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Evaluating User Experience and Functionality in Blood Pressure Mobile Applications

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Abstract

A systematic review is carried out of all at present accessible blood pressure applications for the working frameworks iOS and Android. We considered the quantity of recently released blood pressure applications, target user groups, acquisition cost, range of functions, languages, available interfaces, user ratings and connection among acquisition cost and user ratings. Furthermore, we analyzed regardless of whether the accessible applications serve the exceptional needs of blood pressure patients by carrying expert-based usability evaluation. We distinguished applicable watchwords, near classifications, and their determinations. In this manner, we played out the application audit dependent on the data given in the Google Play Store, the Apple App Store, and the applications themselves. Moreover, we did an expert based ease of use assessment based with respect to a representation of 10% example of blood pressure applications. An immense number of blood pressure applications as of now exist, yet the majority offer comparable functionalities and join just a single to two functionalities in one application. Patients and doctors alike ought to be associated with the application development procedure to a more prominent degree. We expect that the transmission of well-being parameters to doctors will acquire significance in future applications. The convenience of blood pressure applications for patients established was moderate to great. In any case, this outcome is connected fundamentally to applications offering a

little range of functionalities. Multifunctional applications performed significantly more terribly as far as ease of use. Besides, the presence of documentation or examination work brought about fundamentally bring down usability scores.

Key Words: *Mobile applications; mHalth; blood pressure; systematic review; usability test; market analysis; expert review; mobile health apps.*

Introduction:

From last couple of decades smart phones are penetrating our lives as the functionalities increasing day by day. Various tasks are managed by many mobile applications. In the Apple App Store more than 900,000 apps of iOS operating system and Apple developer, are available and in Google Play Store more than 700,000 apps are available for Android operating system and Google developer [1]. These mobile apps related to health are increasingly fast paced as in 2013 increased by 31,000[2].

Apps are supporting illnesses managing in the health care sector by promoting health knowledge and safety [3, 12]. There exist so many apps that have been designed to assist patients who have high blood pressure. The reason behind the increasing number of blood-pressure apps is the rapidly increasing number of blood-pressure patients. The high self-therapy prospective indeed has the key encouragement on the increasing number of available apps.

The researcher in this paper undertook a cross-sectional survey on all accessible blood pressure apps in the iOS and the Android operating system, in March-April 2017. When reviewing it was focused on giving an overview of various blood pressure apps, the number of functions, the cost of acquiring the app, the targeted audience, the ratings/popularity, the languages available and lastly, a comparison with the manual blood pressure measuring instrument.

To our knowledge, until now, no review for blood pressure apps has been published that links blood pressure apps with results confirmation.

Related Work:

In recent years, the proliferation of smartphones has led to a surge in the development of health-related mobile applications. Among these, blood pressure monitoring apps have gained significant traction, offering convenient and accessible tools for managing hypertension. However, the quality and effectiveness of these apps vary widely.

A systematic review conducted by [3,15] aimed to assess the availability, functionality, and user experience of blood pressure apps on iOS and Android platforms. The study analyzed a significant number of apps, evaluating their features, user ratings, and cost [13,14]. The results

highlighted that while many apps are available, a majority offer similar basic functionalities, such as blood pressure tracking and medication reminders. However, there is a lack of comprehensive apps that integrate advanced features like personalized recommendations, data analysis, and integration with healthcare providers.

The review also emphasized the importance of user experience. While many apps offer basic functionality, their user interface and user experience can vary significantly. Some apps are user-friendly and intuitive, while others may be complex and difficult to navigate [16,17]. The study found that apps with a simpler design and fewer features tended to have higher user ratings.

The study highlighted the potential for future research in the field of mobile health. This includes developing more sophisticated apps that incorporate artificial intelligence and machine learning algorithms to provide personalized recommendations and early warning systems [18]. Additionally, there is a need for further research to evaluate the clinical effectiveness of these apps and their impact on patient outcomes.

While blood pressure monitoring apps offer a convenient way for individuals to track their blood pressure, it is crucial to carefully evaluate the quality and functionality of these apps. By focusing on user experience, data privacy, and clinical accuracy, developers can create more effective and impactful tools for managing hypertension.

Materials and Methods:

This review focuses on the iOS and Android operating system for smart phone devices. This analysis was done with the help of Google Play Store and Apple App Store. Researcher was searching just for apps related to blood pressure but in English version only.

First, considerations were made with the aim of confirming that all the relevant blood pressure apps were found by choosing appropriate keywords. Following English words were chosen which are directly relevant to the blood pressure: Blood Pressure, Blood Pressure Checker, Blood Pressure prank. Every hit was examined in terms of relevancy. This pre-selection of apps was obligatory because of the increasing number of spam techniques for mobile apps and misleading description. Currently, there are no specific admission requirements for newly developed blood pressure apps. On iOS, newly developed apps undergo an internal review by the iOS review board. All apps with a clear association to blood pressure were included in the study. The framework for comparative market analysis was organized by the main categories and their respective sub-categories in Table 1.

Table 1: Classes and subclasses extracted from the Blood pressure apps.

Categories	**Specifications/Subcategories**
General Information	App Name App Language Date of release / latest update date Availability of a desktop application
Operating System	Apps for the Android operating system Apps for the iOS
Developer Information	Name of the developer
Acquisition Costs	Freeware Exact Price Trail versions of paid apps
User Rating/ Popularity	Number of installations or downloads Number of user ratings User ratings
Range of Functions	Information function Analysis function Reminder function Documentation function Data forwarding
Target User Groups	Patients Qualified health consultants Both user group

An Android application analysis was conducted using data from Google Play Store, with reference to Table 3-1 while the analysis of the iOS apps used data from the Apple App Store. The App Store also provides some filters based on thematic subcategories of the results found. But up to the present, the Google Play Store lacks features that offer the options to sort the apps based on user's prerequisites. Further, the number of hits in search results were not only the number of apps but it also includes the searched keyword in description of apps and in the name of apps. Researchers defined one complete day (12/22/2020) to record the data about apps title and developer name. 272 apps were found after removing the duplication from different keyword results.

Credibility evaluation is a usability evaluation technique here the evaluators pretend to be the current or potential user of the product. Since only final developed apps were included in the review, the researcher conducted the summative evaluation. A 10% sample of the available blood pressure apps was tested for usability as of March 22, 2017, and the sample was taken randomly. Three people assessed the evaluation, and Nielsen and Barnum support this decision [5]. The participants were identified based on their knowledge of the use and testing of smartphones and applications. Besides, they had specific knowledge in blood pressure and how to regulate it. As for the case-study implementation of the adopted guideline-based usability testing approach, recent guidelines were employed depending on propositions from prior research [8-10]. The identified criteria got the set of main and sub-criteria. Moreover, the characteristics of each criterion and corresponding assessment benchmarks were described in detail. The professionals evaluated each sub-criterion on a 5- point Likert scale and where outcomes were applicable, a dichotomous scale that facilitated the expression of certain characteristics. The score of main conditions was calculated from the meaning of the corresponding sub-criteria.

Android and iOS offer different user-friendly features for people with imperfect or reduced intellectual and physical abilities. In a single test run, the operability of three features of every app is tested.

The following features are chosen which are available in iOS and Android operating systems. The navigation and screen reader features which include Talkback in Android Smartphone and Voiceover in iPhone were assessed via binary approach. Thus, the “Larger Type” were added as complementary criterion for the “the ability to adjust size of images and interactive items” which was evaluated on the binary scale. The “Invert Color” tool was assessed based on the following 5-Likert scale regarding “sufficient color contrast”.

When carrying out their assessments, the assessors stuck strictly to the methodology proposed by Barnum; this involved moving through typical usage scenarios. They examined the perspective of a blood pressure patient. Every professional went through the basic features of the app, each of which are described in the following. Huawei P8 is used for testing the Android Apps and all iOS apps are tested by an iPhone 5. The chosen method has high observability and reliability since it relies on guidelines and encourages the use of closed categories of responses.

Table 2: Usability and assessment criteria for blood pressure apps.

Categories	**Characteristics**	**Examination Criteria**
Comprehensibility	use of clear semantics unambiguousness and interpretability of depictions Self-explanatory, simple menus	For all three points 5-point scale (1=do not apply at all; 5= fully apply)
Presentation of data (Text and Images)	Sufficient color contrast Inverted colors Large size of operating components	5-point scale (1=do not apply at all; 5= fully apply) Dichotomous scale for 3rd point (applicable, not applicable)
Usability	Immediate and understandable feedback Spontaneous usability Simple recognition of click sensitive areas Accessibility features Talkback for android and Voice over for iOS	For all three points 5-point scale (1=do not apply at all; 5= fully apply)
General characteristics	Well-organized fault management Password security facilities	5-point scale in which 1 means do not apply at all; and 5= fully apply) Dichotomous scale for 2nd point (applicable, not applicable)

Results:

- **Search and Screening:**

Researchers examined 336 applications in total, in this review process total none of iOS apps were 64 and android apps were 272. Operational language for the apps was English. All the reviewed apps running on android and iOS operates in English language.

- **Acquisition Costs:**

Android offers a higher number of free apps and a lower pay app to free app ratio than does Apple iOS. Certain applications were meant to be used with portable devices or could synchronize with compatible measurement instruments thus they could only be operated with corresponding hardware. Another point was a principal difference in the prices of paid apps on iOS and Android operating systems. The highest price of the Android app is 6.5 USD and the minimum price for android apps is 0.8 USD. On the other hand, the highest price of the iOS app is 28 USD, and the minimum price of the iOS app is 1 USD. The average price of an Android app is 2.9 USD, and the average price of an iOS app is 4 USD.

Table 3 shows the comparisons between two operating systems. Fig. 1 shows the percentage of paid and free apps of android OS in which only 7% apps are apps are apps are paid apps to use for the users and the 93% apps are free to use. The iOS has different statistics in which paid apps are 27% and free to use apps are 73% which is shown in Fig. 2. Apps which are available for both operating systems are 53 among them 42 are free, which is 79% of the total available apps and 11 apps are paid which is 21% of total available apps.

Table 3: Costs of Android and iOS apps.

OS	Total	Free	Paid
Android	272	254	18
iOS	64	47	17
Android & iOS	53	42	11

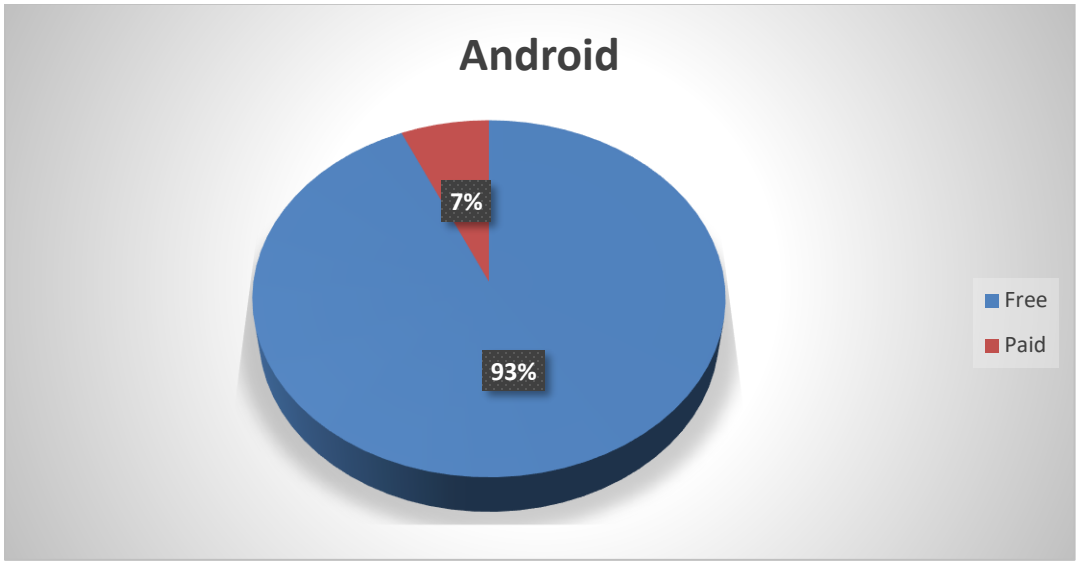

Fig. 1: comparison between free and paid apps of Android OS.

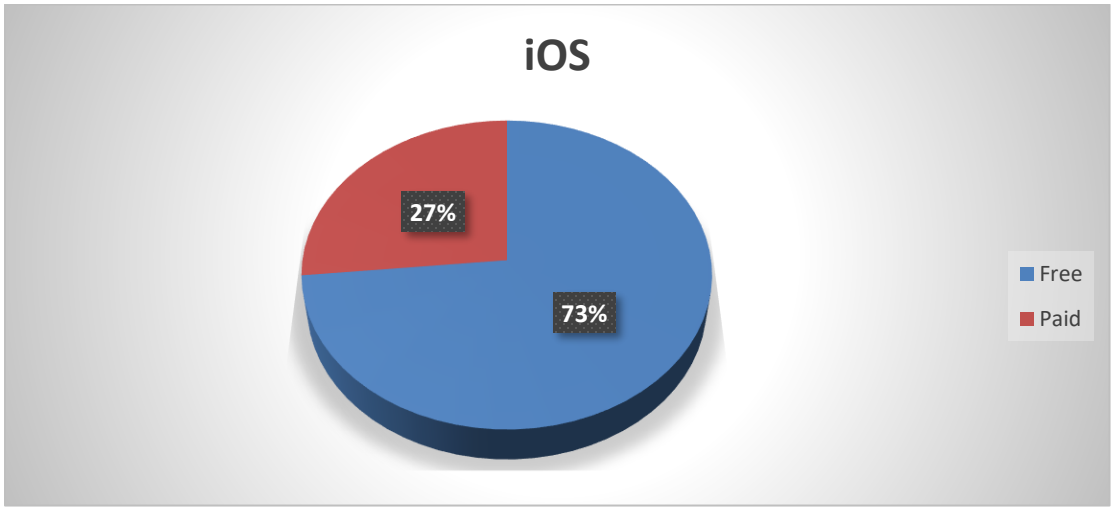

Fig.2: Comparison of free and Paid apps of iOS.

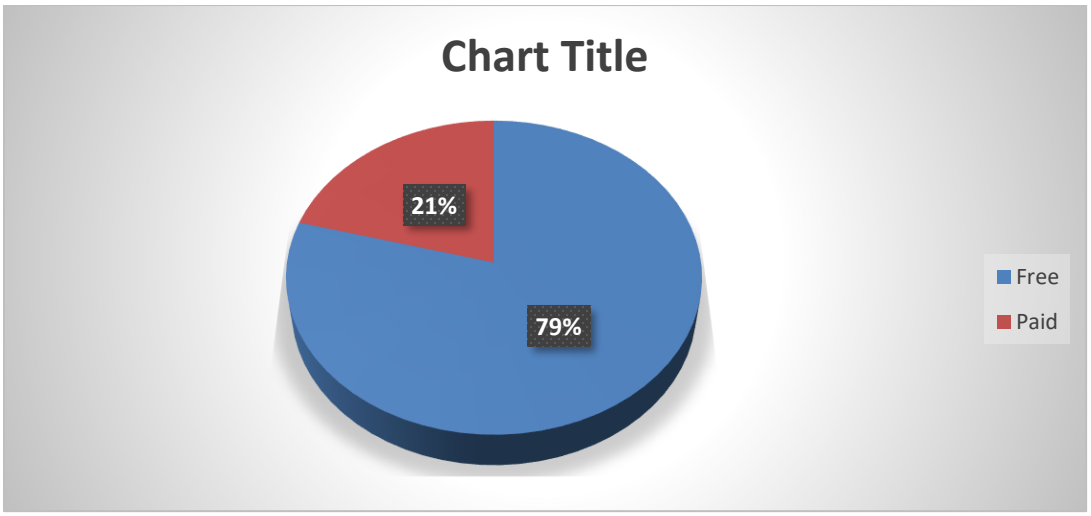

Fig.3: Comparison of free and paid apps of iOS and Android.

The price comparison revealed the fact that there is much greater availability of free applications compatible with the Android OS than with iOS.

- **Range of Functionality:**

Study showed during the examination of the range of functionality that most of the blood pressure apps are limited to only one function which are 62% in Android OS and 47% in iOS. The apps which comprise two functions are 27% in Android OS and 36% in iOS. Blood pressure apps which contain three or more functionalities are only 11% in android operating system and in iOS these are 17%.

Almost all blood pressure apps come with the documentation feature which enables users to document the measured blood pressure values, and this can be represented more graphically or tabularly. This functionality force users to watch and monitor the progress of their ailment.

As a rule, values are entered manually; however, some of them allow data transfer from a measuring device to a mobile device using Bluetooth technology in several cases.

The last documentation feature can be associated with an analysis function; thus, users can analyze record data and display the results in a proper and convenient way. Further, the documentation function includes such tasks as tracking and logging off the eating behavior of individual participants. Some of them also display battery level, or the number of times the user physically moves, or the medical treatments they insert. This documentation feature is commonly associated with a chronological-hour reminder, which helps us to think about the medicine taken or set beforehand. Some of the current apps also provide features for monitoring illness courses for the members of a family applying a comprehensive approach.

These apps also come equipped with an info menu that includes information regarding the disease, its symptoms, stages, and treatments, prescriptions, and other secondary ailments.

Some apps provide the facility of data forwarding function or communication function. This functionality helps the user to forward the data via email to the physician as well as to the family members or some friends. Some apps also provide the facility to connect with some forums with this facility user can discuss his/her blood pressure values with others after uploading the values on the forum.

But some blood pressure apps provide features, such as consultative ones or other forms of therapy support. However, the number of such apps which use the recorded data to offer advice that is tilted towards helping patients take their meds, eat healthily, or exercise, is still small.

Table 4: The functions of blood pressure apps, target user groups and user satisfaction.

Category	**Subcategory**	**iOS (n=64)**	**Android (n=272)**	**Both iOS & Android (n=53)**	**Total (n=336)**
Number of functions per app.	Single Function	20 (31.25%)	68 (25.00%)	09 (16.98%)	88 (26.19%)
	two Function	23 (35.93%)	115 (42.28%)	15 (28.30%)	138 (41.07%)
	Three Function	11 (17.18%)	60 (22.06%)	19 (35.85%)	71 (21.13%)
	>3 Functions	10 (15.62%)	28 (10.30%)	10 (18.87%)	38 (11.31%)
Target User Group	Patients	37 (57.81%)	195 (71.69%)	31 (58.49%)	232 (69.05%)
	Health Professional	7 (10.94%)	11 (4.04%)	17 (32.07%)	18 (5.36%)
	Both, Patients and Health Consultant	20 (31.25%)	66 (24.26%)	5 (9.43%)	86 (26.59%)
User Ratings/Popularity	Share of apps with ratings	25 (39.06%)	112 (41.18%)	27 (50.94%)	137 (40.77%)
	Median of Ratings	8	11	4.	8
	Median of Likert stars	3.8	4.0	4.0	3.9

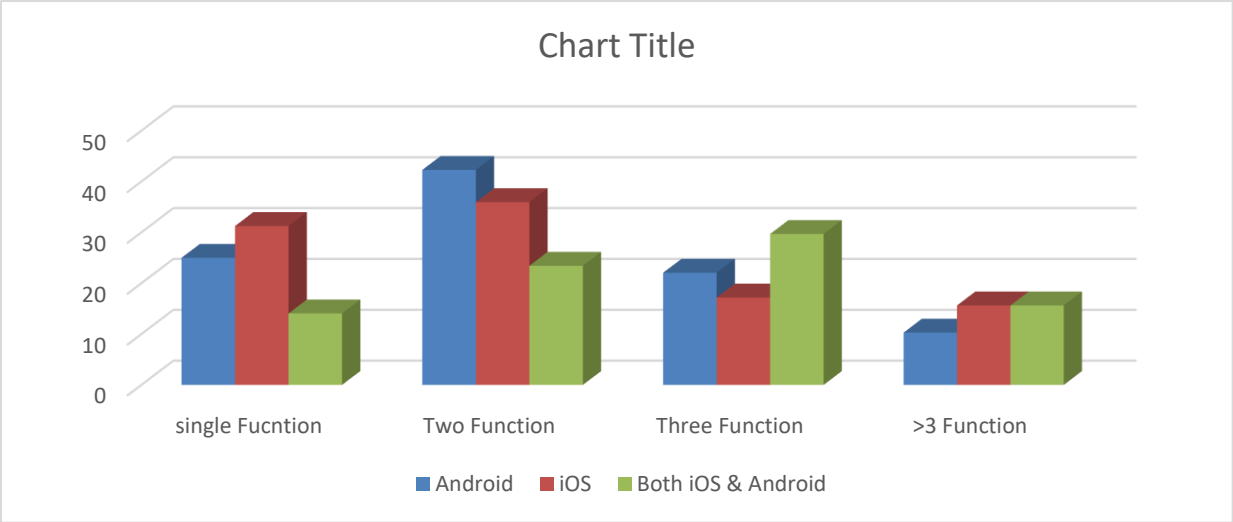

Fig. 4: Comparison Range of functionality among iOS and Android

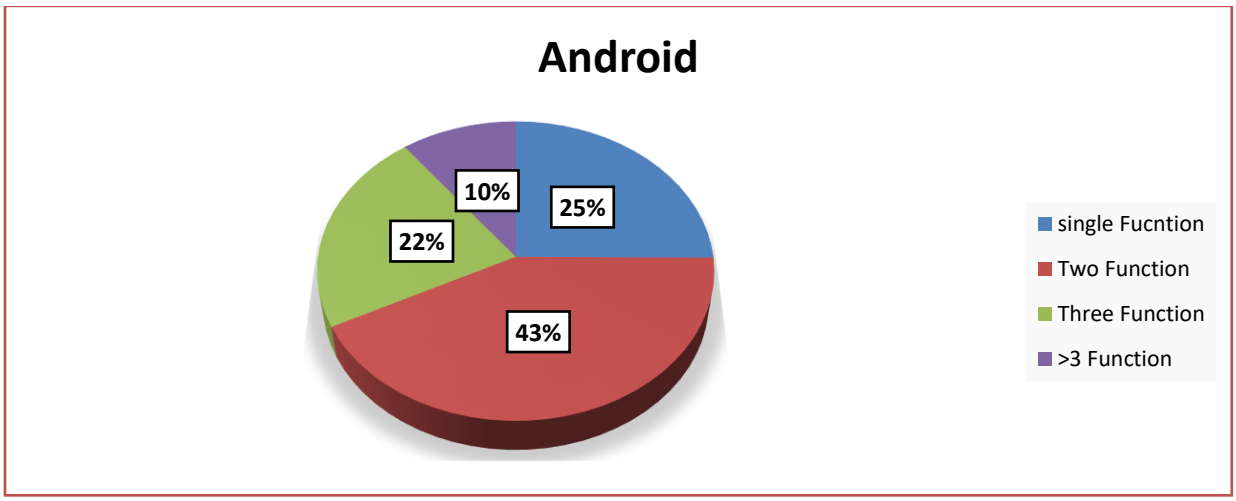

Fig. 5: Range of functionality in Android OS

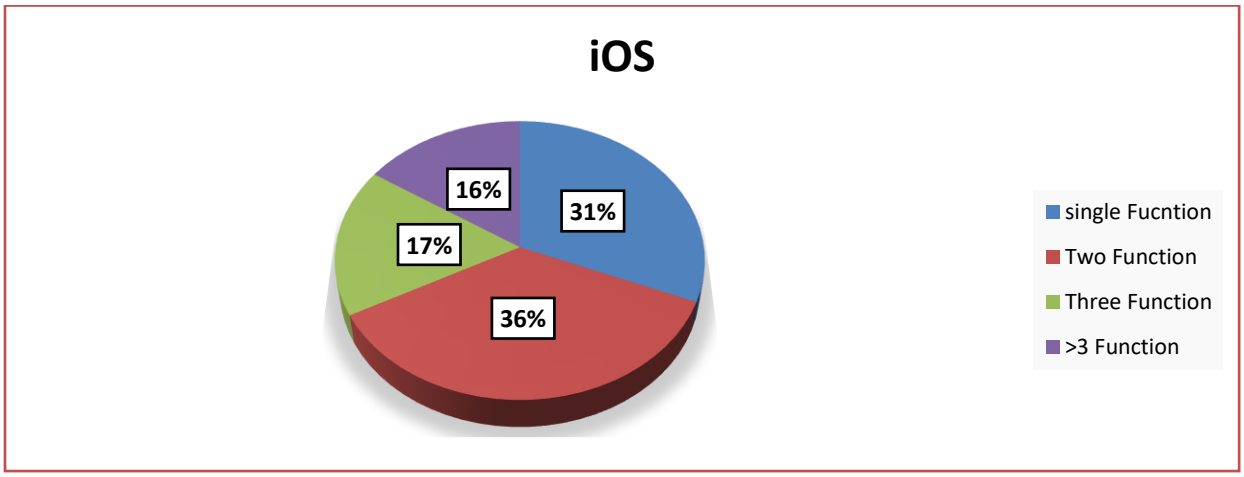

Fig. 6: Range of functionality in iOS

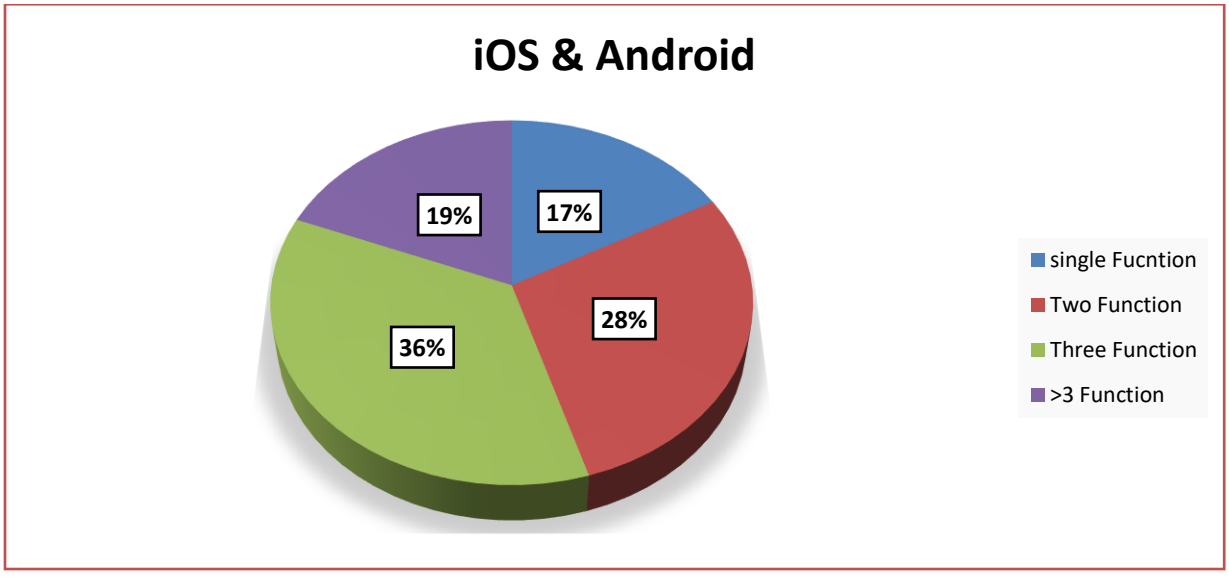

Fig. 7: Range of functionality in apps for Both iOS & Android

- **Target User Groups:**

Most of the applications investigated were initially intended for patients; only a small part of the applications considered were designed for both patients and skilled care givers, 3.7 % of applications; 7.6% applications were meant for qualified healthcare personnel or physicians only. The primary cause for this may just be probably the chance for a patient to better address and maintain a certain level of blood pressure control.

- **User Rating and Popularity:**

User rankings are extremely valuable and immensely assessed of the further reimbursements of apps. The iOS apps are rated less than the apps in Android operating system, the reason might be the procedure of rating in iOS required some steps. It is more complicated compared to Google Play Store. The average rating varied between 3.5 and 4 stars.

The Google Play Store also gives information about the overall downloads or installations that give another measure of an app's popularity. Unfortunately, this information can be found on Market, but not on Apple App Store; thus, performs cannot compare this aspect between Android and iOS.

- **Link Between Acquisition Costs and User Ratings:**

When we were carrying out the study, we found a relationship between the overall ratings of a user and the price of the app. The findings revealed that both the unit cost of acquisition as well as the stars' ratings manifested a positive relationship with pricing levels of between 100 and $200. If the acquisition costs exceeded 2 USD, the correlation lean towards inverse, and the apps acknowledged inferior evaluations. On the other hand, when comparisons are made to free apps, there are not any strong differences noticed in the number of given stars as user ratings.

- **Availability of Interfaces to External Sensors/Devices:**

Surprisingly, when compared with the first hypothesis, we discovered that very few of the blood pressure apps have an interface to interact with other measuring tools or sensors (e.g., for the dimension of user's (BP) blood pressure). Apps of Operating system iOS offered 7.8%, 5/64 this feature in comparison with Android operating system's apps which offered 5.15%, 14/272.

Most applications that allow for connection to external sensors or measuring devices use a Bluetooth connection to send data. This interface allows for wireless transfer of data to a PC or a mobile device.

4.8 Expert-Based Usability Evaluation

10% sample is taken, hence in total 34 blood pressure apps out of 336 are taken for usability evaluation. In which 27 apps are taken from the android OS and the 7 apps are taken from the iOS.

Assessment of all three professionals is averaged from all criteria. Values in the main criteria shown in Table 3 represents the mean of the corresponding sub criteria. In fact, the overall usability score was computed with all classification values having been assigned on a 5-point Likert scale. When the usability evaluation results were being analyzed, the greater part of the assessments tolerated a rating of 3.0 to 4.0 that corresponds to a moderate to decent usability for the blood pressure apps included in the 10% sample of the study. All tested apps were granted the highest possible score for the criteria defined as "clear semantics" and "clarity and interpretability of images," and the result amounted to 4.1 on average shown in Table 3. All blood pressure apps which are used in examination for the usability evaluation independent of operating system acknowledged the poorest ratings for the criteria "fault tolerance" which is 2.8.

We assessed three of the features we had identified as being useful in accessibility, and the findings suggest that the actual operationalization of these features was somewhat diminished. When conducting the systematic review, we assumed that usability declines with the rising number of functions.

Table 5: Usability scores from expert-based usability evaluation.

Categories	**Sub-criteria**	**Operating System**		
		Android	iOS	iOS and Android
		n=18	n=7	n=9
Comprehensibility	use of clear semantics	4.3	4.4	3.8
	unambiguousness	4.3	3.3	3.9
	and interpretability of depictions	4.3	4.5	4.1
	Self-explanatory, simple menus			

Presentation (Text and images)	Sufficient color contrast	4.1	3.8	4.2
	Sufficient color contrast with accessibility feature "Invert colors"	4.1 4.0	4.2 4.2	4.1 3.9
	Large size of operating components	3.9	4.1	4.2
	Ability to adopt the size of the operating elements and displayed images	3.8	3.8	3.8
	Ability to adopt the size of operating elements with accessibility feature "Large Type"			
Usability	Immediate and understandable feedback	3.8 3.8	3.8 3.7	3.2 3.3
	Spontaneous usability	3.8	3.7	3.9
	Simple recognition of click sensitive areas	3.2	3.2	2.3
	Accessibility features Talkback for android and Voice over for iOS			
Common characteristics	Well-organized fault management	2.3	2.8	2.8

	Password security facilities	1.7	1.7	1.7

Discussions:

The systematic assessment reveals that a large number of blood pressure apps exist. It should be noted that the number of patients with pressure problems is gradually growing so there may be more supply to the market. However, from the user perspective, it becomes difficult sometimes to locate an app that perfectly suits personal needs due to a wealth of choices. This problem is triggered by deficiency of effective search criteria and filter functionalities in the app stores. More often, apps are selected that are on the top of the page in the search results for blood pressure. The ways of sorting such applications are far from clear, and it may be impossible for new applications from inexperienced developers to get to the top of the rating. Altogether, many apps perform similar tasks, and the distinctions can be seen in the arrangement of the menu and the configuration of the design. Consumers expect target elements and deconstruction of complicated visuals, absence of opacity, and straightforward navigating through menus. Nevertheless, many applications revealed their inappropriateness and even indirect usability to their primary target audience. Some apps were created without enough consultation or, otherwise, before being tested for usability with patients and healthcare professionals.

Some of the apps are certified, for instance, apps that can communicate with outside sensors or any other measuring instruments; but, for now, there are no standards that call for certification of the apps as a medical product. Google's Play Store, which has the largest market share as an Android app store, does not use the concept of peer review to determine which app should be approved for listing. This, however, causes a lack of certification hence safety and effectiveness cannot be validated.

In the future, it is expected that the information forwarding function and particularly with reference to physicians will continue to grow. Submission of data to the healthcare provider couple with feedback is another useful aiding treatment since most patients in the rural areas have poor access to doctors.

Nevertheless, there are still questions about data safety, traveling solutions, availability of network coverage, integration into the health insurance programs and documentation. In the same way, integration of the measured values into external devices via a programmed real time

transmission, a function that up to now has only been developed for the transmitting of values of other variables and is expected to grow in the future, will be a major factor in improving user convenience.

5.1 Expert Based Usability Evaluations:

We also performed an expert assessment of currently available Blood pressure application using usability evaluation method. As we analyzed the outcomes of the evaluation, they were characterized by the rates of 3.0 to 4.0, which corresponds to the criteria defined by Demidovich et al. (2012) except for "fault tolerance." The lowest of the criteria was ''Comprehensibility,'' which has the highest average score of all criteria with a value of 4.0. This is especially helpful for the elderly person as they need simple language and mostly the picture and illustrations to be self-explanatory due to their limited use of mobile devices and applications.

The assessment results on the core criterion "Presentation" were described as moderate. Specifically, we tested three accessibility features and found good functionality of screen readers, and particularly the Voiceover feature of iOS. The worst ratings were received by the "Fault Tolerance" criterion, implying the absence of rigorous fault handling in the developed blood pressure apps. Thus, usability results of these apps that are based on expert's evaluation of the App's medical content should be considered very seriously because they are dealing with medical information. Our results also stress the benefits of automated transfer of measured values from blood pressure apps to mobile devices. Our regression and correlation analyses specified a strong association between usability and the number and kind of functions. In specifically, all main usability criteria and the number of functions were considerably negative correlated. It also offers a clearer understanding of the conclusion that we have arrived at when analyzing the results from our usability test. Specific to a patient with blood pressure, it was pointed out earlier that they would find easily understandable as well as all-round support quite useful.

Still, in the context of the set functionalities, documenting and analyzing apps poorly addressed usability issues. This result is somewhat incongruous because as seen in figure 3, the documentation function is represented as the highest percentage, 53.0%. This function can be highly useful for the users with hypertension problems who compare and check their levels often. However, the use of these two functions comes at the cost of a higher level of interaction between human and technology thus in turn resulting in a higher chance of developing faults as well as usability issues.

Based on the usability criteria reflected above, app developers must devote appropriate attention and, if necessary, correct the identified shortages and deficiencies. Many new avails are not necessary; instead, the existent capabilities should be enhanced.

Future Work:

The systematic review and expert-based usability test were conducted to address the question: "In a way that a mobile app can be developed to really fit the needs of the self-management patient with blood pressure." The initial study of our market provided basic information for a questionnaire given to patients and physicians. As for the job in the product development stage, potential users and usability specialists are often incorporated into the entire process. Using both user- and expert-based usability tests, we perform the tests constantly and implement the discoveries continuously until the finalization of the app.

Limitations:

The review carried out in this research only targeted apps in the currently popular operating systems; Android and IOS. Only android based blood pressure apps which were available in Google play store were considered for the study and other operating systems like Blackberry OS, Windows Phone, Symbian etc. were not considered. Whereas for the iOS apps, the date of release of app was only provided, for Android the date for update latest to that date was taken. Because of this, the results concerning the annual availability of new blood pressure apps were not directly comparable. Descriptive information in app stores and in the apps, themselves were used in compiling app statistics. Further information, including download statistics, was not available for the study, and would have been beneficial in trend analysis in gender and age diversities among the young downloaders.

In the quantitative usability assessment during the usability testing, we did not consider the quality of functions or content but only strictly the usability aspects. It was also not possible to assess the efficacy of the content and functions disseminated by the distinct. In addition, this is only one usability evaluation and as such cannot be used to fully capture all possible and important usage situations.

Moreover, we provided a feasibility assessment of all existing BP apps instead of the app that is developed exclusively for elderly users. For this reason, it is possible that most of the apps we analyzed cannot be recommended for any distinct age category.

Conclusions:

Altogether, many blood pressure apps can currently be found on the market, but most of them contain a rather restricted set of related features. Since the primary audience is patients and doctors, the latter should be involved in creating the app to rectify the above shortcomings in terms of usability and needs orientation. As for the future requirements of the system, we think that information forwarding functionalities and the opportunity of the automatic transmission of the measured values to the mobile devices will gain a growing importance.

Nevertheless, the degree of usability to which the patients accessed and appreciated the BP apps was considered sufficient to decent, but this was general to apps with limited features. Multifunctional apps were rated considerably lower in terms of usability than apps with a narrow functional purpose. Namely, two of the functions, such as documentation and analysis, were given much lower usability ratings. Further, the navigational tabs of blood pressure apps had comparatively low overall accessibility, with only the "screen reader" feature being utilized to some degree.

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