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Research Paper

A biopsy of Breast Cancer mobile applications: state of the practice review

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ABSTRACT

Background: Breast cancer is the most common cancer in women. The use of mobile software applications for health and wellbeing promotion has grown exponentially in recent years. We systematically reviewed the breast cancer apps available in today's leading smartphone application stores and characterized them based on their features, evidence base and target audiences.

Methods: A cross-sectional study was performed to characterize breast cancer apps from the two major smartphone app stores (iOS and Android). Apps that matched the keywords "breast cancer" were identified and data was extracted using a structured form. Reviewers independently evaluated the eligibility and independently classified the apps.

Results: A total of 1473 apps were a match. After removing duplicates and applying the selection criteria only 599 apps remained. Inter-rater reliability was determined using Fleiss-Cohen's Kappa. The majority of apps were free 471 (78.63%). The most common type of application was Disease and Treatment information apps (29.22%), Disease Management (19.03%) and Awareness Raising apps (15.03%). Close to 1 out of 10 apps dealt with alternative or homeopathic medicine. The majority of the apps were intended for patients (75.79%). Only one quarter of all apps (24.54%) had a disclaimer about usage and less than one fifth (19.70%) mentioned references or source material. Gamification specialists determined that 19.36% contained gamification elements.

Conclusions: This study analyzed a large number of breast cancer-focused apps available to consumers. There has been a steady increase of breast cancer apps over the years. The breast cancer app ecosystem largely consists of start-ups and entrepreneurs. Evidence base seems to be lacking in these apps and it would seem essential that expert medical personnel be involved in the creation of medical apps

1. Introduction

Breast cancer is the most common cancer in women both in the developed and less developed world [1]. It is estimated that worldwide over 508 000 women died in 2011 due to breast cancer [1]. Incidence rates vary greatly worldwide, ranging from 27 per 100,000 in Middle Africa and Eastern Asia to 92 in Northern America and 89 in Western Europe [2]. Low incidence rates from less developed regions however are probably due to a lack of early detection programmes. Fortunately, thanks to advancements in treatments, breast cancer survivorship is on a steady rise [3,4] and this cancer is no longer thought of as an acute illness but rather a chronic condition. This means that we need to treat breast cancer as such, with a focus on long term goals and wellbeing promotion [5]. Breast cancer survivors must be aware of the long-term consequences of their treatment and be given information to encourage a proactive approach to their overall health [5,6]. Many authors now claim that the ever increasing number of breast cancer survivors require new models of care. These models should include a personalized needs assessment; a self-management based care approach as well as individualized follow-up and support [7]. Also, the rising cost of

Abbreviations: App, mobile software application; Avg, average; CI, confidence Interval; DG, Diego Hernán Giunta; EG, Estefanía Guisado-Fernández; GG, Guido Giunti; IQR, interquartile range; JLB, Jackie Bender; LF, Luis Fernández-Luque; mHealth, mobile health; OS, operating system; SHF, Santiago Hors-Fraile; SE, standard error

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healthcare presents a compelling argument for developing more effective health education and communication strategies aimed at improving health outcomes [8,9].

Connected Health is a healthcare delivery model that aims to maximize healthcare resources and provide increased, flexible opportunities for patients to engage with clinicians and better self-manage their care using technology [10]. The use of mobile software applications (apps) for health and wellbeing promotion has grown exponentially in recent years [11]. Between 2013 and 2014 the global use of smartphones increased by 406 million, reaching 1.82 billion devices (up 5% in a year), and Internet usage via mobile devices has increased by 81% in one year [12]. Mobile health (mHealth) is defined as the delivery of healthcare or health related services through the use of portable devices [13]. There are currently thousands of healthcare related mobile software applications (mHealth apps) available through app stores [14]. This rapid proliferation of mHealth apps makes it increasingly difficult for users, health professionals, and researchers to identify and assess which apps may be helpful and which may be ineffective or even harmful. Concerns regarding the absence of healthcare professionals involvement in app development has been raised time and time again [15–19].

Bender et al. [20] published a review in 2013 exploring the distribution of cancer mHealth apps across the four major smartphone platforms at that time, which found that most apps (45%) focused on breast cancer. The focus of this review, however was only to assess apps for the general public. Another review published in 2014 [21] targeted apps related to breast disease but it did not provide in depth study of apps focused on breast cancer. Moreover, the past few years have seen a dramatic change in manufacturers and operating system (OS) market share, with some big players having almost disappeared today (ie: Symbian [22]). Finally, the use of game elements in non-game contexts, commonly called gamification [23] has been gaining traction in health apps and is now a popular strategy in both commercial and academic fields [24–27], however current gamification prevalence in breast cancer apps is unknown.

We systematically reviewed the breast cancer apps available in today's leading smartphone app stores and characterized them based on their features, evidence base and target audiences.

2. Methods

2.1. Study design

A cross-sectional study of breast cancer apps was performed to characterize apps from the two major smartphone app stores: iTunes App and Google Play Store, which together represent more than 98.9% of the smartphone app market share [22]. Building upon the approach used by Bender [20] we systematically searched both stores to identify all relevant apps and provide a systematic presentation and synthesis of the characteristics of the apps.

2.2. Setting

On February 24th 2016, we searched both stores from the United States using the keywords "breast cancer". The iTunes App Store is a digital distribution platform developed and maintained by Apple Inc., for mobile apps on iOS. The iTunes App Store had 2 million apps available as of June 2016 since its launch in 2008 [28]. Google Play store (originally the Android Market) is a digital distribution service operated and developed by Google. It serves as the official app store for the Android operating system. The Google Play store reached over 2.2 million apps as of June 2016 since its launch in 2008 [28]. We downloaded all apps that partially or fully matched the keywords using the software application for audience targeting called 42matters [29].

2.3. Selection criteria

Apps were included if the title and/or store description of the app was about breast cancer or breast cancer conditions, or cancer in general, but contained specific mentions about breast cancer. A small random sample (10%) was independently reviewed by two reviewers with ample mHealth experience (GG and JLB) who evaluated the eligibility of the apps against the selection criteria. In order to assess clarity of the selection criteria, inter-rater reliability was assessed using Fleiss-Cohen's Coefficient. Basic and "premium" versions of the same app were considered as separate apps as were versions of the same app for different operating systems. This distinction was considered because of the phenomenon of mobile device fragmentation in which different versions of the same app must co-exist due to version capabilities or store submission processes. This distinction is also common practice in this type of systematic app reviews [20,30]. Disagreements were resolved by consensus involving a third reviewer when necessary.

2.3.1. Inclusion criteria

- title and/or description is about breast cancer or breast cancer related conditions
- title and/or description is about cancer in general but contains information about breast cancer

2.3.2. Exclusion criteria

- description is not written in English
- duplicates from the same store
- title and/or description is not about breast cancer (ie. astrology, breastfeeding, breast augmentation, chicken breast recipes, etc.)
- title and/or description is about other specific type of cancer (ie. Pancreatic Cancer App)

2.4. Data extraction

Data was automatically extracted from the store description of the app using the software application 42matters. Data extracted included app information on: year of release, costs, downloads, ratings, title of app, app description, categories, tags, languages, app websites, screenshots, etc.

GG and EG independently manually reviewed that information extracted using structured forms by reading the store descriptions and websites of the app that had unclear store descriptions or did not provide screenshots to extract information on: origin (eg, healthcare related agencies, non-governmental organizations, universities, etc), evidence base, features and intended audiences.

2.5. Data coding and classification

Apps were classified based on their main purpose as described in the store description into only one category following Bender et al. [20] classification and our own scheme. If the purpose of the app was not clear from the description, a proper classification was discussed among reviewers until consensus was reached. To ensure classification quality, another randomly produced sample (10%) was selected from the list of included apps and two reviewers with ample mHealth experience (GG and EG) classified them. Inter-rater reliability was once again assessed using Fleiss-Cohen's Coefficient.

2.5.1. Application purpose

The application purpose classification scheme follows the work done by Bender et al. [20]:

- Awareness-raising: tools to raise public recognition of cancer as a societal problem.

- Fundraising: tools to attract financial resources for cancer control.
- Promote an organization: encourage awareness about a charitable organization raising awareness and funds for cancer or providing support to people affected by cancer.
- Disease and treatment information: provide general information about cancer (eg, disease or treatment options).
- Prevention: provide information and practical tools to avoid cancer, including the recurrence of cancer.
- Early detection: provide information and tools to assist in the identification of cancer before the emergence of symptoms or signs.
- Disease management: provide information and practical tools to deal with the medical, behavioral, or emotional aspects of cancer.
- Support: provide access to peer or professional assistance.

Additionally, apps with an alternative or complementary medicine component (such as healing prayers, hypnosis, etc) were flagged for later analysis.

2.5.2. Application origin

The app title, description and developer and/or uploading entity were analyzed and coded based on the following criteria:

- Healthcare related Agency: hospitals, clinics, pharmaceutical corporations or governmental organizations directly related to healthcare (ie Public Health branches).
- Governmental Agency: any governmental agency or organization not directly involved in healthcare (ie IT departments).
- Non-governmental Agency: any organization that is neither a part of a government nor a conventional for-profit business (ie Cancer Foundations).
- Educational Organizations: any educational organization such as Universities, Colleges, Libraries or Schools not directly related to healthcare (ie Science School Projects).
- Conferences and Journals: scientific journals, patient and/or medical conferences.
- Small and Medium-sized Enterprises: startups, software developing companies or any other private organizations that identified themselves as an enterprise and not individuals (ie Digital Health Startups).
- Patient Organizations: societies or organizations that specialize both in general health improvement as well as illness-specific objectives and offer support groups (ie Patient Empowerment Organizations).
- Individuals: developers or uploader entities who are listed as individuals or have not identified themselves as enterprises (ie John Smith).

Whenever discrepancies were found between descriptions and developer or uploading entities, description was considered instead.

2.5.3. Application target audience

The app descriptions were analyzed to assess intended target audience and coded based on the following criteria:

- Patient-oriented: intended to be used by the general public, patients and/or their family members.
- Physician-oriented: intended to be used by healthcare professionals or students from health related fields.

2.5.4. Application credibility and disclaimers

App descriptions were explored for any type of disclaimer of use or attribution of content, such as the presence of References.

2.5.5. Gamification in data set

In order to assess the presence of gamification elements, two gamification specialists (SHF and GG) examined all of the included apps' description and title independently and marked those they suspected might contain gamification elements. Due to the novelty of gamification as a discipline, specialists were defined as individuals with more than 3 years of first-hand work experience designing gamification interventions. Gamification elements include: self-representation with avatars; three dimensional environments; narrative context (or story); feedback; reputations, ranks, and levels; marketplaces and economies; competition under rules that are explicit and enforced; teams; and time pressure. These elements are in line with what was described by Reeves and Read [31] and the current body of literature used or discussed in the literature for impacting health behavior [24–26,32,33]. Fleiss' Kappa was calculated between the two specialists and the outcome was used as our "gold standard" for gamification in our data set. More information on this process is detailed in another article [34].

2.6. Statistical methods

Categorical variables are presented as absolute and relative frequencies. Quantitative variables are presented as mean and standard deviation or median with interquartile range depending on distribution. Landis & Koch's standards for Fleiss-Cohen's Coefficient are used [35]. Statistical analysis was performed using STATA version 13.

3. Results

The complete flow of this study is shown in Fig. 1.

3.1. Selection

A total of 1473 apps matched the search terms of "breast cancer", of which 692 matches were from the iTunes App Store and 781 from the Google Play Store. A random sample (n = 146) was independently reviewed by two reviewers (GG and JLB) following the selection criteria. Inter-rater reliability was determined using Cohen's Kappa and found to be more than acceptable at 0.91 (SE 0.04 CI 95% 0.83 − 0.98). One reviewer applied the inclusion/exclusion process with the remainder of app sample. After removing duplicates only 599 apps met the eligibility criteria (317 for iOS and 282 for Android).

3.2. Classification

Another randomly produced sample (n = 68) was selected from the list of included apps and two reviewers (GG and EG) independently classified them following the classification scheme. Cohen's Kappa was also acceptable at 0.80 (SE 0.02 CI 95% 0.76–0.84) therefore one reviewer completed the classification of the remaining sample.

Table 1 shows a description of the app population that we explored. The vast majority of apps were free 471 (78.63%) and this remained constant independently of the OS (Android: 235 (83.33%); iOS: 236 (74.45%)). Android app developers classified their apps mostly in "Health and Fitness" and "Medical" categories (Fig. 2). iOS developers used different tags with a greater dispersion as can be seen in Fig. 3.

English language was predominant for both OS. Chinese, Japanese, Korean and Russian followed English for Android; while German, Spanish and French followed for iOS. Android had a high number of missing language information for these apps.

Using the information available for each app about its release date, we can see yearly growth in breast cancer apps and changes in app market distribution over the years (Fig. 4).

3.2.1. Application purpose

Based on our classification, the most represented type of application are Disease and treatment information apps (29.22%), followed by Disease Management (19.03%), then Awareness Raising (15.03%) and Prevention apps (10.18%). These proportions held true for iOS and Android. Almost 1 out of 10 apps dealt with alternative or homeopathic medicine (see Table 2); in some cases these apps included misleading

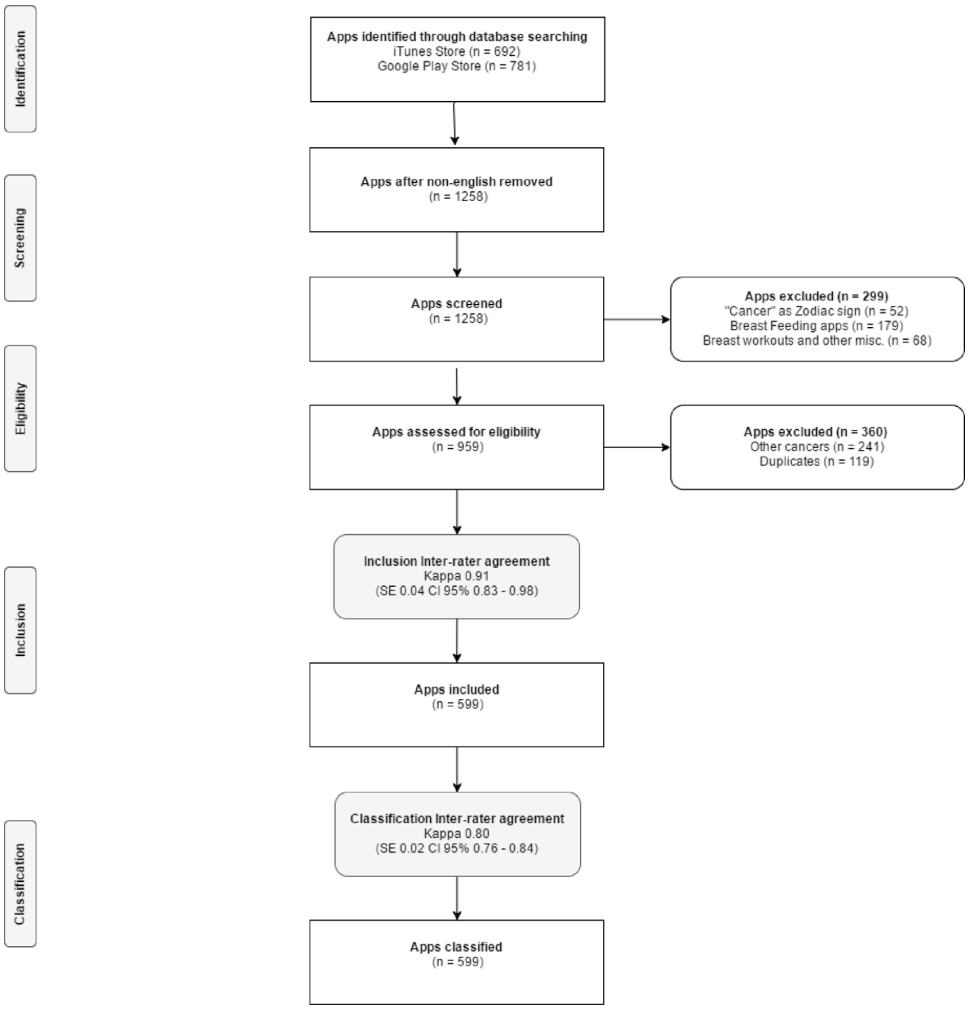

Fig. 1. Study Flow.

information such as using hypnosis or meditation to "cure" breast cancer.

3.2.2. Application origin

SME and Individuals develop more than half of the breast cancer mHealth apps. Only 1 app was developed by a Patient Organization. See Table 3 for more information. Fig. 5 and Fig. 6 show the proportion of app types for each developing agency group.

3.2.3. Application target audience

The majority of the apps were intended for patients (75.79%) and this was true for both Android (78.01%) and iOS (73.82%). See Table 2.

3.2.4. Application ratings

Apps can be rated by users using a five star rating system to indicate their opinion. Less than half of the apps were rated (41.57%); Android apps were more frequently rated than iOS apps (69.15% vs 17.03%) (see Table 1).

3.2.5. Application downloads

Number of app downloads was only available for Android applications. The store provides this information in terms of download ranges (see Table 1). Close to a quarter of Android apps (24.47%) were downloaded more than 1000 times but only a handful has been downloaded more than 10,000 times (6.73%).

3.2.6. Application credibility and disclaimers

Table 3 also shows references and disclaimers per operating system. Only a quarter of all apps (24.54%) had any kind of disclaimer about usage and less than a fifth (19.70%) had any mention of references or source material. References and disclaimers for iOS apps were close to a quarter for each (25.55% reference and 25.87% disclaimer) while in Android disclaimer presence almost doubled that of references (23.05% disclaimer and 13.12% references). See Table 4. shows the presence of references in app description per year.

3.2.7. Gamification in data set

After reviewing our app data set, the two gamification specialists determined that 19.36% (n = 116) might contain gamification elements. Apps with gamification elements in iOS doubled the amount of Android apps (25% vs 13%). The inter-rater reliability between specialists on this was 0.84 (SE 0.06, CI 0.71–0.96).

4. Discussion

4.1. Principal results

This is the first study to provide an in-depth analysis of the breast cancer applications available to consumers. Our study paints a picture of the current ecosystem and the active stakeholders involved in it. We classified apps based on their features and characteristics: the most common type of breast cancer apps were about disease and treatment information, followed by disease management and awareness raising apps. We assessed the presence of references to source material to understand the reliability of the information offered to consumers. Our work is also the first to evaluate the extent of gamification elements

Table 1
Basic app characteristics.

	Android	iOS	All
n	282	317	599
Commercialization			
Free	235 (83.33%)	236 (74.45%)	471 (78.63%)
Paid	47 (16.67%)	81 (25.55%)	128 (21.37%)
Rated	195 (69.15%)	54 (17.03%)	249 (41.57%)
Users rating† (avg)	58.62	5.21	30.36
Users rating† (median IQR)	2 (11)	0 (0)	0 (5)
Rating (number of stars)‡			
★	2 (0.71%)	0 (0.00%)	2 (0.33%)
★★	4 (1.42%)	6 (1.89%)	10 (1.67%)
★★★	15 (5.32%)	9 (2.84%)	24 (4.01%)
★★★★	81 (28.72%)	29 (9.15%)	110 (18.36%)
★★★★★	93 (32.98%)	10 (3.15%)	103 (17.20%)
Number of downloads※			
1–5	19 (6.74%)		
5–10	9 (3.19%)		
10–50	54 (19.15%)		
50–100	23 (8.16%)		
100–500	85 (30.14%)		
500–1000	23 (8.16%)		
1000–5000	32 (11.35%)		
5000–10000	10 (3.55%)		
10000–50000	16 (5.67%)		
100000–500000	3 (1.06%)		
Not Available	8 (2.84%)	317 (100.00%)	

†Number of users who have rated the app; ‡Apps are rated based on a 5-star rating system; ※Number of downloads are provided as a range by Google, this information is not provided for iOS apps.

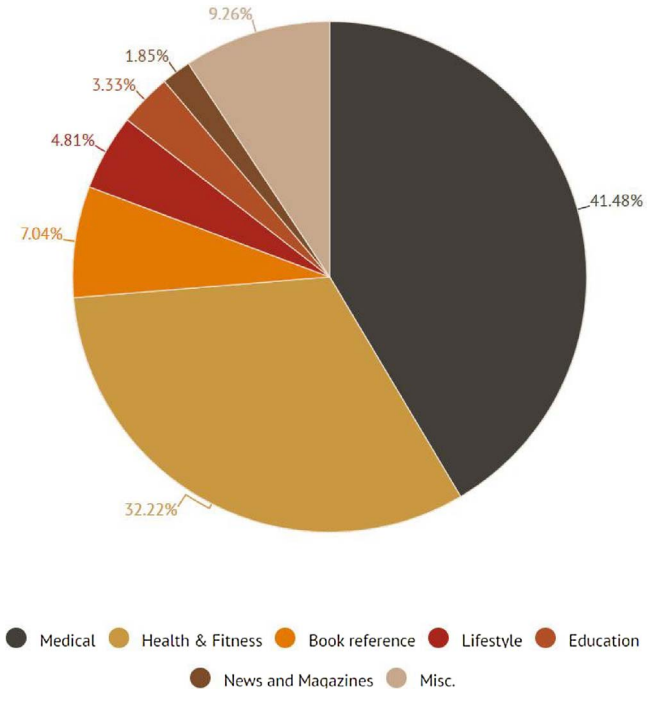

Fig. 2. App categories for Android.

present in breast cancer applications.

Based on our study, the breast cancer app ecosystem largely consists of start-ups and individual entrepreneurs. This is evidenced by more than 60% of all breast cancer apps being developed either by SME or individuals. As such, it's strange that both disease management and disease and treatment information applications were mostly developed by SME and individuals instead of healthcare related agencies. The

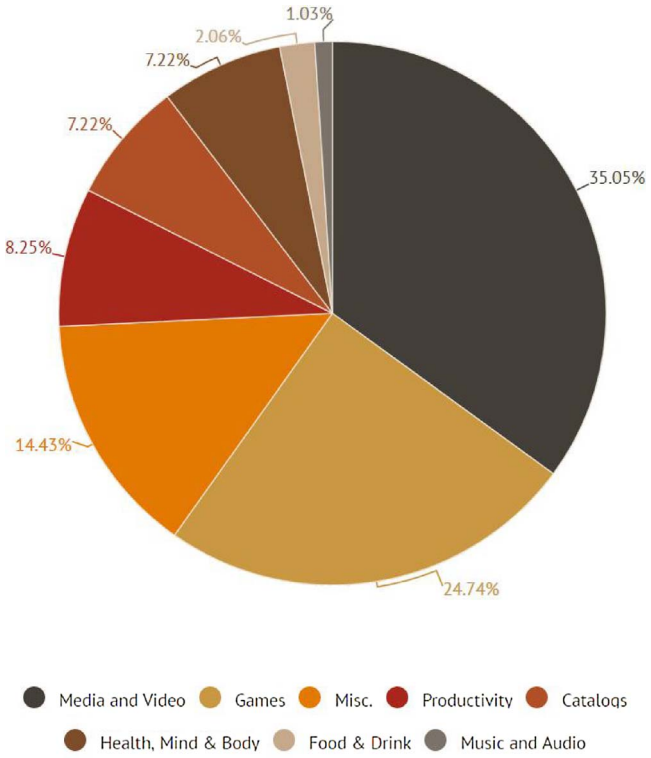

Fig. 3. App categories and tags for iOS.

absence of healthcare professionals involvement in app development continues to be raised time and time again. These concerns revolve around app design and app content alike [15–19]. Production of medical apps from non-medical stakeholders has benefits in terms of creativity in design of apps and bridging disciplines, but there remains a larger concern regarding the credibility of medical information within such apps. It would seem essential that expert medical personnel be involved in the creation of medical apps yet this seldom happens.

Areas such as breast cancer prevention and early detection should have more active participation from healthcare organizations and governmental agencies, however this is not the case. There is little involvement from these stakeholders. Emerging trends in software design like user-centered design or participatory design are characterized by involving end-users in the phases of design [36–38]. The value of including relevant stakeholders and users as part of the design team is well recognized, and an essential aspect of good design practice for adults and children alike [39–43].

The lack of academic reference found in our study is consistent with Mobasheri's previous work [21] and the available literature for other disciplines. Authorship disclosure within app descriptions was highly inconsistent making it difficult to determine involvement so unless specified, no involvement was assumed. The US Food and Drug Administration (FDA) has regulations for medical smartphone apps which directly influence patient treatment [44], however most medical apps are not formally evaluated under the current guidance [45,46]. Sources and references were absent in almost 80% of app descriptions which is alarming considering that over 70% of breast cancer apps regarded disease management, disease information and awareness.

The work done by Bender et al. [20] in 2013 showed how breast cancer applications occupied a predominant role in cancer mHealth apps. This is consistent with the steady increase in breast cancer apps that our study shows for both operating systems. This pace could also be explained by the increasing penetration of smartphones [12] as well as the continuous growth of mHealth applications [11]. However, not all of these apps are continuously maintained by their developers so the danger of outdated information is present. App developers seem to be

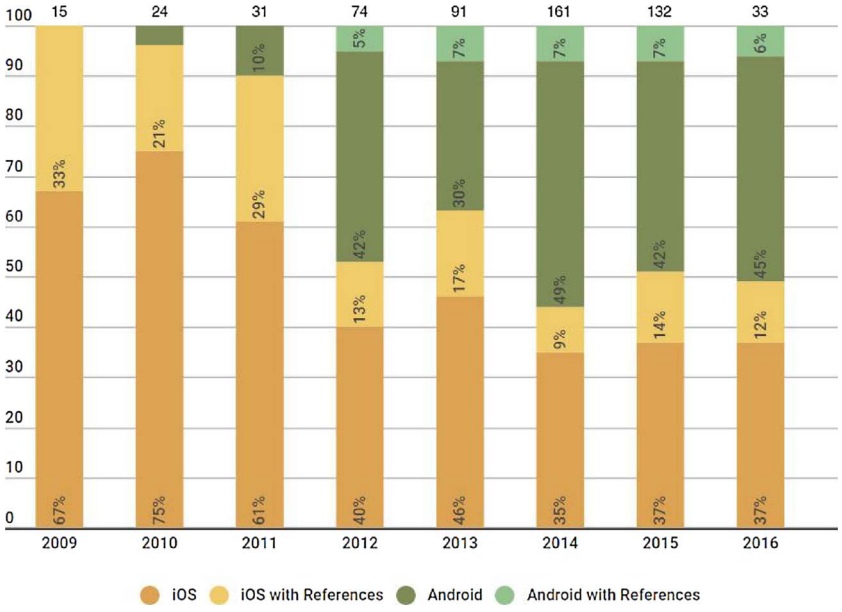

Fig. 4. New apps per year by OS and apps with references. Total number of apps displayed on top of each year bar. Release date was missing in 38 apps. * only first two months.

Table 2
Apps per type by OS.

	All
n	599
Awareness-raising	90 (15.03%)
Fundraising	39 (6.51%)
Promote an organization	54 (9.03%)
Disease and treatment information	174 (29.04%)
Prevention	61 (10.18%)
Early detection	34 (5.67%)
Disease management	114 (19.03%)
Support	33 (5.51%)
Gamification elements	116 (19.36%)
Alternative Medicine	58 (9.68%)
Patient-oriented	454 (75.79%)
Physician-oriented	167 (27.88%)

Table 3
References, Disclaimers and developing agency by OS.

	Android	iOS	All
n	282	317	599
References	37 (13.12%)	81 (25.55%)	118 (19.70%)
Disclaimer	65 (23.05%)	82 (25.87%)	147 (24.54%)
Healthcare related Agency	26 (9.22%)	52 (16.40%)	78 (13.02%)
Governmental Agency	2 (0.71%)	0 (0.00%)	2 (0.33%)
Non-governmental Agency	42 (14.89%)	53 (16.72%)	95 (15.86%)
Educational Organizations	2 (0.71%)	5 (1.58%)	7 (1.17%)
Conferences and Journals	27 (9.57%)	41 (12.93%)	68 (11.35%)
Small and Medium-sized Enterprises	133 (47.16%)	103 (32.49%)	236 (39.40%)
Patient Organizations	1 (0.35%)	0 (0.00%)	1 (0.17%)
Individuals	48 (17.02%)	64 (20.19%)	112 (18.70%)

mentioning and citing sources for their apps more each year as can be seen in Fig. 4. It would be interesting to study if this is in respond to consumer demands or the market maturing.

The submission process and data organization is different for the two stores so one to one comparison was not possible. There are substantial differences from store to store. Google Play uses a category structure for internal classification while iTunes store uses tags and categories. However, it is interesting to note that Android apps classification system allows faster identification of medical or health related apps (Fig. 2).

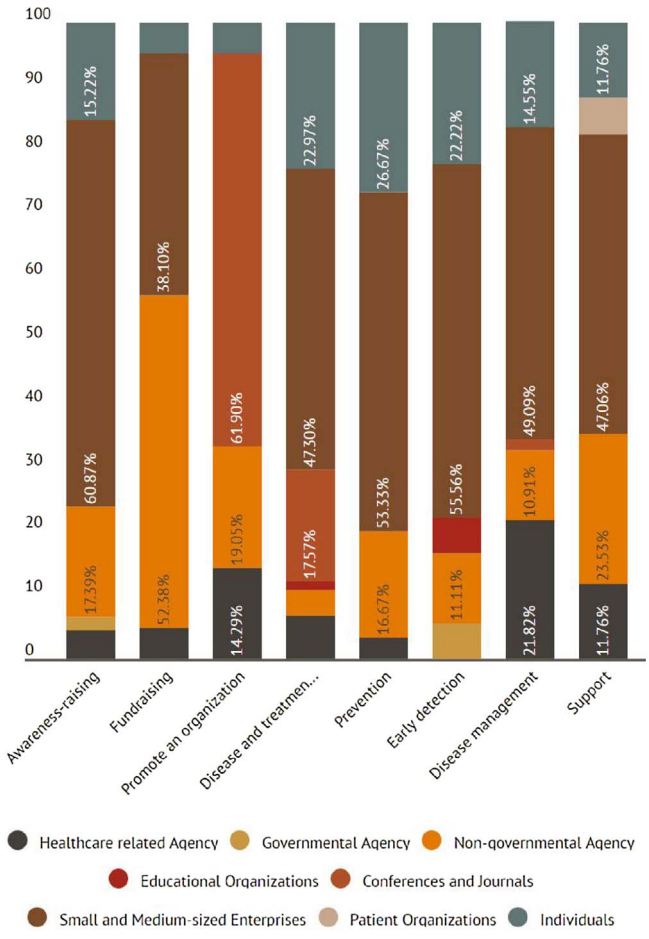

Fig. 5. App type per developing agency for Android.

Gamification trends seem to be present also in breast cancer apps as 1 in 5 apps contained some game element as reported by our experts. Another interesting find was the relatively few of alternative or complementary medicine apps in this topic. One in ten breast cancer apps deal with healing through hypnosis, herbal replacements or faith healing. To our knowledge there are no other studies that cover the

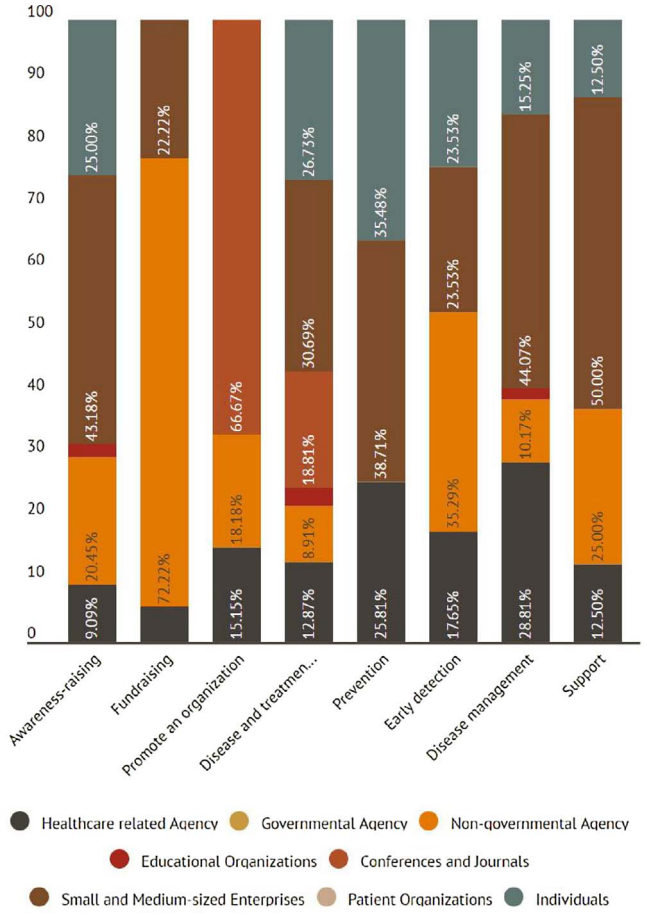

Fig. 6. App type per developing agency for iOS.

Table 4
References and disclaimers per app type.

	References		Disclaimer	
	iOS	Android	iOS	Android
Awareness-raising	1 (2.27%)	1 (2.17%)	1 (2.27%)	0 (0.00%)
Fundraising	0 (0.00%)	0 (0.00%)	0 (0.00%)	1 (4.76%)
Promote an organization	1 (3.03%)	0 (0.00%)	0 (0.00%)	2 (9.52%)
Disease and treatment information	46 (45.54%)	17 (22.97%)	43 (42.57%)	30 (40.54%)
Prevention	13 (41.94%)	3 (10.00%)	13 (41.94%)	8 (26.67%)
Early detection	2 (11.76%)	0 (0.00%)	2 (11.76%)	4 (22.22%)
Disease management	18 (30.51%)	16 (29.09%)	21 (35.59%)	19 (34.55%)
Support	0 (0.00%)	1 (5.88%)	2 (12.50%)	1 (5.88%)

prevalence of alternative or complementary medicine in mHealth apps.

Usually, App Store's star rating systems and download ranges are used to indicate popularity and indirectly measure the "success" of these apps. These methods are not ideal as beyond the stores' star ratings published; little information on the quality of apps is available. Using this popularity criteria yields little or no meaningful information on app quality as has been discussed on occasions [47]. The lack of standardized quality measures continues to be concerning, as app use carries risk and can lead to adverse outcomes for both patients and clinicians [48–50]. Additionally, the way the stores handle ratings as app versions evolve affects the star system. In iOS for example, ratings and reviews are limited to the most recent version as these reset when apps receive upgrades. iTunes App Store approval process would usually take up some time [51] and developers wouldn't release a new version very often. This is now likely to change as apps are approved in a matter of hours and Apple will let developers keep historical ratings and reviews [52].

4.2. Limitations

This study has two main limitations. One is the fact that search algorithms within stores return partial matches as well as full matches so it's possible for some apps to have been missed in our search. Keywords used could have left out potentially valid breast cancer applications. The other is its reliance on app store descriptions for data extraction and classification. It was beyond the scope of this project to download all the applications, many of which require payment for installation. Although it is possible that in some instances developers may only disclose sources, features or affiliations once in-app, this seems unlikely given that such features are positive selling points and would therefore likely be mentioned in app store descriptions if present. Furthermore, app store descriptions are the only information available to most consumers when deciding whether to download a given application.

We used apps available in the United States stores only which might have caused some apps to be excluded (published in the UK or Canadian stores for example). Structural differences between stores made it impossible to compare certain aspects (ie. iTunes doesn't disclose number of downloads per app; categories differ among stores, etc.). Restricting app stores to Apple and Android based smartphones could also introduce a selection bias as proportions might differ in less popular platforms such as Windows or Blackberry phones.

It's important to note that iTunes App Store and Google Play Store have different processes and steps for app submission. These differences can account for variability in the presence or absence of certain descriptive elements. Fields that are required in one store might be optional in the other.

Our breast cancer app review focuses on all breast cancer apps commercially available to patients, health professionals and public in general. To our knowledge, this is the first study to assess the prevalence of gamification in breast cancer apps and to describe the prevalence of alternative and complementary medicine in the breast cancer app population. Although previous works may have considered evidence-base or medical professional involvement in development, our study also depicts what proportion each type of developing entity takes of the available population.

5. Conclusions

This study analyzed a large number of breast cancer-focused apps available to consumers. Most breast cancer apps were designed for patients and focused on Disease and Treatment Information, Disease Management and Awareness Raising. Use of these applications to empower patients and encourage preventive strategies, monitor symptoms and behaviors, and provide effective interventions is appealing; however there continues to be a lack of involvement from healthcare professionals, and a lack of properly cited source material or references in these applications.

The continuous growth of breast cancer applications shows a very active ecosystem driven mainly by SMEs and Individuals with the patient as the ultimate target of the app. Apps for healthcare professionals were mainly conferences or journal apps with little in the way of helping patient education. This presents an interesting opportunity to improve these patient facing apps and address the lack of healthcare providers end of the equation.

Future research

Understanding why a breast cancer application is successful is complex as there is no standard for what a successful breast cancer app may be. Thus, what makes it successful remains uncertain. We intend to

explore our current data set and look for associations between variables to create a model that would allow to weigh in the different factors that could account for a successful breast cancer app.

For both stores the main focus of development was towards patients and not healthcare professionals which poses questions as to why. This presents a gap in the current repertoire of mHealth apps that should be explored.

More study should also be done to understand how to improve healthcare professional involvement during app design and testing.

Author contributions

GG conceived, designed, led overall study conduct, carried out the data collection, led analysis and interpretation of the data, and drafted the manuscript. DG participated in overall study conduct, analysis and interpretation of study data. GG, JLB and EG carried out the data coding and data interpretation. LF contributed to the analysis and interpretation of study data, and conceptualized, reviewed and suggested modifications to contents related to rigor and presentation of results. All authors read and approved the final manuscript.

Conflicts of interest

None.

Summary Points

- Breast Cancer patients and survivors represent a unique group who must be aware of the long-term consequences of their treatment and be given information to encourage a proactive approach to their overall health
- The use of mobile software applications for health and well-being promotion has grown exponentially in recent years.
- A 2013 cancer mobile applications review exploring the distribution of all types of cancer in mHealth apps, which found that most apps (45%) focused on breast cancer.
- A breast cancer specific mobile applications review took place in 2014 but the smartphone app industry has dramatically changed since then.
- The most represented type of application are Disease and treatment information apps (29.22%), followed by Disease Management (19.03%), then Prevention (10.18%).
- Our study found that the breast cancer app ecosystem largely consists of start-ups and entrepreneurs.
- The prevalence of Alternative and Complementary Medicine in Breast Cancer apps is assessed.
- First Breast Cancer App Review to explore the presence any gamification or game elements.

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