Original Paper

The Potential for mHealth Interventions to Support Women with Breast Cancer after Active Treatment

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Abstract

Breast cancer is the most commonly diagnosed cancer among women worldwide. Chances of living one-year after diagnosis are high (~98%), and health self-management is essential to reduce risks of recurrence. Mobile health (mHealth) has emerged as a wide-reaching and cost-effective way of providing health information and support. Therefore, we conducted a narrative review of the currently available mHealth literature and synthesised the literature according to the impacts of mHealth interventions on patient outcomes, the potential mechanism for behaviour change and innovative approaches to developing future mHealth interventions. Results found a small amount of evidence for the value of mHealth interventions (text message programs, smartphone applications and activity trackers) for supporting women after breast cancer treatment. However, accessibility, cost and gender inequities may pose barriers to implementation. Developing consumer-led mHealth interventions based on lived-experiences will be essential to improving user outcomes. In conclusion, mHealth interventions are widely available and have the potential to support women after breast cancer treatment and further robust research will determine effectiveness in specific subgroups and populations.

1. Introduction

1.1 Breast Cancer Prevalence and Current Care

Breast cancer is the most commonly diagnosed cancer among women globally and the leading cause of cancer-related death in both developed and less developed countries (11.8 and 14.9 age standardised weight per 100,000 females, respectively) (Organization, 2008; Bray, Ferlay, Soerjomataram, Siegel, Torre, & Jemal, 2018). However, due to improvements in early detection, treatment and secondary prevention strategies, women have an 80-90% chance of surviving five years post-diagnosis (Hortobagyi et al., 2005). During active treatment, women typically attend weekly hospital visits and receive mental and physical support from healthcare professionals. After treatment, the visits reduce to annually (Khatcheressian et al., 2006; Senkus et al., 2015) and women are encouraged to maintain a healthy lifestyle, including a healthy diet, participating in moderate-intensity physical activity (Maura, Boyle, La Vecchia, Decarli, Talamini, & Franceschi, 1998) and remaining adherent to medications (Hershman et al., 2011). The subsequent transition from hospital to independent health management can be mentally and physically challenging due to ongoing side effects, reduced interactions with hospital staff (Lawler, Spathonis, Masters, Adams, & Eakin, 2011; Australia, 2016) and perceived social isolation (Harder et al., 2017). Simple and cost-effective strategies are needed to support breast cancer survivors during recovery and beyond.

2. Methods

In this paper, we conducted a narrative review to explore the impacts of mobile health ("mHealth") interventions on patient outcomes, accessibility in rural communities, secondary prevention and self-efficacy, as well as innovative approaches to co-developing future mHealth interventions. Synonyms and plurals of the following terms were used alone or in combination to non-exhaustively search PubMed, Medline via OVID (1946-present) and grey literature: "mobile health", "mHealth", "text messaging", "SMS", "breast cancer NEAR5 survivor", "smartphone", "application", "rural", "low-income", "self-management", "activity tracker", "smart watch", "wearable device", "mental health", "depression", "anxiety", "medication adherence". Peer-reviewed journal articles related to cancer survivorship and/or mHealth, which appeared on the first or second search page were included. Non-peer-reviewed papers or peer-reviewed papers related to primary cancer prevention (cancer screening or vaccine reminders) were excluded. Relevant papers were included in the following narrative review.

3. Results and Discussion

3.1 mHealth and Patient Outcomes

mHealth is defined as the use of mobile technologies, such as text messages, smartphone applications, and activity trackers, to support healthcare delivery (Kay, Santos, & Takane, 2011). Typically, mHealth interventions provide health education (Krishna, Boren, & Balas, 2009), biofeedback (e.g., heart rate, accelerometer) (Kheirkhahan et al., 2018) or motivation through personal or interpersonal challenges to improve health-promoting behaviours (Krishna, Boren, & Balas, 2009). Recent systematic reviews and meta-analyses have found that mHealth interventions have improved smoking cessation (pooled Relative Risk [RR] 2.16 [95% CI 1.77-2.62] p<0.0001), medication adherence (*p*<0.05) and appointment attendance (pooled RR 1.06 (95% CI 1.05-1.07, I^2=6%) for health care consumers from a variety of ages and health backgrounds (Free et al., 2013; Free et al., 2013; Park, Howie-Esquivel, & Dracup, 2014). mHealth interventions have also been found to improve adherence to chronic disease management programs (Hamine, Gerth-Guyette, Faulx, Green, & Ginsburg, 2015), physical and mental health outcomes (Berrouiguet, Baca-Garc ń, Brandt, Walter, & Courtet, 2016), motivate behaviour change (Redfern et al., 2016; Job, Spark, Fjeldsoe, Eakin, & Reeves, 2017; Asimakopoulos, Asimakopoulos, & Spillers, 2017) and are well-liked (Redfern et al., 2016; Job, Spark, Fjeldsoe, Eakin, & Reeves, 2017; Lloyd et al., 2016) by people at risk or living with a chronic disease. mHealth interventions may therefore provide a simple and effective way to support women after breast cancer treatments.

3.2 Mobile Technology to Support Secondary Prevention for Breast Cancer

There are numerous examples of mHealth interventions that can provide support for women following active breast cancer treatment, including the use of text message programs, smartphone applications and activity trackers. An overview can be seen in Table 1.

Table 1. How mHealth is Used to Provide Support for Women with Breast Cancer

	SMARTPHONE APPLICATIONS	TEXT MESSAGES	ACTIVITY TRACKERS
APPOINTMENT REMINDERS	✅ Mobasheri, Johnston, King, Leff, Thiruchelvam and Darzi (2014)	✅ Guy, Hocking, Wand, Stott, Ali and Kaldor (2012); Kerrison, Shukla, Cunningham, Oyebode and Friedman (2015)	
EXERCISE TUTORIALS OR TRACKING	✅ Harder et al. (2017)		✅ Valle, Deal and Tate (2017)
WEIGHT LOSS	✅ McCarroll et al. (2015); Hales et al. (2016)		✅ Spillers and Asimakopoulos (2014)
SYMPTOM TRACKING	✅ Patel, Klasnja, Hartzler, Unruh and Pratt (2012)	✅ Mougalian et al. (2017)	

HEALTH INFORMATION	✔ Alanzi, Alobrah, Alhumaidi and Aloraifi (2018)	
MENTAL HEALTH SUPPORT	✔ Mobasheri, Johnston, King, Leff, Thiruchelvam and Darzi (2014)	
MEDICATION ADHERENCE	✔ Santo et al. (2018)	✔ Mougalian et al. (2017) and Spoelstra et al. (2015)

3.2.1 Text Message Programs

Over 5 billion people own mobile phones worldwide (Intelligence, 2019) and send over 18 billion text messages per day (Burke, 2016). Text messages are therefore a simple and wide-reaching strategy for providing health information. Recent research reveals that women enjoy receiving health information via text messages (Redfern et al., 2016; Job, Spark, Fjeldsoe, Eakin, & Reeves, 2017) and text message programs are cost-effective for the healthcare system (Burn et al., 2017). There is a small body of research that shows that text message programs can help reduce women's weight (mean weight loss ranged from 0.82kg-4.2kg), improve exercise duration (mean increase/day ranged from 3.5-10-minutes) (Job, Fjeldsoe, Eakin, & Reeves, 2018; Spark, Fjeldsoe, Eakin, & Reeves, 2015), stay motivated to achieve health goals (Job, Spark, Fjeldsoe, Eakin, & Reeves, 2017) and help breast cancer survivors adhere to endocrine therapies (>80% adherence) (Mougalian et al., 2017). However, most studies provide short follow-up (3-6 months), which may not account for long-term participant attrition (Eysenbach, 2005). However, participants have stated wanting programs to continue beyond study endpoints (Job, Spark, Fjeldsoe, Eakin, & Reeves, 2017; Mougalian et al., 2017), providing support that these programs may be beneficial long-term. Long term (12-24 month) randomised controlled trials are needed to provide evidence of continued participant engagement and benefit.

Most of the current evidence for text messages to support breast cancer survivors are for appointment reminders. For women with breast cancer, follow-up appointments are essential for early recurrence detection and maintaining health (Khatcheressian et al., 2013). Forgetfulness has been reported as one of the most common reason for non-attendance at breast screening appointments (Crump, Mayberry, Taylor, Barefield, & Thomas, 2000; Aro, De Koning, Absetz, & Schreck, 2001; Baysal & Gozum, 2011). However, text message reminders provided 48 hours prior to an appointment have been found to significantly improve attendance rates (Kerrison, Shukla, Cunningham, Oyebode, & Friedman, 2015), although messages sent 24, 48 or 72 hours prior to an appointment have been found to be equally beneficial (Guy, Hocking, Wand, Stott, Ali, & Kaldor, 2012). For patients who did not attend the first appointment, a text message reminder providing a "reschedule" option further improved attendance within 60 days of the original appointment compared to usual reminder letters, and these improvements were more pronounced for women living in disadvantaged areas (Kerrison, Shukla, Cunningham, Oyebode, & Friedman, 2015). Moreover, text message reminders have been found to be cost-effective

compared to traditional letter reminders (Arora et al., 2015). Text message appointment reminders may therefore be a promising cost-effective strategy for supporting breast cancer survivors to attend follow-up visits.

3.2.2 Smartphone Applications (Apps)

There are currently more than two billion smartphone users worldwide (Intelligence, 2019). Smartphone apps provide a simple, readily available and engaging way to provide health information, as they include interactive and customisable features, are user-friendly and are often low-cost or free (Pandey, Hasan, Dubey, & Sarangi, 2013; Santo, Richtering, Chalmers, Thiagalingam, Chow, & Redfern, 2016; Vollmer Dahlke, Fair, Hong, Beaudoin, Pulczinski, & Ory, 2015). As of 2013, one study reported 295 cancer-related apps available across the app stores, 138 (47%) were breast cancer-specific (Bender, Yue, To, Deacken, & Jadad, 2013) and this number is increasing each year (Mobasheri, Johnston, King, Leff, Thiruchelvam, & Darzi, 2014). Another study conducted a systematic search of the four app stores and reported 72 apps specifically related to breast cancer survivorship or management (Vollmer Dahlke, Fair, Hong, Beaudoin, Pulczinski, & Ory, 2015). App themes include general breast cancer information, prevention strategies (weight-loss, healthy eating, early detection via breast check reminders), disease management (symptom tracking) (Mobasheri, Johnston, King, Leff, Thiruchelvam, & Darzi, 2014; Bender, Yue, To, Deacken, & Jadad, 2013), appointment management and psychosocial supports (Mobasheri, Johnston, King, Leff, Thiruchelvam, & Darzi, 2014; Vollmer Dahlke, Fair, Hong, Beaudoin, Pulczinski, & Ory, 2015; Bender, Yue, To, Deacken, & Jadad, 2013). Table 2 outlines some examples of apps, their features and benefits that can be useful for women with breast cancer in disease management and survivorship.

Despite the abundance of cancer-related apps, few provide evidence-based information (Pandey, Hasan, Dubey, & Sarangi, 2013; Vollmer Dahlke, Fair, Hong, Beaudoin, Pulczinski, & Ory, 2015) and some apps provide misinformation that may be harmful to consumers (Mobasheri, Johnston, King, Leff, Thiruchelvam, & Darzi, 2014). Although preliminary results of tested apps are promising, most apps focused on improving one specific health outcome and/or had short-term follow-up (1-6 months) (McCarroll et al., 2015; Santo et al., 2018). Further research into app safety, the effect of multi-domain apps (psychosocial, medication adherence, physical activity, nutrition) and long-term app-use on patient outcomes and attrition (Eysenbach, 2005) is needed.

3.2.3 Activity Trackers

Activity trackers are devices worn on the body or attached to clothing, and can be used to track steps, sleep stages, heart rate, and remind or motivate the wearer to exercise (Benedetto, Caldato, Bazzan, Greenwood, Pensabene, & Actis, 2018). For example, people who wore a activity tracker continually for 12-weeks had a significant increase in moderate to vigorous physical activity at 12-weeks compared to people who wore an activity tracker during weeks 1 and 12 only (Hartman, Nelson, & Weiner, 2018). Activity trackers also typically offer the ability to join social exercise challenges and can be linked to smartphone applications to track progress (Spillers & Asimakopoulos, 2014).

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Table 2. Summary of Apps and Examples for Breast Cancer Survivorship or Management

	IMPORTANCE FOR WOMEN WITH BREAST CANCER	APP FEATURES	BENEFITS OF APPS	EXAMPLES
WEIGHT MANAGEMENT	• Overweight/obesity is associated with increased risk of being diagnosed with breast cancer and breast cancer recurrence (Garcia-Estevez & Moreno-Bueno, 2019)	• Tracking physical activity, nutrition and weight loss goals • Peer messaging • Video exercise demonstrations • Specialised information • Exercise tracking	• Women received automated feedback and encouragement, lost weight and improved confidence with nutrition choices • Improved weight loss compared to standard weight tracking app • Encourage women to continue with post-surgery arm exercises	Loseit! app McCarroll et al. (2015) SocialPOD app Hales et al. (2016) bWell app Harder et al. (2017)
SYMPTOM TRACKING	• Side effects of breast cancer treatments can include fatigue, depression, anxiety and sleep disturbances (Shapiro & Recht, 2001)	• Women track at least 1 health related issue • Graphs to track symptoms over time	• Women tracked 8.8 health issues on average through the app • App easier to use than paper-based tracking • Women can show accurate information to healthcare staff • Tracking helped women visualise health improvements • Helped women feel empowered about health self-management	HealthWeaver Patel et al. (2012)
MEDICATION ADHERENCE	• Some breast cancer survivors recommended to take hormone therapy medications for up to years post active treatments (Burstein, Griggs, Prestrud, & Temin, 2010) • Hormone therapy medication can have side effects (hot flushes, joint pain, fatigue) (Cella & Fallowfield, 2008)	• Adherence tracking • Medication information videos • Side effect information links • Personalised feedback and encouragement	• Improve medication adherence for people with heart disease—can be translated for use in other chronic disease e.g.: breast cancer	Santo et al. (2018)
SOCIAL SUPPORT	• Strong social supports after treatments can improve mood, quality of life and overall survival (Hinzey, Gaudier-Diaz, Lustberg, & DeVries, 2016)	• Social network support via peer discussion	• 30% of women believed peer support apps would be useful, 35% not sure, 35% thought not beneficial.	Phillips et al. (2017)

In recent years, activity trackers have become increasingly popular and have been validated for use by prostate cancer survivors (Van Blarigan, Kenfield, Tantum, Cadmus-Bertram, Carroll, & Chan, 2017). Therefore, we will discuss the potential for activity trackers to promote physical activity for breast cancer survivors. For women with breast cancer, it is important to stay active and maintain a healthy weight to minimise chances of recurrence (Job, Fjeldsoe, Eakin, & Reeves, 2018). In a group of 270 survivors, approximately 90% felt that a technology-supported exercise program would be helpful immediately after or within the first year after completion of active treatments (Phillips et al., 2017). Moreover, these women felt that activity trackers would be the most beneficial exercise support (Phillips et al., 2017). In addition, African American breast cancer survivors were significantly more likely to maintain or lose weight at the end of a 6-month program if they wore an activity tracker in addition to daily weighing and tailored weekly emails compared to daily weighing and emails alone or a delayed-intervention control, indicating that self-monitoring may play an important role in achieving fitness goals (Valle, Deal, & Tate, 2017). Interestingly, many women did not feel that integrating social networks, peer fitness competitions or messaging systems would be beneficial to achieving exercise goals (Phillips et al., 2017).

While the use of activity trackers can be a positive method for women with breast cancer to track their physical activity, it is also important to discuss the potential limitations of these devices. Firstly, one tracker has been seen to underestimate heart rate by almost 30bpm (Benedetto, Caldato, Bazzan, Greenwood, Pensabene, & Actis, 2018). This is potentially dangerous for users who may be working in different heart rate zones than they realise and therefore overdoing their activity. In fact, in a validity test of 8 different activity trackers, heart rate differed at different exercise intensities and across all devices and as exercise intensity increased, there was greater underestimation of heart rate (Boudreaux et al., 2018). Furthermore, placement of activity monitors can impact upon their accuracy. Some monitors should be worn on the dominant wrist, which can be problematic for breast cancer patients as they may have limited range of motion on the affected side (Walker, Hickey, & Freedson, 2016).

3.3 mHealth Supports and Barriers for Women in Rural and Low-income Areas

mHealth may be a potential practical solution to providing health information to rural (Mahmud, Rodriguez, & Nesbit, 2010; Müller, Alley, Schoeppe, & Vandelanotte, 2016), low socioeconomic regions (Müller, Alley, Schoeppe, & Vandelanotte, 2016; Kallander et al., 2013) and developing countries (Müller, Alley, Schoeppe, & Vandelanotte, 2016). However, many barriers exist, including accessibility, gender inequities in mobile internet use, and device costs (Intelligence, 2019). Currently, 87% of people worldwide are covered by a mobile network (Intelligence, 2019). However, in rural communities, only 33% are covered. Moreover, only 44% of people globally are connected to the mobile internet and there is limited mobile content in minority ethnic languages. In addition, 327 million fewer women than men use mobile internet services in low- or middle-income countries (LMICs). The high cost of mobile internet and mHealth devices (smartphones, tablets) has also been a barrier to accessing mHealth apps. However, entry-level costs are reducing annually (0.1% p.a.,

2014-2017) (Intelligence, 2019). There are also many free cancer-related apps (symptom or medication tracking, weight-loss, psychosocial support) available on the app stores (Vollmer Dahlke, Fair, Hong, Beaudoin, Pulczinski, & Ory, 2015), but their effectiveness has yet to be studied. Text message interventions may currently be the best way to provide health information to rural communities and LMICs, as they do not require an internet connection[63] and have been found to be a well-liked method of receiving information (Redfern et al., 2016; Lloyd et al., 2016; Kratzke & Wilson, 2014). For example, one study surveying women in rural New Mexico (USA) found that women preferred to receive breast cancer information and appointment reminders via text message versus voice-calls (Kratzke & Wilson, 2014). However, more research is needed to understand the efficacy of mHealth interventions, including text messages, for delivering health information to people in rural communities or LMICs.

3.4 Co-designing Future mHealth Interventions with Women with Breast Cancer

Co-design with end-users has recently emerged as a critical factor in developing engaging and effective healthcare interventions (Elg, Engström, Witell, & Poksinska, 2012). For example, during the development of a post-breast surgery, arm exercise app, women with breast cancer reported that exercise reminders, tailored health information, video demonstrations and a system to track accomplishments were important features for influencing behaviour change (Harder et al., 2017). Women also provided feedback that end-point goals may be discouraging, and that incremental goals may provide more motivation for app-users. Moreover, women reported differing information from healthcare providers regarding post-treatment guidelines, a lack of understanding about post-treatment self-care and a sense of isolation during the transition from the hospital to health self-management (Harder et al., 2017). By elucidating these barriers to post-treatment self-care via co-design (breast cancer survivors, healthcare professionals) mHealth interventions can be developed to provide evidence-based information in an easy-to-digest way to improve women's support and recovery after active treatment.

3.5 Next Steps—Implications for Future Studies

mHealth interventions via text messages, apps and activity trackers are promising for supporting people with breast cancer during recovery and beyond. These technologies are easily integrated into everyday life, have varying levels of interaction, can be beneficial for improving a variety of physical and mental health outcomes and are well-liked by women with breast cancer (Lloyd et al., 2016). Large, adequately powered studies are needed to investigate the long-term benefits of these interventions and monitor participant attrition. Moreover, user-focused development of interventions based on self-efficacy, behaviour change theory and qualitative evaluations will be critical to the future success of mHealth interventions. However, it is important to consider intervention privacy and safety (Mobasheri, Johnston, King, Leff, Thiruchelvam, & Darzi, 2014), and the cost of mHealth interventions, as high prices may be a deterrent (Intelligence, 2019). Lastly, most studies investigating breast cancer mHealth interventions are tested on women. Further research is needed to provide information and support to male breast

cancers survivors. It should also be noted that we have presented a non-exhaustive narrative review of the current literature, which likely did not include all relevant papers. A systematic review of the literature could provide further insights into the potential for mHealth interventions to support breast cancer survivors.

4. Conclusion

mHealth interventions are a simple and wide-reaching solution to health dissemination to women with breast cancer in urban and rural communities. Breast cancer-specific mHealth interventions are proliferating. However, safety and efficacy need to be further investigated in large, adequately powered trials using qualitative, quantitative and cost evaluations.

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