Consumers' Online Social Network Topologies and Health Behaviours

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Abstract

Personally controlled health management systems (PCHMS) often consist of multiple design features. Yet, they currently lack empirical evidence on how consumers use and engage with a PCHMS. An online prospective study was designed to investigate how 709 consumers used a web-based PCHMS to manage their physical and emotional wellbeing over five months. The web-based PCHMS, Healthy.me, was developed at UNSW and incorporates an untethered personal health record, consumer care pathways, forums, polls, diaries, and messaging links with healthcare professionals. The two PCHMS features that consumers used most frequently, found most useful, and engaging were the social features, i.e. forum and poll. Compared to participants who did not use any PCHMS social feature, those who used either the poll or the forum were 12.3% more likely to visit a healthcare professional (P=0.001) during the study. Social network analysis of forums revealed a spectrum of social interaction patterns – from question-and-answer structures to community discussions. This study provides a basis for understanding how a PCHMS can be used as a socially-driven intervention to influence consumers' health behaviours.

Keywords:

Personal health record, social network, consumer, health behaviour, social features, forum, poll, internet.

Introduction

Worldwide, governments have made multi-billion dollar investments in E-Health, aiming to modernise health services delivery. Questions about the uptake, benefits and cost effectiveness of these investments remain unanswered [1, 2]. In particular, personal health records (PHRs) now form a crucial component in many large-scale national E-Health reform strategies worldwide. However, uptake and utilisation of PHRs is not as widespread as anticipated [1, 2], and there is often a gap between proposed and actual PHR benefits. Finding approaches that effectively engage consumers in E-Health, with the intention to improve health outcomes, remains a high priority. Therefore, understanding consumers' use of and engagement with a PCHMS is crucial to assessing the efficacy of PCHMS as health interventions.

The aim of this study is to examine consumers' use of social features in a PCHMS, and to provide suggestions on ways to engineer a socially-driven PCHMS in order to enhance consumers' health behaviours and online communication patterns.

Materials and Methods

Study Design

An online prospective study was designed to measure consumers' use of a personally controlled health management system (PCHMS) called *Healthy.me*, developed at the University of New South Wales (UNSW) [3]. Students and staff from all faculties were approached via email lists and online university advertisements to participate in the study. 1985 students and staff from a university in Australia were recruited to use the PCHMS during an academic semester (five months) for their physical and emotional wellbeing needs. At pre- and post-study, participants' self-rated physical and emotional wellbeing were measured using charts developed from the Dartmouth Primary Care Cooperative Research Network and the World Organization of National Colleges Academies (COOP/WONCA) [4], which have demonstrated to be a valid and feasible screening assessment for mental disorders [4]. Participants' self-reported health behaviours, such as health advice-seeking and advice-providing networks (i.e. the number of people they sought (or provided) health advice during the study), and their intentions to practice a healthy lifestyle, were also collected pre- and post-study. In addition, participants' self-reported help-seeking behaviours during the study, and their feedback on the PCHMS were recorded at post-study.

Intervention Design

The PCHMS integrated an untethered personal health record (PHR) with consumer care pathways (i.e. journeys), diaries, messaging links with health service providers (primary care and counselling), and social communication spaces, supporting the rich interaction across the continuum of care between participants and clinicians [5-7].

Social features on the PCHMS included: i) a poll system in which participants could answer simple health questions (e.g. how much sleep did you get last night?), where they could then view and compare their response with other participants' aggregated answers in graph format (Figure 1); and ii) forums moderated by clinicians (general practitioner (GP) or counsellor), where participants could either post their entries on the forum or send one-on-one email messages to the moderators or other consumer participants on the PCHMS. The poll is located on the bottom right hand corner of every page on the PCHMS. The forum can be navigated via the top menu bar, and inside each individual journey page.
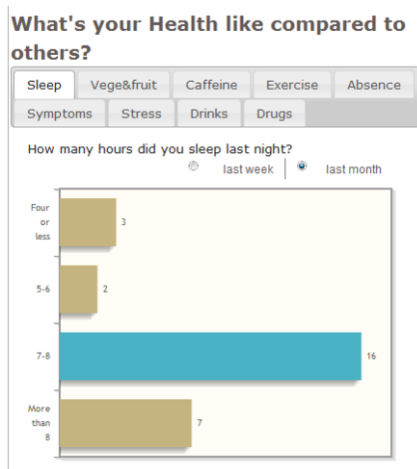

Figure 1- Poll features on Healthy.me and the distribution of participants' answers in the study.

Three forums were available to participants in this study: two were dedicated to men and women health issues, and the other forum was about healthy lifestyles (Stay Healthy). Participants could seek answers from fellow participants, the GP or the counsellor on all three forums. Guidelines on forum use and for responding to concerns in the forum were approved by the UNSW Human Research Ethics Committee.

Data coding and network analysis

Posts on forums were coded to analyse for topic of discussion and participants' response mode, informed by literature on interaction patterns found in online social network and question and answering websites [8, 9]. The coding scheme was pre-determined before coding commenced, where a random selection of 20% of forum posts were used to develop the coding scheme iteratively until consensus was reached on coding rules and definition of each category.

Code categories for discussion topics included: i) *medical* (i.e. seeking for advice on a medical issue); ii) *lifestyle* (e.g. dietary, exercise); iii) *emotional wellbeing* (e.g. distress, stress), iv) *women's health* (i.e. topics specific to women issues, such as pap smear), and v). *miscellaneous* (i.e. topics that do not fit into any of the above-mentioned areas). Code categories for participants' response types were i) *asking a new / follow-up question*, ii) *providing advice/support/information*, iii) *sharing experience*, and iv) *expressing thanks*. Each forum post was able to be coded with more than one topic and interaction mode. The coding process was conducted by NM, and AL in-

dependently reviewed 10% of data randomly selected in each code category to ensure consistency.

A network analysis of the forum interactions was next carried out. Patterns of communication were characterised, where connections between individuals represented responses. Degree centrality was assessed by the number of incoming and outgoing connections for each person in the network. Reciprocity was measured by the proportion of connections that were returned, indicating the level of conversation. We tested reciprocity against a random baseline using a method described elsewhere [10].

Data analysis

Data analysis was performed using Statistics Package for the Social Sciences (SPSS) version 20.0. Tests performed were two-tailed and assumed a cut-off of P <0.05 for statistical significance. Participants' self-reported wellbeing, health status and health behaviours pre- and post-study were compared using the McNemar's test and chi-square. Participants' feedback about the PCHMS was summarised using descriptive statistics. Social networks of online forum communication patterns amongst consumers and with clinicians, namely a GP and a counsellor, were drawn using Cytoscape 2.8.2 [11] and analysed using MATLAB 7.11.1 (MathWorks, Natick, MA).

Results

In total, 1985 participants completed a pre-study questionnaire and 709 completed a post-study questionnaire. Analyses were conducted on participants who completed both pre- and post-study questionnaires. The three features most utilised in the PCHMS were journey (84%, 95% CI: 81-87), poll (46%, 95% CI: 42-50) and forum (16%, 95% CI: 13-19). Further, the poll and the forum (i.e. the social features of the PCHMS) were the two features rated most frequently by participants as "useful" (poll: 32%, 95% CI: 29-36; forum: 30%, 95% CI: 27-34) and "fun or engaging" (poll: 35%, 95% CI: 32-39; forum: 16%, 95% CI: 13-19).

Compared to participants who did not use any of the social features, chi-square analyses showed that participants who used a PCHMS social feature (i.e. poll or the forum) were at post-study i) 12.3% more likely to visit a healthcare professional ($\chi^2 = 10.90$, df = 1, P=0.001), ii) 9.3% more likely to seek formal or informal assistance for a physical wellbeing concern ($\chi^2 = 6.33$, df = 2, P=0.04), iii) 7.3% more likely to self-rate being physically fit ($\chi^2 = 8.88$, df = 1, P=0.004), iv) 7.6% more likely to report a higher intention to practice a healthy lifestyle ($\chi^2 = 4.14$, df = 1, P=0.05), and v) 5.7% more likely to have at least one person in his/her advice-seeking network ($\chi^2 = 4.86$, df = 1, P=0.03).

Forum

The most frequently posted topic was 'medical' for both men's (64%, 14/22) and women's (61%, 20/33) forums. For the 'Stay Healthy' forum, the most frequently posted topic was 'lifestyle' (52%, 15/29). Across all three forums, the most frequent interaction mode was "providing advice/support/information" (men: 72% (34/47); women: 73% (40/55); Stay Healthy: 47% (103/221)).

Amongst participants who reported accessing or posting on the forum (n=260), more than half the participants (55%) found

the posts were helpful or answered their question, 34% reported the posts influenced their health action and/or decision, 17% reported the forum reduced their need to visit a healthcare professional in person, and 10% said it led them to visit a healthcare professional. Overall, 46% of participants reported enjoying the support on the forum.

Table 1 outlines the social networking characteristics for the three forums. The women's forum most closely represented a star-shaped pattern, centred on the GP (80% of the connections involved the GP) (Fig. 2a). The GP position reflects a question and answer structure (featuring high levels of reciprocity), suggesting that the level of engagement was one-on-one conversations rather than community-based. The men's forum was also centred on the GP but the level of engagement with other members of the forum was higher (48% of connections did not involve the GP) (Fig. 2b). This network also featured high reciprocity (39% of connections were returned), and all reciprocal connections involved the GP.

Table 1 - Social network characterization for the three forums

	Women's Health Forum	Men's Health Forum	Stay Healthy Forum
Size	35	33	67
Density	3.8%	4.2%	3.2%
Degree centrality of Healthy.me GP (% of connections)	37/46 (80%)	24/46 (52%)	6/146 (4.1%)
Reciprocity (% of connections)	18/46 (39%)	12/46 (26%)	42/146 (29%)
Reciprocity percentile (vs random baseline)	1.00	1.00	1.00

Although there were some individuals with higher numbers of incoming connections, the 'Stay Healthy' forum least resembled the star-shaped pattern and also featured high levels of reciprocity (29% of connections were returned) (Fig 2c). However, clinicians in this forum did not play a central (only 4% of connections involved the GP). The degree of centrality and the reciprocity in the 'Stay Healthy' forum indicated a more conversational structure between participants compared to the men's or women's health forums.

Poll

Amongst participants who reported using the poll (n=248), 70% reported they enjoyed learning how their health compared with others, 41% were surprised by others' answers about their health, and 33% mentioned the poll changed their perception of how healthy they were, or how healthy others were, compared to themselves.

Interestingly, 13% reported using the poll changed some of their health actions and decisions. The results of McNemar's test conducted on poll data shows that there was a significant increase in number of participants reporting being healthier than others after using the poll compared to before usage ($\chi^2 = 41.57$, df = 3, P<0.001). Chi-square analysis shows that participants who used the poll were 9.6% more likely to seek formal or informal assistance on an emotional health issue ($\chi^2 = 9.10$, df = 2, P=0.01), and 7.9% more likely to visit a healthcare professional than those who did not use the poll ($\chi^2 = 4.10$, df = 1, P=0.05).
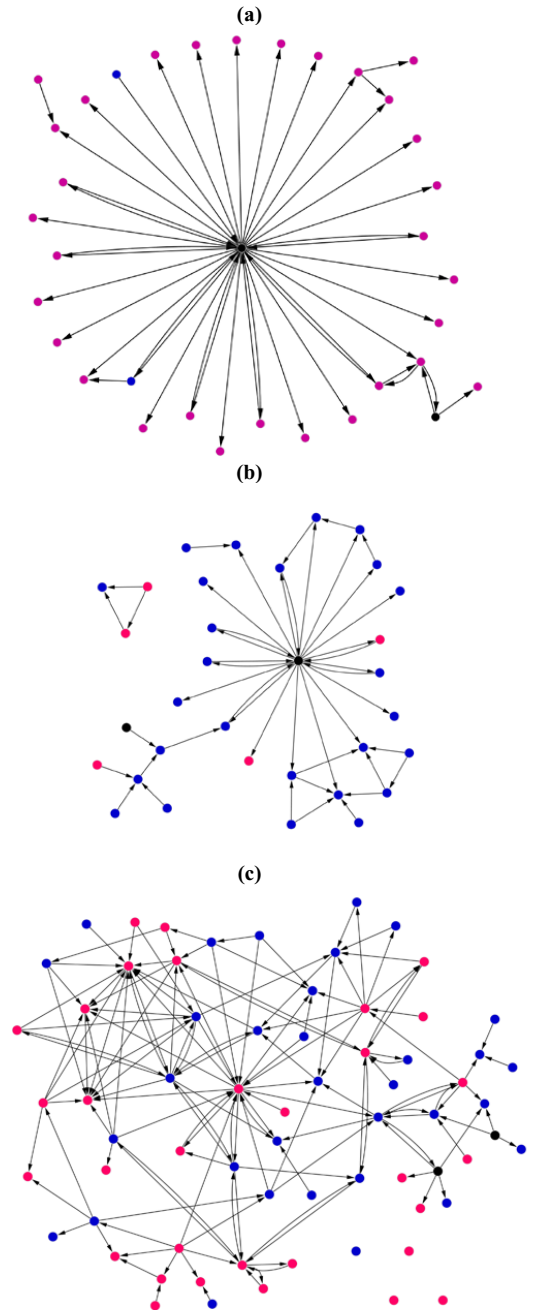

Figure 2 - Networks for the three forums (a) women's forum, (b) men's forum, and (c) the stay healthy forum are coloured by sex. Blue circles are male, pink circles are female, the Healthy.me GP and/or counsellor is represented in black.

Discussion

In this study, we found that the social features of the PCHMS (the poll and the forums) were one of the most frequently used features amongst consumers, and were reported to be most useful and engaging. Consumers also reported these social features had a significant impact on their health behaviours.

This study also contributes to our understanding of communication patterns in an online community (i.e. structure of a forum), and shows that it can differ depending on the purpose of the social space (e.g. medical advice seeking vs. personal experience sharing), and the types of people participating in the space (e.g. consumer vs. clinician). Findings on network centrality and reciprocity suggest that when it comes to consumers seeking answers to medical questions (e.g. on men health and women health forums), the forum follows a star-pattern with the GP in the middle. This pattern could be interpreted where as the "authority" (i.e. GP) contributes, the conversation in that particular topic stops. However, when it comes to sharing lifestyle experiences (i.e. Stay Healthy forum), the forum did not follow a star-shaped network topology, consumers freely communicated with each other and the GP no longer played a central role of mediating the conversation in the forum.

Evidence that guides the design of features in consumer E-Health applications is sparse. Choi and colleagues have recently proposed a typology for online Question-Answering (QA) forums into four categories [9]. Community-based QAs refer to those where the motivation is to build a community, and participants develop altruism and reciprocity such that they will learn from and help each other. Often, opinion-seeking / sharing experience is the most common form of communication [9]. Collaborative QAs facilitate users to collaborate and contribute to questions or answers over time (such as WikiAnswer). Expert-based QAs are those where answers are provided by experts rather than the community. Social QAs incorporate those where participants seek answers to questions from their personal social networks, such as Twitter or Facebook.

Our paper provides a preliminary examination of how the presence of experts in QA forums may have affected the patterns of communication, suggesting a potential for more consumer engagement in community-based QA forums when an expert does not play a significant role. More empirical and theoretical studies are needed to investigate ways to design an *optimally social-engineered communication space,* according to its intended purpose and the anticipated interaction mode (e.g. with similar peers, collaborators, experts, or friends). For example, in a community-based QA, would having informed "expert peers" [12] rather than "medical professionals" be more appropriate to act as moderators? How can online social space be optimally designed and its peers trained to be informed moderators that would encourage interaction between participants without compromising the safety of the forum or the accuracy of the information exchanged?

The poll was one of the most frequently used features in the PCHMS, and was regarded as the most useful and engaging. Yet, its use in consumer E-Health applications is not widespread, and it is still unclear how we can effectively design and incorporate information about social norms to influence health behaviours in a positive manner. As Christakis and Fowler have demonstrated in the past decade, social networks are associated with health behaviours and outcomes for a variety of conditions (such as happiness, loneliness, depression and obesity) [13-16]. When applied in the right context, social norms information has shown to significantly influence health behaviours (such as reducing alcohol consumption [17, 18]). In addition, Centola has y demonstrated that homophily (i.e. similarity of social contacts) and social network structures can significantly influence our online health behaviours [19, 20].

Yet, to the best of our knowledge, no studies have examined how we can best utilise these social influence findings to inform the design of PCHMS and other consumer E-Health applications. While past literature and our preliminary findings suggest that information about social norms (such as via the poll) are associated with significant changes in consumers' health beliefs and behaviours, E-Health researchers need to examine ways to design socially-driven interventions that encourage consumers' uptake of positive health behaviours and reduce the spread of negative health beliefs. This is especially important in cases when the "norms" may hold an incorrect or misleading view of what is considered healthy.

Limitations

Some limitations in this study include setting, self-reporting, attrition rate, and causality. Participants in a university setting may have been more motivated, or possess higher levels of health and e-health literacy than the general population to use new technologies. While this study relied on self-reports, they have shown to be acceptable in studies of help-seeking and mental health related studies amongst young people [21, 22]. One of the possible reasons for the high attrition rate is that participants were asked to complete their questionnaire during the long university break. Future studies should avoid commencing or completing a study during these periods. In addition, findings in this study are limited by its cross-sectional nature, and that we could attribute no causal relationships. However, our findings concur with Couper and colleagues' study which found that website engagement was significantly associated with consumers' health behaviours [23].

Conclusion

The PCHMS has been advocated as the next generation tool to improve health behaviours and outcomes. This study provides preliminary evidence that social features in a PCHMS were amongst the most frequently used features, considered to be most useful and engaging, and were associated with consumers' health behaviours. We also examined how consumers interacted online, indicating the variability in the "dose" and structure of the PCHMS social features utilised by consumers.

With the emergence of online social networking websites, E-Health researchers should consider ways we can *systematically* manipulate the "crowd" to positively influence health behaviours and beliefs (e.g. via social comparison, social support, social norms, buddy systems, peer modelling, social capital, or designs of social spaces). For example, if a PCHMS were able to "change" the social network around a person, would that be sufficient for him/her to come into contact with a pivotal person who would encourage help-seeking and early intervention? If so, what "doses" and structural forms are needed to provide sufficient efficacy and tolerability in a socially-driven intervention to influence health behaviours and beliefs? Future designs of PCHMS should explore ways we can "alter" a person's social network, and evaluate its efficacy as a complex social intervention that impacts the health behaviours and outcomes of consumers and patients across different health settings and conditions.

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