD	No	No	No	No	No	No	No	No	No	3/19/14
G97	RC	No	Yes	No	No	No	Yes	Yes	Yes	Yes	11/11/13
A26	RC	No	Yes	No	No	No	Yes	Yes	Yes	Yes	9/27/12
G98	FD	No	Yes	No	Yes	Yes	No	No	Yes	No	3/18/13
G99	FC, E	No	No	No	No	Yes	Yes	No	No	No	2/1/14
G100	FD	No	No	No	Yes	No	No	No	No	No	12/7/13
G101	FD	No	Yes	Yes	No	Yes	No	No	No	Yes	5/23/13
A27	FD	No	Yes	No	No	Yes	Yes	No	Yes	Yes	6/21/13
G102	R	No	Yes	No	No	Yes	Yes	No	Yes	No	12/10/13
A28	R	No	Yes	No	No	Yes	No	No	Yes	No	10/7/13
G103	FD	No	No	No	No	Yes	No	No	No	No	4/15/14
G104	FC	No	No	No	No	Yes	Yes	No	Yes	Yes	2/27/14
G105	FD	No	No	No	No	Yes	No	No	Yes	Yes	11/3/13
G106	FD	No	No	No	No	No	No	No	No	No	7/11/13

(-) means that the app could not be assessed because of installation problem

(*) means that this information has been extracted only from the app description in the repository. Acronyms: FD: Find donors, FC: Find centers, R: Record, BT: Blood types, BC: Blood calculation, RC: Related to a center, E: Eligibility, and GI: General information

Fig. 2 BD apps ID per BD apps type
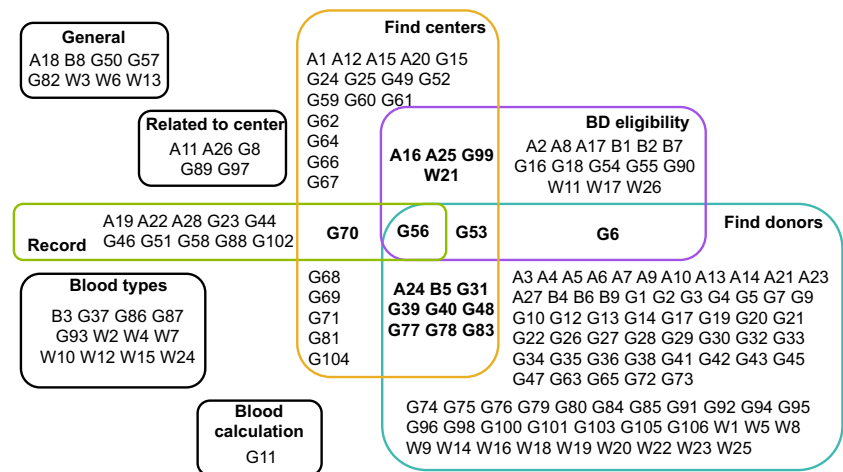
which can be classified in Record, Find donors, Find centers and BD eligibility. Around 7 % of the apps selected provide explanations about blood types, 5 % of them provide general information about the BD process, while 3 % of them have been developed for special centers and therefore provide information that is solely related to those centers. Figure 3 shows the free BD apps types per app repository. Around 69 % of apps with which to find donors are available in Google Play, while 58 % of Blood types apps are Windows Mobile apps. Record apps are only available in Google Play and App Store. Only one app for Android calculates the user's blood type on the basis of her/his relatives' blood types.

RQ3. Installation and access problems

Table 5 presents the 33 BD apps that have installation or access problems and could not be evaluated in order to extract their characteristics. Some apps could be installed but had access problems. Either no link was available to

create a profile or there were problems as regards logging in. One app had a problem concerning its connection to the server. It was possible to install only three Blackberry apps, while the others were not compatible with the OS version. It was not possible to install almost half of the Windows apps, although only 14 % of the iOS apps and 10 % of the Android apps could not be installed.

The following section will assess the remaining 136 apps which could be installed.

RQ4. BD apps characteristics

Of the 169 free BD apps only 136 were evaluated to extracted the 8 aforementioned characteristics. The results are presented in the following subsections. Note that installation problems were not considered as an exclusion criterion in order to provide an overview of the existing set of BD apps in repositories. A further reason why these apps were not excluded is that this problem may be resolved in future updates.
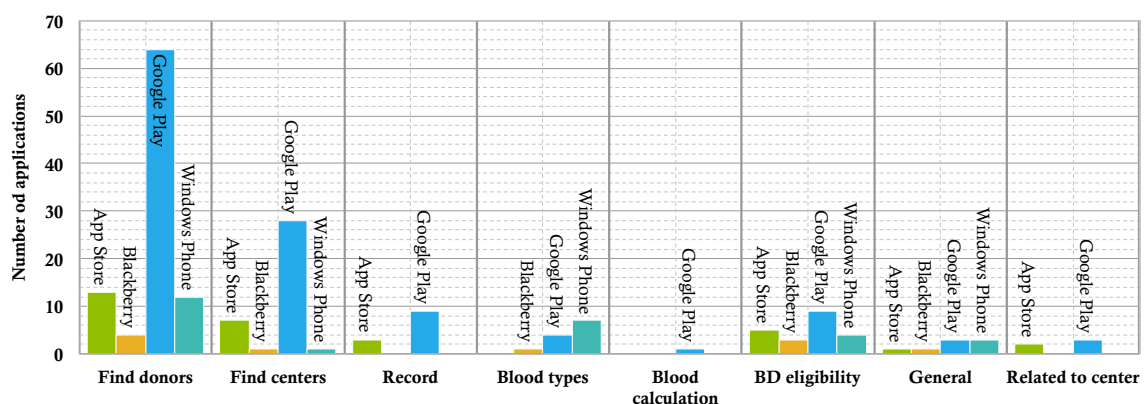

Fig. 3 BD apps types per apps repository

Table 5 Installation and access problems

Problem	ID
Incompatible with Android version	G41
No link to create profile	G47
App cannot be opened	G59
Error connecting to the server	G82
App crashes immediately after opening	G39 G92
User cannot create login	G68 W9 W25
Apps cannot be installed	A11 A12 A16 A21
	B1 B2 B3 B4
	B5 B6 G24 G57
	G66 G90 W2 W5
	W7 W10 W12 W15
	W16 W17 W18 W21

Authentication method

Around 55 % of the BD apps that it was possible to install have open access and do not require any login. Table 6 presents the authentication methods identified in the BD apps that were installed. In the A17 and W26 apps, the PESEL number is required when registering for the first time in order to create a login account, and the user can not have a login account without it. The PESEL number is the national identification number used in Poland. In the W19 app a hospital code is required to access the app. Around 26 % of the installed apps request the user to create an account in order to have a login, and, 14 % can be accessed only via a social network login, principally via a Facebook (FB) account. Some apps provide the possibility of choosing between a FB and a Twitter (Tw) login. Only 4 % of

Table 6 Authentication methods

Authentication	ID	#
Login	A1 A2 A7 A15 A19 A20	33
	A22 A24 A27 A28 G5 G7	
	G9 G10 G12 G19 G22 G26	
	G28 G34 G36 G44 G46 G70	
	G75 G77 G79 G80 G85	
	G101 W1 W3 W14	
Social network login	A6 A13 A14 A23 A26 G4	19
	G17 G32 G33 G40 G42 G56	
	G65 G67 G88 G89	
	G95 G97 W22	
Login or Social network login	G1 G31 G43 G76 G98	6
	G102	
Login + PESEL	A17, W26	2
Login + Hospital code	W19	1

the installed apps give the user the choice of accessing the content via either a normal login or a social network login.

Languages

Table 7 presents the identified languages available in the installed applications. English is used in 80 % of the installed BD apps. However, it is the only language used in 73 % of the installed apps. The second language identified is French which is available in 7 % of the installed apps, followed by Dutch and Spanish. The other languages identified are: Arabic, Bulgarian, Czech, Hebrew, Indonesian, Italian,

Table 7 Languages available on the selected BD apps

Language	Apps ID	#
English	A1 A2* A3 A4 A5* A7* A6 A8 A9	110
	A10 A13 A14* A15 A17* A18* A19	
	A20 A22 A23* A24 A25 A26 B8 B9	
	G1 G3 G5 G6 G7 G9 G10 G11 G12	
	G13 G14 G15 G17 G16* G18 G19 G2	
	G20 G21 G22 G23* G25 G26 G27 G28	
	G29 G30 G31 G32 G33 G34 G35 G36	
	G37 G38 G40 G42 G43 G44 G45 G56	
	G58 G60 G61 G63 G65 G69 G70 G72	
	G73 G74 G75 G76 G77 G78 G79 G80	
	G84 G85 G86 G87 G88 G89 G91 G94	
	G95 G96 G97 G98 G99 G100 G101*	
	W1 W3 W4 W6 W8 W11 W13 W14	
	W19 W20 W22 W23 W24 W26*	
French	A2* A7* G23* G49 G50 G51 G52 G81	9
	G101*	
Dutch	A2* A7* G16* G46 G71 G83 G101*	7
Spanish	A2* A7* B7 G23* G54 G55 G101*	7
Arabic	A2* A14* G101* G105 G106	5
Hebrew	A2* A7* A18* G101* G104	5
Russian	A2* A28 G101* G102 G103	5
Italian	A2* G8 G53 G101*	4
Polish	A2* A17* G101* W26*	4
Portuguese	A2* A7* G62 G67 G101*	5
Bulgarian	A2* A27 G101*	3
Czech	A2* G64 G101*	3
Indonesian	A2* G93 G101*	3
Slovenian	A2* G48 G101*	3
Thai	A2* A5* G101*	3
Turkish	A2* G4 G101*	3
Japanese	A2* A23* G101*	3
Others	A2* G101*	2

The symbol * means that the app is available in more than one language

Japanese, Polish, Portuguese, Russian, Slovenian, Thai, and Turkish.

Geographical limitation

Figure 4 provides an overview of the installed apps which are dedicated to a country or a specific area. A free online tool [33] was used to design the map shown in Fig. 4. Half of the installed BD apps are not restricted to any specific country or area. Around 15 % of the installed apps are dedicated to the people of India, while 6 % are for the USA. The remaining apps are dispersed in the countries which appear colored in Fig. 4. The following apps, which could not be installed, are dedicated to specific countries according to the description in their repositories: G66 for Brazil, A12 for Canada, W25 for Indonesia, G82 for Israel, B5 and B6 for Philippine, G59 for Spain, A21 and G24 for the USA, W2 and W21 for Egypt, and G57 for Germany. These apps are not shown in Fig. 4 because they could not be assessed.

Notifications

The characteristic of notification differs in each BD app type. Notification can be a reminder of the day on which the user will be eligible to donate, a message from someone who needs to receive a BD from the user, or a reminder of a BD event organized by a center. Around 60 % of the installed apps do not notify the user. Figure 5 shows the installed app IDs which have this characteristic and those that do not have it. Of the installed apps, 50 % in iOS,
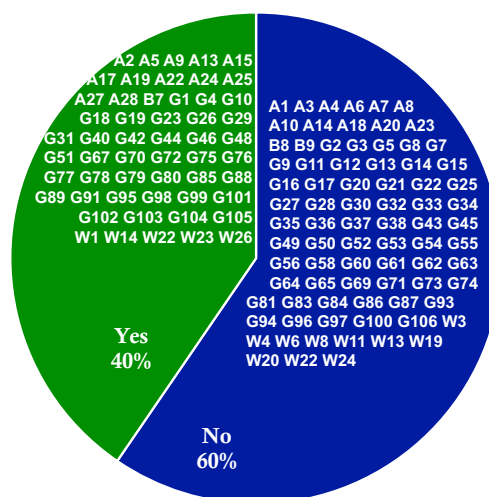

Fig. 5 BD apps which include the characteristic of notification

39 % in Android, 36 % in Windows Phone, and 33 % in Blackberry notify the user.

Geolocation

Figure 6 presents an overview of the installed apps IDs which provide the user with the possibility of visualizing maps in order to find either centers or donors. Around 65 % of the installed apps do not have this feature. None the Blackberry apps that it was possible to install provide this functionality. Of the installed apps, 50 % in iOS, 35 % in Android and only 21 % in Windows Phone display maps.
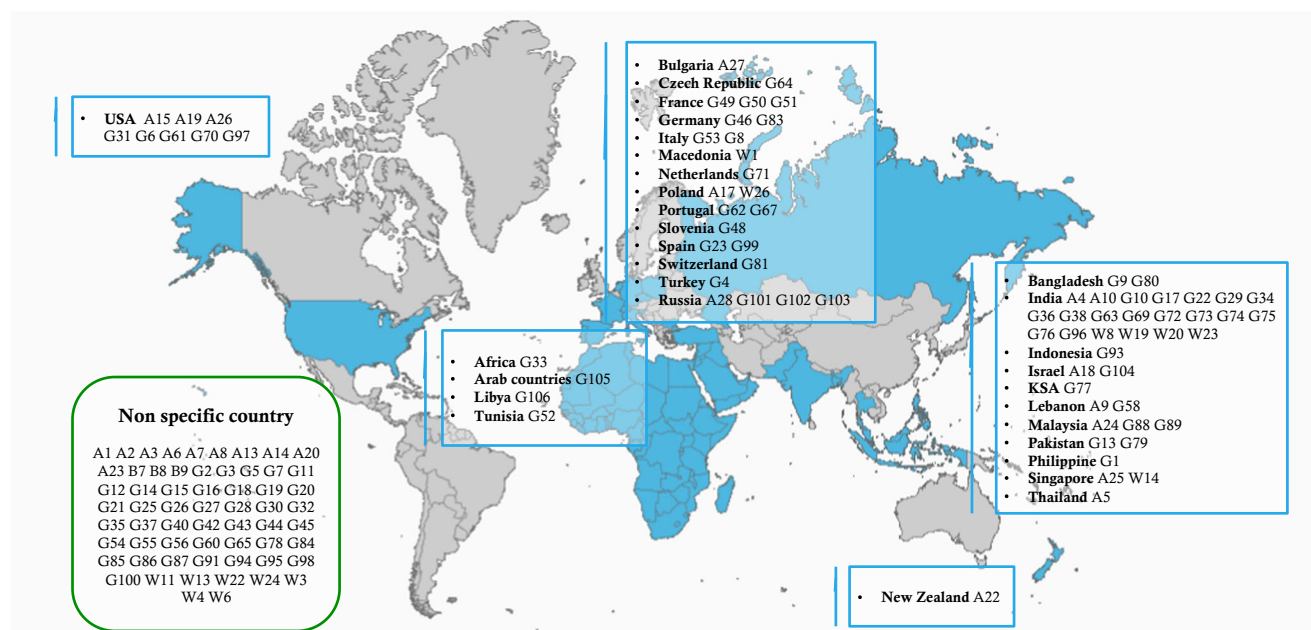

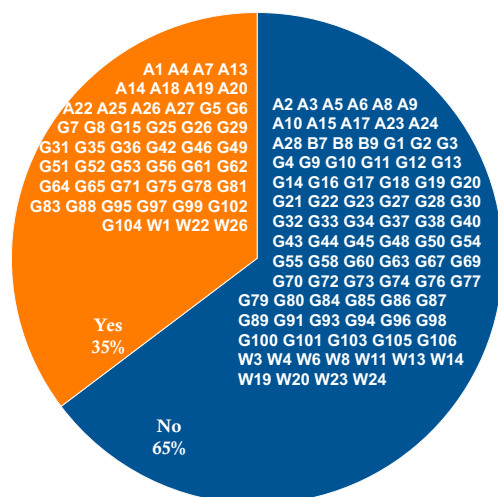
Fig. 4 BD Apps per countries

Fig. 6 BD apps which include the characteristic of geolocation

User communication with information systems

No apps receive BD information from other sources except the A26 and G97 apps which are the same app developed for Android and iOS smartphones. These two apps are connected to a laboratory which sends information to the user upon request after the introduction of the donation unit's number. They are available only in the USA.

Social networks

Around 45 % of the installed apps allow the user to share information via social networks, while 39 % of the installed apps connect to FB, 21 % to Tw, and 11 % to Google+ (G+). Table 8 presents the IDs of the installed apps that can connect to social networks. "Various" in Table 8 refers to other social networks such as LinkedIn, besides FB, Tw and G+.

Table 8 BD apps which connect with social networks

S.N	ID	#
Tw	G35 W14	2
FB, Tw, G+	G30 G33 G40 G56 G76 W3	6
Various	G8 G12 G15 G23 G45 G50 G71 G72 G75 G87 W23	11
FB, Tw	A2 A4 A9 A10 A13 A14 A26 G17 G20 G31 G48 G58 G63 G65 G79 G97 G98 G105 W20 W22	20
FB only	A6 A7 A17 A18 A23 A24 A27 A28 G1 G4 G6 G32 G42 G43 G53 G67 G73 G88 G89 G95 G102 G104 W26	23

BD recommendations

Around 62 % of the installed apps do not give the user any recommendation concerning the BD process. Only 35 % of the installed apps provide the blood donor with general recommendations and hints. Table 9 presents the recommendation source of each installed app. If no source specification is mentioned in the installed apps, the recommendations are marked as general.

Discussion

This section discusses the results and the main findings of this paper. Recommendations for BD apps developers are also presented.

RQ1: The search for the free BD apps was carried in May 2014. A total of 169 apps were selected from the 188 apps identified. More than half of the apps selected were available in Google Play which could be explained by the high availability of Android smartphones in the world. According to IDC, 78.6 % of the smartphones sold in the world in 2013 are Android smartphones [34]. Although there are approximately 20,000 medical iOS apps available in comparison with the 9,000 medical apps that are available for Android [12], the number of free BD apps for Android is over three times that of the free iOS BD apps. In contrast, even if Windows Phone had 3.3 % of the 2013 market share [34], the number of free BD apps available for Windows would be similar to that for iOS. More BD apps should be developed for Blackberry as it is gaining a greater market share thanks to Blackberry 10 OS [35]. Among the interesting results obtaining in this study is the identification of non free BD apps. Two iOS apps, three Android apps and one Windows app were not free. Although these numbers are not particularly significant when compared to the total

Table 9 BD apps which give BD recommendations

Recommendations	ID	#
German Red Cross	G16 G46	2
American Red Cross	G6	1
Spanish Health Law	G23	1
Malaysia's National Blood Center Website	G42	1
General	A2 A3 A7 A8 A9 A18 A25 A26 A27 B8 G12 G13 G15 G21 G22 G49 G51 G53 G55 G58 G60 G62 G64 G65 G79 G81 G88 G89 G91 G97 G105 W3 W4 W6 W13 W14	36

number of apps identified, it might be expected that since BD is such a noble cause, apps dealing with this subject should be free or should allow adds to have an income but not be sold. Previous research has shown that even monetary rewards for donors may crowd out BD [36]. Figure 7 shows the number of BD apps selected per latest date of update. Since May 2012, at least one app has been updated each month. The decrease in May 2014 could be owing to the fact that the date on which the apps were selected was the 18th of May. This figure also shows that BD seems to be attracting the interest of more developers.

RQ2: More than half of the free BD apps selected help users to find donors. Finding donors by using apps, especially in disaster situations, provide laboratories and blood banks with additional support [37] and could help save a tremendous amount of lives. In addition to the routine communication channels, push messages in smartphones can be used to notify donors about the need for blood after a disaster. BD records are only available in Google Play and App Store. A portable health record that is available anytime and anywhere is valuable when coordinating the medical history among multiple doctors and reduces the chance of donor selection errors. Moreover, personal health records may support personalized medicine when matching donors to patients, using extended blood typing and genetically determined storage characteristics of blood components [38]. The BD eligibility apps identified in our study are only focused on calculating the eligible date for BD based on the latest BD date. There are many evidence-based selection criteria to protect blood donors [39] which may be considered in the development of future BD apps. In general, most BD centers require the donor to weigh a minimum of 110 pounds, be at least 16 years old and be generally healthy [40]. One interesting finding is that many apps combined different types in order to give the user a greater set of functionalities. The majority of the apps that interact in more than one type are either Find centers and Find donors apps or Find centers and BD eligibility apps. These kinds of apps calculate for the donor the eligible date for her/his next BD and show the nearest BD centers that can receive her/his donation.

RQ3: Of the 169 apps selected, only 136 could be installed. Several reasons could cause the failure of app installation, such as: the phone software used in the evaluation does not support the app, the app is exclusive to a different mobile provider or the app is not available in the user's region. The characteristics of the apps were extracted only from those which could be installed in order to attain an accurate view of the actual existing characteristics of each app.

RQ4.1: Half of the free BD apps installed do not require any authentication to access the content. This result makes a sense because some BD app types do not have to have a high security level, as is the case of Blood type apps, apps to find centers, Blood calculation apps, apps which contain only general BD information and those apps that are related to a center. With the exception of accessing records that may contain sensitive information about the user [41, 42], there is no real need for authentication in BD apps. The three apps which require additional codes to the login were developed to help users find donors in specific countries. The PESEL and the hospital number will oblige the user to make a serious request for BD and avoid the making of trivial requests which could be made under the shelter of anonymity [43]. Unfortunately, such codes can be applied only in a specific area or a country. New means biometric authentication are now being developed for smartphones [44–46], and may be used in future BD apps.

RQ4.2: Only 8 % of the installed apps are available in more than one language. This could be explained by the fact that donors will most probably give blood in their surrounding areas [47]. The language most frequently used by the installed apps is English because it is currently considered to be a universal language [48]. In fact, it is the only language available in 73 % of the installed apps. This may be owing to the fact that English is the official language in India, Pakistan, The Philippines and New Zealand besides the UK and the USA. The other languages that were identified in some of the installed apps, result from the geographical limitations of these apps. Only the A2 which is a BD eligibility app, and G101, which is an app to find donors in Russia, are available in more than 20 languages. This
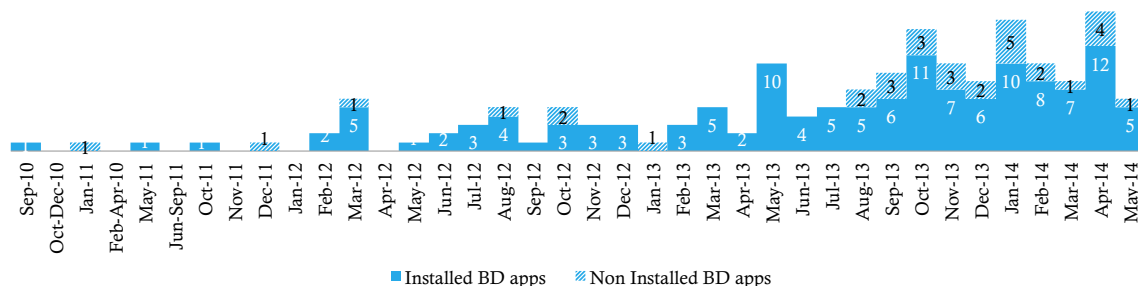

Fig. 7 Number of the BD apps per the date of update

result shows that even if an app is developed to be used in one country it could be accessible in more than 20 languages in order to allow non-native citizens or tourists to donate or find blood donors. Medical tourism is an emerging phenomenon in the sense of traveling for the purpose of seeking health care [49]. However, travelers from areas with an endemic disease might serve as the vehicles for the introduction of new viruses into a population [50].

RQ4.3: Half of the installed apps are open to universal use while the other half are restricted to specific areas. The most frequent type of BD installed app, which is not specific to a region, is Blood types (83 %). Although a total of 32 human blood group systems have been recognized by the International Society of Blood Transfusion (ISBT), ABO and the RhD antigen are the most important classifications. Both include four blood types (A, B, AB and O), with + and - denoting RhD status. Blood type apps can therefore be used by everyone. Around 27 % of the installed apps are available for Asian countries. One interesting finding concerns the number of BD apps that are available only for people in India, which is 15 % of the installed apps. The number of Indian apps exceeds the number of apps for the USA which is 6 % of the installed apps. Apps for India almost equal those that are available for all European countries together (18 % of installed apps). These results can be explained by the fact that India is ranked second in the world in terms of population, with its 1.2 billion inhabitants accounting for 17.4 % of the world's population [51]. There is a high prevalence rate of HIV (0.29 %), HBV (2-8 %) and HCV (approximately equal to 2 %) in the general population, but approximate blood collection is only 60 % of the required units [52]. New technologies can therefore play an important role in this challenging task. M-health apps are transforming and improving the health services in India [53–55]. Some apps are not specific to one country as is the case of G33 which is dedicated to finding donors in Africa and G105 which attempts to find donors in Arab countries that form the Middle East and North Africa region. The small number of apps in African countries may be explained by the problems which developers face in Africa such as: limitations in bandwidth, coverage, and electric power [56]. If African countries can overcome these problems, then BD apps will be of great help to those in need of BD, particularly, in critical zones confronted by war and poverty.

RQ4.4: Notification is a good feature which allow the user to be notified that the time of the next donation has come or whether someone in urgent need of blood. Receiving the adequate blood type at the right time can save the life of the person who requested it [57]. Notifications allow the user to know that an event is occurring, even if she/he has the app closed. More than half of the installed apps do not provide the user with this functionality.

RQ4.5: Geolocation is an important feature in apps as it helps people to search for locations in need of BD by using maps [58, 59]. Only 35 % of the installed apps provide users with geolocation services. Since donors should not be asked to make long journeys to give blood, blood services will tend to be concentrated in areas in which more people are likely to donate [38]. This characteristic may therefore be very helpful as regards identifying the nearest BD centers or BD donors. Previous research has shown that accessibility to clinics has a positive impact on donor turnout [60], the return of donors and more frequent donations [61]. However, the bad usage of GPS may jeopardize the app's user personal information [62, 63], and geolocation may be used for purposes other than BD [64].

RQ4.6: With the exception of one app that is available for iOS and for Android and gives the user the opportunity to receive blood test information from a laboratory in the USA after BD, none of the other installed apps connect with laboratories, hospitals or third parties. This characteristic can be added to the apps for specific countries or the apps related to centers. Even if some apps are related to centers, there is no direct connection between the donor and these centers. These apps provide only general information about events or advertisements for the centers that they were developed for. Receiving BD tests can be very useful as regards deciding whether the donor can either give blood in the future or that she/he is not eligible owing to a disease [65, 66]. An electronic linkage between the hospital patient information system and the transfusion laboratory computer should exist in order to link the information on patient diagnoses and blood usage [38]. Apps could capture diagnostic information and be a method by which to deliver the information to the patient.

RQ4.7: Less than half of the installed apps allow users to share BD information through social networks, mainly FB, Tw and G+. Sharing BD information in social networks may increase the awareness about BD and may encourage more non-remunerated volunteers to donate blood, which is one of the targets of WHO [17]. Moreover, thanks to its widespread use, communication through social networks could help attract new, and especially young, donors [67]. There is evidence that people become strongly motivated to act in the broader interest of the networks with the aim of maintaining social relationships that they trust [68]. In these cases, the decision to donate blood is explained by the donors' desire to enhance the status of their membership within their social networks [69]. A better understanding of the factors that influence donor behavior is essential to develop strategies, including new technologies that will encourage new and existing donors to donate more frequently [61].

RQ4.8: According to WHO [17], each country has to set its own BD guidelines and recommendations. For

example, unlike some other countries, Canada, the UK and the USA have abolished the upper age limit for blood donation. Donor selection guidelines are essential to protect both donors and patients from acute and long-term harm. Moreover, guidance based on new evidence should be continually updated. Since many apps are dedicated to specific countries, we expected to find more official recommendations adapted to those countries. However, only a few of the installed apps provide BD recommendations that are adapted to a particular country as is the case of G16 and G46 which provide their users with recommendations from the German red cross. Note that 35 % of the installed apps give general tips and information explaining the BD process and BD requirements. This kind of information is really important as it could save the time, effort and frustration of a willing donor who discovers that she/he is not allowed to donate upon arriving at the BD center. Online health assessment questionnaires could be associated with these recommendations to ensure that the donor is eligible to donate [70].

Only four apps (A27, G6, G42, G88) provide users with functionalities as regards notifications, geolocation, an SN connection and BD recommendations. There may be a number of reasons why the remaining apps do not provide users with the aforementioned functionalities: (i) these apps are targeting specific users who are therefore provided with specific functionalities, as is the case of BD type apps which do not need to include notifications, SN or geolocation functionalities; (ii) although geolocation can be used in health mobile apps [71, 72], some programmers' lack of app programming experience may have affected their ability to enhance the apps' functionalities; (iii) the developers' limitations as regards their knowledge of BD could be one reason why they do not provide users with basic BD information; (iv) the absence of a BD organization that can sponsor the app and requires the fulfillment of a software requirements specification document which may include both these functionalities and other requirements.

Hints for developers

Based on the results of this study, we encourage BD apps developers:

– To develop more record apps which include the possibility of finding donors, centers and BD eligibility in order to provide the user with the full aspect of a BD app.
– To allow their apps to show the user's notifications and to use full functionality of GPS by displaying maps based on the user's locations.
– To enhance their apps by adding tips and information about the BD process, types and eligibility.

– To develop apps for Africa, South America and Australia.
– To consider the compatibility problems with the OS in existing smartphones by using the packages that are available for different platforms.
– To enable social network information sharing via their developed apps.
– When developing for a specific country, to display the proper recommendations of that country.

Developers should bear in mind that by developing BD apps they are serving a noble cause.

Limitations

There may have been some limitations to this study such as: (i) the search string used to identify the BD apps, which may not have contained some of the words that were relevant to our search. PICO criteria have been used to alleviate this threat, (ii) the limited functionalities of the app repositories which may have limited the search range for BD apps, (iii) the application of IC2 and IC4 which may have omitted relevant apps from our study. These limitations may have slightly affected the results of our study. Nevertheless, we believe that our findings may be used in future works on BD.

Conclusion and future work

In spite of the medical progress made during the past decade, which allows major surgery to be carried out without donor transfusion [38], more than 92 million blood donations are collected every year around the world [15]. In particular, ageing populations in developed countries will lead to more complex surgical procedures for which transfusions and blood availability are necessary [73–75]. This increasing need for BD and the increasing usage of smartphones have affected the BD app market. This paper has studied the types of 169 free BD apps selected from 188 apps identified. This paper has also extracted and presented the features and functionalities of 136 installed apps from the 169 apps selected. Our findings conclude with a set of recommendations made for BD app developers. This study may be used to analyze other m-health apps besides BD by adapting the RQs and characteristics to other health disciplines. The quality aspects (usability, privacy, security, etc.) of the free BD apps selected in this study will be assessed in future work [76–79].

We also plan to prepare a reusable requirements catalog [80–82] in order to develop a BD app, which may be adapted, refined and expressed in the form of software and system requirements. In order to illustrate the viability of the proposal, a security and privacy best practices catalog

[83–85] has already been proposed in the e-health domain. Lastly, the architecture and implementation of a BD app that will fulfill the specifications identified in our research will be developed.

Appendix A: The selection results

Tables 10, 11, 12, 13, and 14 present the list of the apps selected in this study. Each Table contains the selection result for each app repository.

Table 11 Selection results: Blackberry App World

ID	App name	App website
B1	Blood Donation Calculator	http://goo.gl/uFw9Da
B2	Blood Donation Date Calculator	http://goo.gl/94cKVQ
B3	Blood Group Chart	http://goo.gl/0g6FhD
B4	Blood4LifeID	http://goo.gl/cohNnW
B5	BloodLink	http://goo.gl/RRYTP8
B6	BloodLinkV2	http://goo.gl/YCaF5H
B7	Donante	http://goo.gl/i1o9Cc
B8	Donate Blood (v1)	http://goo.gl/gv3PxE
B9	my Blood Bank	http://goo.gl/zkQEDn

Table 10 Selection results: Apple App Store

ID	App name	App website
A1	Blood Bank of Delmarva	http://goo.gl/e9Bpu4
A2	Blood Buddy	http://goo.gl/LaRAqX
A3	Blood donation	http://goo.gl/lxTNyj
A4	Blood Monk	http://goo.gl/DhG0Qe
A5	Blood of Hope	http://goo.gl/t0gBHf
A6	BloodShare	http://goo.gl/WPVuq3
A7	BloodyHelp Free	http://goo.gl/N05FSz
A8	DonorReminder	http://goo.gl/hHdFHQ
A9	DSC Lebanon	http://goo.gl/SefXrD
A10	Friends2Support.org	http://goo.gl/TKz9ia
A11	GIVEBLD	http://goo.gl/7OqVIK
A12	GiveBlood	http://goo.gl/QFRKTK
A13	GiveBloodApp	http://goo.gl/3EA79X
A14	givemehope	http://goo.gl/8vOU3b
A15	iDon8	http://goo.gl/du7wIl
A16	Inova Blood Donor	http://goo.gl/vj7aNm
A17	LifeCircle+	http://goo.gl/9Uv21D
A18	MDA	http://goo.gl/yT6RuK
A19	Michigan Blood	http://goo.gl/vjMxBv
A20	MyDocHub Phlebotomy & Blood Donation center	http://goo.gl/5I8zMk
A21	NCBB	http://goo.gl/nqnmGM
A22	NZ Blood	http://goo.gl/gFdw4h
A23	Pint4Life	http://goo.gl/DwBLgX
A24	Redy: Social Blood Drive	http://goo.gl/s7jKiA
A25	SG Blood	http://goo.gl/iAee1y
A26	The Blood Center Mobile	http://goo.gl/lbrG9D
A27	Dari-kr-v (Bulgarien)	http://goo.gl/yFWtkO
A28	Donor (Russian)	http://goo.gl/Cpv0N5

Table 12 Selection results: Windows Mobile Store

ID	App name	App website
W1	Be Humane Blood Donation	http://goo.gl/L7NrvO
W2	Blood And Health	http://goo.gl/6pRGnN
W3	Blood Buddy	http://goo.gl/cyUGK7
W4	Blood DonRec	http://goo.gl/a1VXsk
W5	BLOOD DRIVE	http://goo.gl/WgOiqE
W6	Blood facts	http://goo.gl/7zuC01
W7	Blood Group	http://goo.gl/bNXB3L
W8	Blood helpers	http://goo.gl/UJxtLl
W9	Blood Sprint	http://goo.gl/FpQDdB
W10	Blood_Groups_D_G	http://goo.gl/I86u6J
W11	blood_in_body	http://goo.gl/xe6esJ
W12	Blood_Test_	http://goo.gl/oqOCFz
W13	BloodDemand	http://goo.gl/nQohZy
W14	BloodDonation_SG	http://goo.gl/RSKlRd
W15	BloodDonorReceiver	http://goo.gl/TWi0n9
W16	BloodDonors	http://goo.gl/ehSS3y
W17	Blutspende-Rechner	http://goo.gl/UC9gX8
W18	Donate Blood	http://goo.gl/TAvB6A
W19	DonorTouche	http://goo.gl/f44zsA
W20	Friends2Support.org	http://goo.gl/CbuvgH
W21	Gaded_Dammak	http://goo.gl/ISm1Bx
W22	GiveBlood	http://goo.gl/GoWy3P
W23	Indian Blood Donors	http://goo.gl/wUzu0P
W24	Know Your Blood Type	http://goo.gl/H2JDmI
W25	Life Saver Indonesia	http://goo.gl/RZ9zQp
W26	LifeCircle+	http://goo.gl/T2Nm73

Table 13 Selection results: Google Play. Part 1

ID	App name	App website
G1	143 Volunteer	http://goo.gl/0QZqpw
G2	24HRBloodBank	http://goo.gl/I0V2jb
G3	24hrDawoodiBohraBloodBank	http://goo.gl/uWuPo4
G4	Acil Kan Bankasi	http://goo.gl/dnyInh
G5	AJS Blood	http://goo.gl/o0htkc
G6	American Red Cross Club at OSU	http://goo.gl/kqYAOm
G7	Any Time Blood	http://goo.gl/ObPwTp
G8	AVIS Toscana	http://goo.gl/nUYzuN
G9	Bangladesh Blood Bank	http://goo.gl/bnZXdd
G10	Blood 4 India	http://goo.gl/9HVNdz
G11	Blood Calc	http://goo.gl/GlPjgM
G12	Blood Call	http://goo.gl/lyqB3T
G13	Blood Corner	http://goo.gl/8e7VsK
G14	Blood Donation	http://goo.gl/LDgMTx

Table 13   (continued)

ID	App name	App website
G15	Blood Donation	http://goo.gl/wEZnZG
G16	Blood donation calculator	http://goo.gl/Rv2bEP
G17	Blood Donation Camps and Banks	http://goo.gl/zofJFz
G18	Blood Donation Reminder	http://goo.gl/hGm4f9
G19	Blood Donor	http://goo.gl/xC0egd
G20	Blood Donor Contact Manager	http://goo.gl/Z5alOy
G21	Blood Donor Contacts	http://goo.gl/QC1JZQ
G22	Blood Donor India	http://goo.gl/4JQUeb
G23	Blood donors	http://goo.gl/TunkPw
G24	Blood Drives United	http://goo.gl/fUwsdU
G25	Blood Gift	http://goo.gl/7438UW
G26	Blood Group Finder	http://goo.gl/ea5w3I
G27	Blood Group Recipient finder	http://goo.gl/Dt0Kfg
G28	Blood Money	http://goo.gl/nsK7rU
G29	Blood Monk	http://goo.gl/a3T2TS
G30	Blood Search	http://goo.gl/eK6PS8
G31	Blood Supply Network	http://goo.gl/FnMSnl
G32	Blood Type	http://goo.gl/gdIVMR
G33	Blood4Africa	http://goo.gl/1X6J16
G34	Blood4Life	http://goo.gl/tdC6bW
G35	Blood4LifeID	http://goo.gl/xYC5re
G36	BloodBoon	http://goo.gl/v3InD8
G37	BloodGroups	http://goo.gl/F5Y7Au
G38	Bloodhelper	http://goo.gl/Kas1R0
G39	Bloodium — World's Blood Bank	http://goo.gl/VFkClv
G40	Bloodline	http://goo.gl/LRVNLh
G41	BloodPedia	http://goo.gl/j02YHn
G42	BloodShare	http://goo.gl/zZR7Oa
G43	BloodyHelp Free	http://goo.gl/YYM9VQ
G44	Bloodzone	http://goo.gl/YG0caF
G45	Bloopedia	http://goo.gl/Zh3G12
G46	Blutspende beim DRK	http://goo.gl/H6y4jW
G47	Bridge	http://goo.gl/0KQCAZ
G48	Daruj Kri	http://goo.gl/33acq0
G49	Don du Sang	http://goo.gl/hTWkbQ
G51	Don du Sang 2.0	http://goo.gl/pxKcDS
G50	Don du Sang á Paris	http://goo.gl/9QFy07
G52	Don du sang Tunisie	http://goo.gl/WduFGR
G53	Dona il SANGUE	http://goo.gl/C44K0I
G54	donación sangre	http://goo.gl/EcdNCJ
G55	Donante	http://goo.gl/D5raBU
G56	Donatebloodtoday	http://goo.gl/mwMSAf
G57	DRK Ortsverein Gescher e.V	http://goo.gl/qG1EvH
G58	DSC Lebanon	http://goo.gl/XinURw
G59	E-xpoSangre	http://goo.gl/C48gpI

Table 14   Selection results: Google Play. Part 2

ID	App name	App website
G60	eDelphyn Donors	http://goo.gl/8EBvrs
G61	Emergency Blood Bank Directory	http://goo.gl/nt6toU
G62	Eu Curto Doar	http://goo.gl/TJlRnF
G63	Friends2Support.org	http://goo.gl/pvyD7K
G64	Give Blood with VZP	http://goo.gl/MSxlqr
G65	GiveBloodApp	http://goo.gl/9hlW2U
G66	Hemogram	http://goo.gl/qzX1gQ
G67	Heroi	http://goo.gl/zKcDE6
G68	HOPE	http://goo.gl/z7VM06
G69	Hyderabad Blood Bank Details	http://goo.gl/uC41BP
G70	iDon8	http://goo.gl/qAEil3
G71	Ik geef bloed	http://goo.gl/1IVO6V
G72	Indian Blood Donors	http://goo.gl/XncpuX
G73	Indore Blood	http://goo.gl/JMA2gD
G74	Infovidisha News & Blood Donor	http://goo.gl/JgV92q
G75	Jain Blood Group	http://goo.gl/B6jz2v
G76	Kerala Blood Bank	http://goo.gl/luaaVh
G77	KSADonors	http://goo.gl/mxH8b1
G78	Life Drop	http://goo.gl/bh9TeB
G79	Life Saver	http://goo.gl/vcf9iM
G80	Lifeline	http://goo.gl/6C6XvJ
G81	Mavietonsang	http://goo.gl/1oRzTL
G82	MDA	http://goo.gl/fyXUN0
G83	MeinDRK - Rotkreuz-App des DRK	http://goo.gl/TRxcbj
G84	My Blood Bank	http://goo.gl/XuVb6t
G85	My Blood for You	http://goo.gl/BVHa6h
G86	My blood type	http://goo.gl/fc2NDh
G87	My Blood Type	http://goo.gl/DkUgKx
G88	MyBlood	http://goo.gl/09j5PQ
G89	NeedBlood	http://goo.gl/NTU05v
G90	Next Blood Donation	http://goo.gl/75l4By
G91	Offline Blood Donor Manager	http://goo.gl/U9OWMX
G92	pint4life	http://goo.gl/yudAJq
G93	PMI Golongan Darah	http://goo.gl/8YREeU
G94	Social Blood Contacts	http://goo.gl/tJPqmd
G95	Socialblood	http://goo.gl/VEm7Tr
G96	Sukrutham	http://goo.gl/xPkS9F
G97	The Blood Center Mobile	http://goo.gl/3Iewr8
G98	Touch4Blood	http://goo.gl/UnGXjh
G99	Where can I donate	http://goo.gl/jjY6No
G100	Zoon Blood Donor	http://goo.gl/PPd5Ce
G101	Volunteers.DonorSearch	http://goo.gl/a0rBxO
G102	Donor	http://goo.gl/WwxWAW
G103	Yadonor	http://goo.gl/Og0sf6
G104	Mda groboot	http://goo.gl/ii22Jk
G105	Ahyeeha	http://goo.gl/j8ZhWD
G106	Bbgroups	http://goo.gl/CJFerP

References

1. Kaur, G., and Gupta, N., E-health: A new perspective on global health. *J. Evol. Technol.* 15(1):23–35, 2006.
2. Moghaddasi, H., Asadi, F., Hosseini, A., Ebnehoseini, Z., E-health: a global approach with extensive semantic variation. *J. Med. Syst.* 36(5):3173–3176, 2012.
3. Fernández-Alemán, J.L., Seva-Llor, C.L., Toval, A., Ouhbi, S., Fernández-Luque, L., Free web-based personal health records:An analysis of functionality. *J. Med. Syst.* 37(6):1–16, 2013.
4. Breen, G.-M., and Zhang, N.J., Introducing ehealth to nursing homes: theoretical analysis of improving resident care. *J. Med. Syst.* 32(2):187–192, 2008.
5. Karthikeyan, N., and Sukanesh, R., Cloud based emergency health care information service in India. *J. Med. Syst.* 36(6):4031–4036, 2012.
6. Yang, X., and Miao, Y., Distributed agent based interoperable virtual EMR system for healthcare system integration. *J. Med. Syst.* 35(3):309–319, 2011.
7. Ouhbi, S., Idri, A., Fernandez-Aleman, J.L., Toval, A., Benjelloun, H., Electronic health records for cardiovascular medicine. In: *36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC, IEEE*, pp. 1354–1357, 2014.
8. Baig, M.M., and Gholamhosseini, H., Smart health monitoring systems: an overview of design and modeling. *J. Med. Syst.* 37(2):1–14, 2013.
9. Uotinen, J., Involvement in (the information) society - the Joensuu Community Resource Centre Netcafé. *New Media Soc.* 5(3):335–356, 2003.
10. Kay, M., mHealth: New horizons for health through mobile technologies, Vol. 3 of Global Observatory for eHealth series, World Health Organization, 2011.
11. Yang, Y.T., and Silverman, R.D., Mobile health applications: the patchwork of legal and liability issues suggests strategies to improve oversight. *Health Aff.* 33(2):222–227, 2014.
12. Aungst, T., Clauson, K., Misra, S., Lewis, T., Husain, I., How to identify, assess and utilise mobile medical applications in clinical practice. *Int. J. Clin. Pract.* 68(2):155–162, 2014.
13. Sama, P.R., Eapen, Z.J., Weinfurt, K.P., Shah, B.R., Schulman, K.A., An evaluation of mobile health application tools. *JMIR mHealth and uHealth* 2(2), 2014. e19.
14. World Health Organization: World blood donor day: Safe blood for saving mothers [cited June 2014]. http://goo.gl/vrIU4v.
15. World Health Organization: Global Database on Blood Safety. Summary Report 2011, (2011) [cited June 2014]. http://goo.gl/TpwreS.
16. Ylipulli, J., Suopajärvi, T., Ojala, T., Kostakos, V., Kukka, H.: Municipal WiFi and interactive displays: Appropriation of new technologies in public urban spaces, Technological Forecasting and Social Change (2013) In Press.
17. World Health Organization: Blood donor selection: guidelines on assessing donor suitability for blood donation, 2012.
18. Martín, J.A.C., Martínez-Pérez, B., de la Torre-Díez, I. ., López-Coronado, M., Economic impact assessment from the use of a mobile app for the self-management of heart diseases by patients with heart failure in a Spanish region. *J. Med. Syst* 38(9):1–7, 2014.
19. Paschou, M., Sakkopoulos, E., Tsakalidis, A., easy Health Apps: e-health apps dynamic generation for smartphones & tablets. *J. Med. Syst.* 37(3):1–12, 2013.
20. U.S. Department of Health and Human Services Food and Drug Administration. Mobile medical applications: guidance for indus-

try and Food and Drug Administration staff, Silver Spring MD, 2013.

21. d'Heureuse, N., Huici, F., Arumaithurai, M., Ahmed, M., Papagiannaki, K., Niccolini, S., What's app?: a wide-scale measurement study of smart phone markets. *ACM SIGMOBILE Mob. Comput. Commun. Rev.* 16(2):16–27, 2012.

22. Martínez-Pérez, B., de la Torre-Díez, I., López-Coronado, M., Sainz-de Abajo, B., Robles, M., García-Gómez, J.M., Mobile clinical decision support systems and applications: a literature and commercial review. *J. Med. Syst.* 38(1):1–10, 2014.

23. Kharrazi, H., Chisholm, R., VanNasdale, D., Thompson, B., Mobile personal health records: An evaluation of features and functionality. *Int. J. Med. Inf.* 81(9):579–593, 2012.

24. Chomutare, T., Fernandez-Luque, L., Årsand, E., Hartvigsen, G., Features of mobile diabetes applications: review of the literature and analysis of current applications compared against evidence-based guidelines. *J. Med. Int. Res.* 13(3), 2011. e65.

25. Bert, F., Giacometti, M., Gualano, M.R., Siliquini, R., Smartphones and health promotion: a review of the evidence. *J. Med. Syst.* 38(1):1–11, 2014.

26. Tian, Y., Zhou, T.-S., Yao, Q., Zhang, M., Li, J.-S., Use of an agent-based simulation model to evaluate a mobile-based system for supporting emergency evacuation decision making. *J. Med. Syst.* 38(12):1–13, 2014.

27. Tian, Y., Zhou, T.-S., Wang, Y., Zhang, M., Li, J.-S., Design and development of a mobile-based system for supporting emergency triage decision making. *J. Med. Syst.* 38(6):1–10, 2014.

28. Joe, J., and Demiris, G., Older adults and mobile phones for health: A review. *J. Biomed. Inform.* 46(5):947–954, 2013.

29. Martínez-Pérez, B., de la Torre-Díez, I., Candelas-Plasencia, S., López-Coronado, M., Development and evaluation of tools for measuring the Quality of Experience (QoE) in mHealth applications. *J. Med. Syst.* 37(5):1–8, 2013.

30. Hassan, O.M.M.: application, Mobile blood donation, Ph.D. thesis, University Utara Malaysia, 2010.

31. Liberati, A., Altman, D.G., Tetzlaff, J., Mulrow, C., Gøtzsche, P.C., Ioannidis, J.P., Clarke, M., Devereaux, P., Kleijnen, J., Moher, D., The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *Ann. Intern. Med.* 151(4), 2009. W–65–W–94.

32. Stone, P.W., Popping the (PICO) question in research and evidence-based practice. *Appl. Nurs. Res.* 15(3):197–198, 2002.

33. Interactive visited countries map — am Charts [cited June 2014]. www.amcharts.com/visited_countries/#MK.

34. IDC: Android and iOS continue to dominate the Worldwide smartphone market with Android shipments just shy of 800 million in 2013 [cited June 2014]. http://goo.gl/Azp7sz.

35. Ludin, A., Learn BlackBerry 10 App Development:A Cascades-Driven Approach, Apress, 2014.

36. Costa-Font, J., Jofre-Bonet, M., Yen, S.T., Not all incentives wash out the warm glow: the case of blood donation revisited. *Kyklos* 66(4):529–551, 2013.

37. Martínez, M., Contingency planning for natural disasters. *ISBT Sci. Ser.* 6(1):212–215, 2011.

38. Williamson, L.M., and Devine, D.V., Challenges in the management of the blood supply. *The Lancet* 381(9880):1866–1875, 2013.

39. Eder, A., Evidence-based selection criteria to protect blood donors. *J. Clin. Apher.* 25(6):331–337, 2010.

40. Council of Europe Blood Transfusion. Background & Mission [cited June 2014]. http://goo.gl/l1zcDs.

41. Carrion, I., Fernandez Aleman, J., Toval, A., Personal health records: New means to safely handle health data? *IEEE Comput* 45(11):27–33, 2012.

42. Li, M., Yu, S., Ren, K., Lou, W., Securing personal health records in cloud computing: Patient-centric and fine-grained data access control in multi-owner settings. In: *Security and Privacy in Communication Networks*, Springer, pp. 89–106, 2010.

43. McMillan, J.E.R., Glisson, W.B., Bromby, M., Investigating the increase in mobile phone evidence in criminal activities. In: *46th Hawaii International Conference on System Sciences, HICSS*, pp. 4900–4909: IEEE, 2013.

44. Klonovs, J., Petersen, C.K., Olesen, H., Hammershoj, A., ID proof on the go: Development of a mobile EEG-based biometric authentication system. *IEEE Veh. Technol. Mag.* 8(1):81–89, 2013.

45. Witte, H., Rathgeb, C., Busch, C., Context-aware mobile biometric authentication based on support vector machines. In: *Fourth IEEE International Conference on Emerging Security Technologies,EST*, pp. 29–32: IEEE, 2013.

46. Meng, Y., Wong, D.S., Schlegel, R., et al., Touch gestures based biometric authentication scheme for touchscreen mobile phones. In: *Information Security and Cryptology*, pp. 331–350: Springer, 2013.

47. James, A.B., Josephson, C.D., Shaz, B.H., Schreiber, G.B., Hillyer, C.D., Roback, J.D.: The value of area-based analyses of donation patterns for recruitment strategies, Transfusion In press, 2014.

48. Pennycook, A. *The cultural politics of English as an international language*: Routledge, 2014.

49. Reed, C.M., Medical tourism. *Med. Clin. N. Am.* 92(6):1433–1446, 2008.

50. Aghaie, A., Aaskov, J., Chinikar, S., Niedrig, M., Banazadeh, S., Mohammadpour, H.K., Frequency of dengue virus infection in blood donors in Sistan and Baluchestan province in Iran. *Transf. Apheres. Sci.* 50(1):59–62, 2014.

51. Central Intelligence Agency: The World Factbook (2014) [cited June 2014]. http://goo.gl/A3RX4.

52. Agarwal, N., Chatterjee, K., Coshic, P., Borgohain, M., Nucleic acid testing for blood banks: An experience from a tertiary care centre in New Delhi,India. *Transfus. Apher. Sci.* 49(3):482–484, 2013.

53. West, D.M., and Valentini, E., How mobile devices are transforming disaster relief and public safety, Brookings Institution, 2013.

54. Singh, P., Thawani, V., Thakur, H., The advent of mhealth in India. *Asian J. Biomed. Pharm. Sci.* 3(19), 2013. O–P.

55. Davey, S., Davey, A., Singh, J.V., Raghav, S.K., Retracted m-health services: Can it be a potential mechanism in improving public health system of India? *Indian J. Commun. Health* 25(3):316–320, 2013.

56. Murugesan, S., Mobile apps in Africa. *IT Professional* 15(5):8–11, 2013.

57. Lederer, S.E., Bloodlines: blood types, identity, and association in twentieth-century America. *J. R. Anthropol. Inst.* 19(S1):S118–S129, 2013.

58. Boulos, M.N.K., and Yang, S.P., Exergames for health and fitness: the roles of GPS and geosocial apps. *Int. J. Health Geogr.* 12(1):18, 2013.

59. Glickman, M., Rao, S.R., Shapiro, G., Diaz, T., Here's to your health: Use of GPS-enabled mobile devised to conduct health surverys, Child mortality in Sierra Leone. *Chance* 25(3):38–42, 2012.

60. Páez, A., Esita, J., Newbold, K.B., Heddle, N.M., Blake, J.T., Exploring resource allocation and alternate clinic accessibility landscapes for improved blood donor turnout. *Appl. Geogr.* 45:89–97, 2013.

61. Cimaroli, K., Pez, A., Newbold, K.B., Heddle, N.M., Individual and contextual determinants of blood donation frequency with a

focus on clinic accessibility: A case study of Toronto, Canada. *Health & Place* 18(2):424–433, 2012.

62. Priyono, H., Tips and tricks to monitor employees on their Android smartphones [cited June 2014]. http://goo.gl/MTNukt, 2013.

63. J. N. Fahlquist: Responsibility and privacyethical aspects of using GPS to track children, Children & Society.

64. Gray, L.: How Does GPS Work?The Rosen Publishing Group, 2013.

65. Oei, W., Janssen, M.P., Poel, C.L., Steenbergen, J.E., Rehmet, S., Kretzschmar, M.E., Modeling the transmission risk of emerging infectious diseases through blood transfusion. *Transfusion* 53(7):1421–1428, 2013.

66. Dorsey, K.A., Moritz, E.D., Steele, W.R., Eder, A.F., Stramer, S.L., A comparison of human immunodeficiency virus, hepatitis C virus, hepatitis B virus, and human T-lymphotropic virus marker rates for directed versus volunteer blood donations to the American Red Cross during 2005 to 2010. *Transfusion* 53(6):1250–1256, 2013.

67. Martín-Santanam, J.D., and Beerli-Palacio, A., Achieving donor repetition and motivation by block leaders among current blood donors. *Transf. Apheres. Sci.* 47(3):337–343, 2012.

68. Smith, A., Matthews, R., Fiddler, J., Recruitment and retention of blood donors in four Canadian cities: an analysis of the role of community and social networks. *Transfusion* 53:180S–184S, 2013.

69. Sojka, B.N., and Sojka, P., The blood donation experience: self-reported motives and obstacles for donating blood. *Vox Sanguinis* 94(1):56–63, 2008.

70. Goldman, M., Ram, S.S., Yi, Q.-L., Mazerall, J., O'Brien, S.F., The donor health assessment questionnaire: potential for format change and computer-assisted self-interviews to improve donor attention. *Transfusion* 47:1595–1600, 2007.

71. Lee, H., Ahn, H., Choi, S., Choi, W., The SAMS: Smartphone addiction management system and verification. *J. Med. Syst.* 38(1):1–10, 2014.

72. Arif, M., Bilal, M., Kattan, A., Ahamed, S.I., Better physical activity classification using smartphone acceleration sensor. *J. Med. Syst.* 38(9):1–10, 2014.

73. The lancet series: Transfusion medicine [cited June 2014]. www.thelancet.com/themed/transfusion-medicine.

74. Ali, A., Auvinen, M.-K., Rautonen, J., Blood donors and blood collection: The aging population poses a global challenge for blood services. *Transfusion* 50(3):584–588, 2010.

75. Armitage, J., Giving the donor his (or her) due. *Transfusion* 54(3pt2):750–752, 2014.

76. Ouhbi, S., Idri, A., Fernandez-Aleman, J.L., Toval, A., Benjelloun, H., Applying ISO/IEC 25010 on mobile personal health records. In: Proceedings of Healthinf Conference, pp. 405–412, 2015.

77. Zapata, B.C., Niñirola, A.H., Idri, A., Fernández-Alemán, J.L., Toval, A., Mobile PHRs compliance with Android and iOS usability guidelines. *J. Med. Syst.* 38(8):1–16, 2014.

78. Ouhbi, S., Idri, A., Aleman, J.L.F., Toval, A., Evaluating software product quality: A systematic mapping study. In: *Joint Conference of the International Workshop on Software Measurement and the International Conference on Software Process and Product Measurement, IWSM-MENSURA, IEEE*, pp. 141–151, 2014.

79. Fernández-Alemán, J.L., Señor, I.C., Lozoya, P.Á.O., Toval, A., Security and privacy in electronic health records: A systematic literature review. *J. Biomed. Inform.* 46(3):541–562, 2013.

80. Insfran, E., Chastek, G., Donohoe, P., do Prado Leite, J.C.S., Requirements engineering in software product line engineering. *Requir. Eng.* 19(4):331–332, 2014.

81. Reddivari, S., Rad, S., Bhowmik, T., Cain, N., Niu, N., Visual requirements analytics: a framework and case study. *Requir. Eng.* 19(3):257–279, 2014.

82. Toval, A., Nicolás, J., Moros, B., García, F., Requirements reuse for improving information systems security: a practitioners approach. *Requir. Eng.* 6(4):205–219, 2002.

83. Sánchez-Henarejos, A., Fernández-Alemán, J.L., Toval, A., Hernández-Hernández, I., Sánchez-García, A.B., Carrillo de Gea, J.M., A guide to good practice for information security in the handling of personal health data by health personnel in ambulatory care facilities. *Aten. Primaria* 46(4):214–222, 2014.

84. Fernández-Alemán, J.L., Sánchez-Henarejos, A., García-Amicis, V.M., Toval, A., Sánchez-García, A.B., Hernández-Hernández, I., Study of the importance and security level of passwords in the healthcare setting. *Gaceta Sanitaria* 29(1):74–76, 2015.

85. Fernández-Alemán, J.L., Sánchez-Henarejos, A., Toval, A., Sánchez-García, A.B., Hernández-Hernández, I., L. Fernandez-Luque: Analysis of health professional security behaviors in a real clinical setting: an empirical study, International Journal of Medical Informatics In press, 2015.