Leveraging Intermediated Interactions to Support Utilization of Persuasive Personal Health Informatics

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ABSTRACT

Behavior change support systems (BCSS) and persuasive technologies for healthcare often entail users interacting with mobile devices. However, especially in developing countries, the target community is unfamiliar with and often intimidated by new technologies. In this paper we propose the use of *intermediaries* to facilitate interaction with a mobile phone-based application and to motivate ongoing use by the target beneficiaries. The application incentivizes utilization through gamification techniques, using badges, scoreboards, and other rewards. For example, a young girl might help her father keep track of his walking and diet, maintaining participation as much for her father's health as for the social awards given by the app. We explain how intermediaries can be leveraged to improve utilization and engagement of the beneficiaries, and describe factors affecting interaction between the participating pairs and interaction with the application. This study highlights the importance of social rapport - typically through a familial relationship - as a key component of the intervention. Finally, we discuss the implications of designing for the motivation of two different users: gamification, personalization and utility play different roles for the intermediary and the beneficiary but ultimately combine to make a more effective application for the beneficiary than one targeting the beneficiary alone.

Categories and Subject Descriptors

H.5m. [**Information interfaces and presentation**]: Miscellaneous; H.1.2. [**User/Machine Systems**]: Human Factors

Keywords

HCI4D, intermediated interactions, persuasive technologies, gamification, personal informatics, motivational affordances, health

1. INTRODUCTION

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Approximately 1.3 billion people are considered to be either overweight or obese worldwide, of which two-thirds are found in low- income or developing countries [34]. While this pandemic used to be considered a "first world problem", urbanization and changing lifestyles have led to increasing problems for the low-income communities of the developing world. For example, 60% of South Africans are overweight, with four in 10 women that are either overweight or clinically obese [24].

A typical intervention from the West might entail development of a persuasive application to encourage healthy eating and exercise behaviors [3, 14]. Persuasive applications on mobile phones are particularly well-positioned for interventions that target psychological processes, because they are pervasively present for the users [16]. Gamification, enabling self-reflection, or more simple strategies such as SMS-based reminders all motivate positive experiences and more frequent engagement [14, 6] The subset of these interventions that target collection of personal history entry, review and analysis is broadly called personal informatics, or personal health informatics (PHI) for health interventions.

However these applications fail to replicate well to typical populations targeted by information and communications technology for development (ICTD) interventions [17]. In part this is due to problems of technology access: people do not own phones, share phones, or do not know how to use them. In the context of obesity, many potential target users are older, further exacerbating the problem. As a result, more typical ICTD interventions target community health workers (CHWs) or other intermediaries as facilitators of access to mobile content [29, 30, 23]. However, Sambasivan et al suggest another resource - young girls and boys in the community can be leveraged as intermediaries for older adults seeking to interact with new technologies [32]. Thus, we propose that persuasive PHI might be more effective if it incorporates intermediaries to motivate participation.

In this paper, we present the results of a series of studies conducted in two townships in Cape Town, South Africa. In these studies, we have deployed a mobile application to support PHI for overweight or pre-diabetic adults. The application primarily incorporates gamification strategies such as challenges, badges, and leaderboards for motivating ongoing use. Each adult elects an intermediary to assist with use of the application, and is given airtime to use the application for two to six weeks. We identify characteristics of effective intermediaries, highlighting social rapport as a key contributor towards effectiveness of the application. Using qualitative feedback from participants, we also discuss

important aspects of intermediated interaction and implications of intermediation on design of persuasive technologies. Ultimately we find that intermediated persuasive technologies are an effective way to improve engagement of adults with PHI.

2. RELATED WORK

Persuasive technologies have evolved from prescriptive nature of information flow in between health care providers and health care recipients [5] to behaviour change support systems (BCSS) [20]. Oinas-kukkonen [25] defined BCSS as "a socio-technical information system with psychological and behavioural outcomes designed to form, alter or reinforce attitudes, behaviours or an act of complying without using coercion or deception".

In order for a system to be persuasive, the persuasion goal in design must be intentional [14]. The persuasive system design (PSD) model proposes a set of functionalities required for a system to be considered a persuasive technology [26]. The first set of functionalities fall under primary task support, which includes but is not limited to: reduction of complex behaviours into simple tasks; guiding the user through experiences while persuade along the way; tailoring of persuasive information to factors relevant to a user group; personalization of content; and self-monitoring for users to keep track of their performance in achieving goals. The second set of functionalities fall under dialogue support, which includes praises, rewards, reminders, similarity, liking, and social roles. The third set functionalities fall under system credibility support, which includes trustworthiness, expertise, surface credibility etc. The last set of functionalities emphasize the role of social support, which includes social learning, social comparison, and competition.

Gamification is also garnering popularity as a means to persuade people because of its ability to invoke users' intrinsic experiences through gameful experiences [14]. Gamification is the use of game design elements in non-game contexts [7] with an objective of increasing engagement in a particular activity. A systematic review on peer reviewed studies found that gamification provides positive effects and these effects are highly dependent on both the context in which gamification is implemented and the users using it [15]. Hamari and Koivisto [13] found out that social motivations for use of a gamified service/system are attributed to social influence, recognition, reciprocal benefit, and network exposure. Some of these attributes resonate with the functionality proposed on the aforementioned PSD model for BCSS.

Typically a BCSS will aim at sustaining engagement over a long period of time [25], but only considers single users. Existing literature does not consider how to design systems that include intermediaries as part of the engagement. In this work, we seek to understand how can one sustain engagement in the context of intermediated interactions. We explore important human factors in intermediated interactions that may affect utilization of persuasive personal health informatics (PHI) that target health behavior change. In the next sub-sections, we discuss literature on social relationships in the context of intermediated technology use, and utilization of human intermediaries in health behavior change through ICTs.

2.1 Intermediaries in ICTs for Healthy Behavior Change

In the context of ICTD, human intermediaries have been previously utilized on behavior change interventions. One study [29, 30] in India used community health workers (CHWs) with help of mobile messages to persuade pregnant and postnatal women together with their relatives on maternal health issues. Community health workers interacted with mobile phones to access persuasive messages to share with their clients. Another study by Molapo and Marsden [23] empowered rural health trainers with a software application that allows them to create digital training content for low-literate CHWs in Lesotho, using images, voice-over, and video clips. While intended only for training, CHWs also chose to save those videos with their clients, having the unintentional effect of persuading people to get tested for diseases such as tuberculosis. In this context CHWs were acting as intermediaries as they provided access to information that had persuasive effects. CHWs are an oft-used intermediary for communities in which direct access to health resources is difficult, and are an effective bridge between communities and government-based resources. However, they are ultimately limited in reach, typically interacting with potential beneficiaries only once every few weeks. Furthermore, in this case, while CHWs are intermediaries with respect to information, facilitating beneficiary access to mobile media. However, in the case of personal health informatics, we expect that the beneficiaries would be the primary users of the mobile device, and choose to explore how their access might be facilitated by intermediaries. As such, CHW access is ultimately too limited for our typically-older and less technology literate target beneficiaries, and we build upon Sambisavan's example of *proximate translation* [32] by leveraging younger members of the same household to sustain an ongoing use of a BCSS even when CHWs are not available.

2.2 Social Relationships in Intermediated Interactions

Poole et al. [28], explored extensively the dynamics of computer help-seeking and giving behaviors in the context of family and social networks settings. One of the factors that contributes to help- seeking behaviors is availability of unlimited help provided as a part of a longer-term relationship, while help-givers are motivated by a sense of being accountable to their family and friends.

Parikh and Ghosh [27] were early pioneers in bringing an HCI (human-computer interaction) perspective towards understanding intermediation in the context of developing world. Their work emphasized an understanding of a taxonomy of intermediated information tasks of where different modes of access have their own design requirements such as cooperative versus dominated interactions or intermediated versus indirect interactions. Sambasivan et al. [32] further conducted an ethnographic study in urban slums of Bangalore in India and proposed the following design implications: that technology should be reoriented to allow sharing and supporting secondary users (beneficiary users) through persistent storage of information for retrieval at later stages; that evaluation metrics of use should go beyond ownership to measuring the ability to benefit from use; and that designs should consider and enable asymmetric engagement. Their work further emphasizes the critical role of human relations, such as interpersonal trust, as the foundation of

intermediated interactions. The concept of social relations is also implicitly discussed by Sukumaran et al. [36] who report on an experiment carried out to investigate if social prominence of an intermediary versus technology affects perceived information characteristics and attitudes towards an interaction by a beneficiary user. Their preliminary findings suggest that when the technology was more visible and an intermediary did not monopolize access (situation of social equality), participants tended to feel more engaged and positive. Ramirez et al. [31] studied of how human factors such as empathy and technical skills of infomediaries influence the outcomes of the process of infomediation to users at public access venues.

In order to sustain frequency of interaction with a particular system, aforementioned initiatives rely on innate intrinsic motivation of intermediary and beneficiary users. As discussed by Sambasivan et al. [32], usually a request for interaction is initiated by beneficiaries, and intermediaries will respond based on existing reciprocal benefits or prior social relationships. Therefore, instigation to engage with a system is mediated by help-seeking behaviors of beneficiary users. An intermediary's decision to help is determined by prior social relationships.

In our approach we continue to emphasize strengthening of existing social relationships through motivational strategies that aim to increase user experience of both intermediary and beneficiary users. We report on (1) motivational factors that increase the frequency of help-seeking behaviors of beneficiary users and (2) factors that motivate intermediaries to instigate help-giving in interacting with a BCSS instead of relying on existing relationships or beneficiaries' help-seeking behaviors alone. We suggest that designing BCSS to enable intermediary engagement will increase sustained engagement on the part of the beneficiary.

3. CONTEXT

Both overweight and obesity are associated with increased incidence of multiple co-morbidities including type 2 diabetes, cancer and cardiovascular diseases (CVD) [12]. Obesity is a developmental problem since it has both an indirect implication on health care systems and gross domestic product (GDP). Abegunde et al. [1] surveyed a total of 23 low-income and middle-income countries found out that an estimated US$84 billion of economic production was going to be lost in between 2006 and 2015 from heart disease, stroke, and diabetes alone if there would not be any measures in place.

We carried out this work in Cape Town, South Africa. South Africa is one of the developing countries having been most affected by the current obesity pandemic [2]. According to data on human development index (HDI) by country, South Africa is among countries grouped in medium HDI countries. A systematic review by Dinsa et al [8] revealed that in countries in the group of medium HDI, the relationship between social economic status (SES) and obesity is largely mixed for men meaning that both people of high SES and low SES are affected, and mainly negative for women; women with low SES are more at risk compared to their counterparts with high SES. This suggests obesity is also affecting the poor in countries like South Africa. Within South African context obesity affects different age groups including old adults [2]. Thus, the focus of our research is primarily on adults from low income suburbs who are not very conversant with technology. We targeted this group since most persuasive PHI do not yet target them, despite the prevelance of obesity in the population.

In initial testing and evaluation of the software prototype we developed, we worked with participants from Philippi and Langa in Cape Town, South Africa. The two suburbs were previously designated for people who were Black Africans during apartheid era. In 2011 the population of Langa was 52,401 with 17,400 households of which 72% of households had a monthly income of ZAR3200 (ũS$210) or less. In the same year the population in Philippi was 191,025 with 61,797 households of which the monthly income of 78% of the households was also ZAR3200 or less. These data are available at the website of Cape Town municipality[1]. The ceiling for low income earners in South Africa is ZAR54,344 per annum (ũS$3500 per annum)[2].

4. SYSTEM DESCRIPTION

The system is composed of two parts as shown in Figure 1. The first part is a native pedometer application developed using open source code. The second part consists of a web application hosted on server at University of Cape Town. The pedometer sends a count of all steps walked by the holder of the mobile phone to the web application. The web application allows users to view step graphs and to record meals eaten by beneficiaries. Additional features include a reward sub-system in which we implemented gamification motivators such points, badges, leaderboard, a botanical garden, and fish tank. Rewards were earned if a user uses the application for both viewing of steps and recording meals, and if a beneficiary user walks a number of steps that exceed a certain threshold that has been set for a particular level of gamification. As a beneficiary user walks more steps and the application is used more regularly, a pair of users that forms a team (a beneficiary and an intermediary) will gain more advanced badges. An advanced badge gives more resources that nurture the garden or fish tank. Also, users can improve upon the quality of their gardens and fish tanks by adopting healthier eating habits and recording the consumption of more fruits and vegetables recorded. Users receive text messages that update them on their status and tips on how to improve on badges, gardens and fish tanks. Text messages are personalized and they are addressed to intermediaries. Each message starts with with an informal greeting and the name of the person and finishes with either a reminder, a tip of how to win rewards, or a feedback on status about rewards. Figure 2 shows screenshots of the web interface.

5. METHODS

5.1 Contextual Inquiry

We conducted a contextual inquiry using a series of semi-structured interviews with a convenience sample of diabetic patients at a diabetes and endocrinology clinic of Groote Schuur Hospital in Cape Town. This was conducted in between March and May of the year 2013. The objective was

[1]https://www.capetown.gov.za/

[2]This data was retrieved on 18th of November 2015 from http://www.unisa.ac.za/news/wp-content/uploads/2013/01/Household- income-and-expenditure-patterns-Press-Release-3Jan2012.pdf

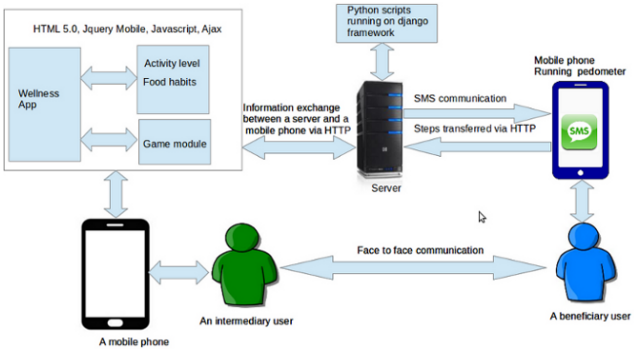

Figure 1: Information flow inside the system

Figure 2: Sample screenshots from the system

to understand patterns in utilization of cellphone technology among adults obese patients. This study was approved by the respective institution's ethical review body.

We interviewed a total of thirty participants of which 67% (20) were females. The average age of these participants was 53 years old with a standard deviation of 11.8 years. Almost 86% (26) of participants were above 40 years of age. A majority of the participants were either overweight or obese and from low income suburbs of Cape Town. Nineteen participants were either unemployed or on a disability grant. Participants were approached opportunistically as they waited to see their physicians. To ensure confidentiality, interviews were conducted in one of the vacant consultation rooms. One researcher and a research assistant carried out the interviews. The main topics in these semi- structured interviews were centred around participants' general utilization of mobile phones, whether they seek help from intermediaries, and, if so, who their preferred intermediaries are.

Although eighteen participants had access to smartphones, utilization of features was not beyond SMS and voice in majority of the participants. Out of 26 people whom were forty years of age and above, not more than eight had already used Internet-based services (e.g. e-mail, WhatsApp, general Internet browsing, Facebook). This suggests that majority of the aged participants were likely to be less conversant with cellphone technology. Only three participants had used their cellphones in management of their health, to look for information on the Internet and to participate in social support groups on Facebook. Only one participant had used a pedometer before.

We also found that twenty participants had asked for informal help from intermediaries before, in tasks such as: (1) to setup or configure services and apps on their phones (e.g. Whatsapp, Facebook); (2) to be taught how to operate or navigate through certain features (e.g. a phone book of a new or unfamiliar cellphone, Whatsapp); and (3) to be helped in interacting with certain features such as SMS, Internet browsing etc. The level of dependence on intermediaries varied depending on frequency of tasks at hand. Tasks such as configuration of services and apps or teaching of individuals occur only at the beginning when there is a new application or device. When participants are not capable of interacting with applications that they use daily, then they seek help more frequently. For either of these tasks, participants chose trusted individuals to act as their intermediaries, typically their children and grandchildren or, less frequently, children of relatives, family friends, or someone at a cellphone shop. 23 out 30 participants preferred to have family members act as their intermediaries.

Apart from utilization of help from intermediaries, we also observed that some of the participants share their phones with their intermediaries. Children borrow their parents' phones to search for school materials on the Internet or to use social network services such as Facebook or Mxit. For instance one participant who had a Blackberry smartphone reported that she does not use Internet on her phone but her kids use it to do their assignments. This is an example of shared device use.

Our findings from this contextual enquiry indicate that a majority of the aged participants relied on expertise of their younger family members in solving problems on both setting up of cellphones and interacting with specific applications. The majority of responses show that these participants were assisted by their sons, daughters, and grandchildren. Based on this observation, we decided to implement a technology that can be utilized through young intermediaries in a family. This finding motivated the use of gamification and the choice of intermediaries age group in phases of evaluation that are explained in the next sub-sections.

5.2 Iterative Design and Evaluation I

We conducted two iterations of design. The first iteration started in July 2013. We developed the first prototype of a web application. This prototype could allow users to self-monitor their diet and walking patterns. In addition, we implemented a reward system that paired a beneficiary user with an intermediary user in a team that could compete with other teams. Scores for each team are presented as points, badges, and the appearance of fish and plants in the tanks and botanical gardens. Within each botanical garden and fish tank, there was a Facebook social plug-in that allowed users from different teams to comment on or like each other. We also utilized Facebook groups to remind users to engage with the application.

In order to test our application, we recruited participants through an NGO based in Cape Town called "***Mamelani Projects***". This NGO carries out outreach programs on health education in less privileged communities. Mamelani trains women them on issues of HIV/AIDS, nutrition, and gender equality. The NGO agreed to help us to recruit participants among people they were training. We gave them the following recruitment criteria: (1) we want participants who were aged 35 or above and (2) those participants must have an intermediary to help them. The NGO helped in identifying the targeted participants in Philippi township, where the NGO was conducting its own activities. T We recruited a total of six participants whom were women above middle age (>=35 years of age).

After recruitment of the six adults, each one of them brought an intermediary to work together with them in a pair. Three intermediaries were girls in between 19-23 years of age. The remaining three intermediaries were boys aged between 14 and 19 years of age. We informed participants about the objectives of the study, that logs on their usage of the phones would be collected, and about their rights as research participants. All participants (intermediaries and beneficiaries) signed consent forms except for intermediaries who were minors. These minors signed assent forms that were approved by their respective parents/guardians. After signing of consent and assent forms, intermediaries were trained on how to use the app. We deployed the application to the field from the end of October 2014 to beginning of December 2014. In order to control the application environment, and limit potential complications from deploying the intervention on multiple platforms, each pair of participants was given one Android phone (Samsung GT-S5300) running the pedometer app. Participants were required to utilize the web application hosted in our institution's server. We gave out airtime as an incentive to each participant including intermediaries. Every week each participant got ZAR30 (ŨS$3) worth of airtime.

In that period of deployment, only two pairs of users engaged with the system for more than a few days. Both of these two pairs consisted of a beneficiary and an intermediary living in the same house— the pairs consisted of mothers working with their sons. One of these two pairs was very motivated and enthusiastic about the system. But after some time they also got bored because they were not getting any competition from other teams and they had attained all the challenges within a short period of time. In a third pair, a girl was working with her mother but they were not living together so it was difficult for her to commit to the application. Intermediaries from the remaining two pairs showed little enthusiasm in the project. We hypothesized this to be due to lack of both motivation to engage with gamification and a lack of a prior social relationship between the two users within each pair. Findings from this informative evaluation led to another iteration in the design. It also informed the manner in which we were going to conduct future evaluations.

We started another iteration of design in January 2015 to address the drawbacks encountered during testing of the first prototype. In this new version we improved the gamification part to make it more challenging and we also integrated SMS reminders. In the next sub section we discuss the evaluation of the improved system.

5.3 Evaluation II

After fixing the bugs, we conducted another round of evaluation. We approached another group of participants who resided in another side of Philippi. The recruitment was facilitated by the same NGO in Evaluation I. Before the commencement of the study, the NGO advised that we withdraw from that area as participants addressed some concerns regarding safety issues. The area was not safe, hence experimental phones would pose risks to both participants and the researcher. In response, we terminated this study and sought participants in Langa, which as a smaller and more central township is safer than Philippi.

As an aside, this incident highlights some of the limits and dangers of doing smartphone-based interventions in low-income areas [22]. However, we still believe that this study has relevance, even for residents of Philippi. Intermediated usage is not limited to smartphone applications. For example, while SMS campaigns are not specifically designed for intermediated interactions, it is not inconceivable that a family member would assist a target beneficiary in an informal proximate interaction [32].

In Langa, we worked with a research facilitator who is a resident of Langa. The research assistant helped with the recruitment process. This time we adjusted criteria for recruitment based on lessons learned during the first deployment in Philippi. The criteria for recruitment were (1) adults aged 35 and above with (2) school-going children living with them or living nearby.

Prior to deployment we provided participants with information about the study. Participants were made aware that the study's cellphone will be collecting their information related to steps and diet and transfer it to the researcher's computer at University of Cape Town. Participants who were minors signed assent forms approved by their guardians/parents who were also part of the study. All other participants signed consent forms. We recruited a total of nine adults (3 men and 6 women). Each adult brought one kid to act as their intermediary hence they formed a pair. There were 3 boys and 6 girls. All adults were relatives of the kids except for one adult who was the tenant of the grandmother of her intermediary. All intermediaries were school-going children but one. We administered a questionnaire at baseline to collect demographic information such as age, number of cellphone applications utilized by each group of participants. Only seven beneficiary participants completed the baseline survey. All nine of the kids completed the baseline survey. The mean age for adults was 49.3 years old (SD=7.9 years) while the mean age for kids was 14 years old (SD=4.3). We compared the average number of applica-

tions on a cellphone utilized by each set of users by using the student's t-test. Intermediary participants had significantly interacted with more applications (M=5.4; SD=1.7) before compared to beneficiary participants with (M=3.4; SD=1.5) applications (t(14)=2.430; p=0.029; 95% CI=3.765 to 3.795 applications).

We trained each kid on how to use the prototype. Each pair of participants was given one android phone installed with a pedometer and a link to access the web application. We left the application in the field for three weeks. We provided airtime as incentives to participants. Each adult received ZAR40 worth of airtime four times in a period of three weeks. In addition, each pair was given 300MB of data to use on the Android phone. After three weeks we conducted interviews with three intermediary participants and the five beneficiary participants who engaged with the application for more than once. Interviews were conducted in English since all the respondents were comfortable with English.

Out of nine pairs of users, eight attempted to engage with the application for at least one day in a period of three weeks. The average number of usage days for these eight participants was 4.88 days with a standard deviation of 3.4 days. Two pairs used the application for only one day. The most active pair used it for 11 days in total. While there were many problems that contributed to non-use, the primary barrier was that the data bundles allocated for the study (300MB per phone) were expended earlier than expected. In addition to the prescribed study use, they also used the data bundle for other apps such as Whatsapp and downloading of games. We elected not to prohibit this since it has been shown that allowing non-prescribed use can motivate ongoing prescribed usage [33]. Ferreira [9] also emphasizes that non-prescribed uses should not be discouraged within the context of ICTD as they can be viewed as capabilities that foster participation and engagement in ICTD projects.

Our synthesis on data collected through interviews uncovered several themes related to social dynamics on usage of a persuasive personal health informatics through intermediaries. We discuss these findings on the next section.

6. FINDINGS

On reflection of findings from both evaluation I and II, we uncovered some useful insights on social dynamics that had an influence on utilization of a BCCS in our context. Usage of the app occurred when intermediaries had access to an experimental phone. Most beneficiaries went to work during the day and hence they carried the phone with them, and also intermediaries went to school during the day. Figure 3 below shows the pattern of the time of which there were users' activities on the app in evaluation II. From the graph, the peaks are shown at 5AM, 5-6PM, and 8PM. These are times when intermediaries and beneficiaries were together.

When a pair meets, one of them would instigate the request to engage with information on the app. Initiation of the request to engage and success or failure in fulfilment of a request were determined by social rapport within a pair, motivational triggers as the result of the app's features, and social interactions among beneficiary participants. The mentioned factors played a part in influencing help-seeking by beneficiaries and help-giving by intermediaries. We present in detail about these factors on the following sub- sections. In addition, we also present perceived health benefits on

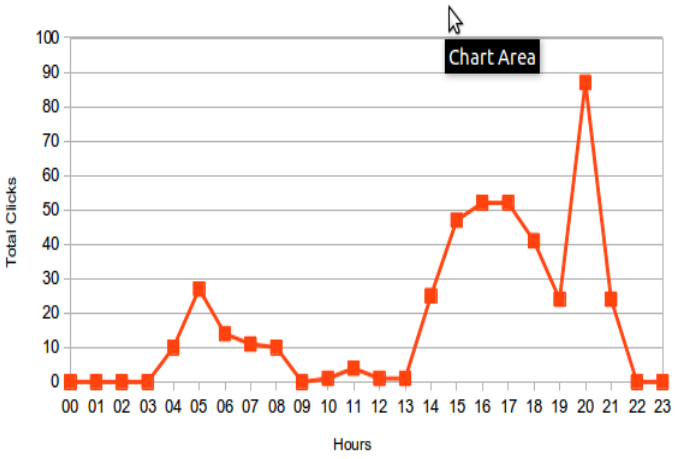

Figure 3: Total clicks on each hour of the day

utilization of the application. All the names used in presentation of findings are pseudonyms in order to ensure confidentiality of participants' identities.

6.1 Social Rapport

We clustered each pair in evaluation II on its respective relationship type as shown in Figure 4. In the parent-intermediary group, there were four pairs. In the relative-intermediary group, there were three pairs, and there was only one pair of where members didn't have a familial relationship. We measured usage on each relationship type through three dimensions and these are;the average number of days per participant; the average number of sessions per participant; and the average number of clicks per participant. We defined the beginning of a new session as when a user activity is detected while there was no user activity for the past one hour. If delay between activities is less than one hour it is then assumed that the last session is still active. If a user comes back after one hour has elapsed since the last detected user's activity then it is assumed they went away from the app and now they are coming back for a new session.

Once members of a pair are together, interaction between them is initiated. The success of this initiation depends on the nature of their social rapport within a pair. In existing work on intermediaries within the context of ICTD, human relationships play a pivotal role in encouraging or discouraging engagement. In our context, we uncovered scenarios of how the relationship of users within a pair played a significant role in facilitating or discouraging requests for engagement. For members of a pair with a prior social relationship, there was an indication of motivation for the two users to work together. Within these pairs, intermediaries showed empathy and a sense of ownership on interaction processes, and believed that the act of helping was for a good cause as it had an instrumental value to the people they care about. For instance **Lulama** (an intermediary from Langa), a 20 years old girl, mentioned that the app was meaningful to her because she was helping the person she cares about, and that was her mother. **Andile**, a 17 years old intermediary who was part of the study in Philippi, felt that it was his duty to support his mother as she took care of him since the

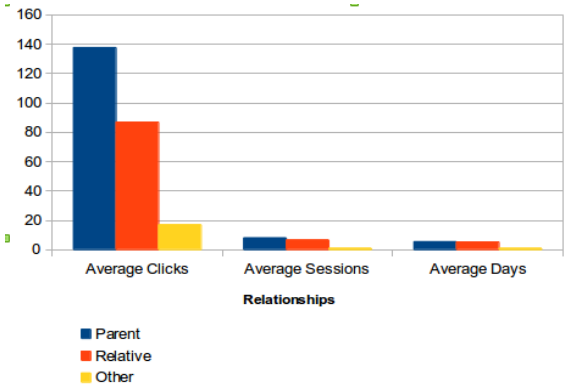

Figure 4: Usage in three groups of relationships

day he was born. These are examples of how intermediaries were reciprocating the benefits of a prior social relationship.

In a pair with no prior social relationship, negotiation for interaction may not be successful even if one user within a pair is motivated to engage with the system. For instance trust and social rapport hindered **Anele** (a beneficiary user from Langa)(a 47 years old woman) from accessing the system. She was working together with an intermediary that was not related to her as we learned during the interviews. The intermediary was the grand daughter of her Landlord.

When there was a prior social relationship (i.e. familial relationship), it played part in mediating the success for negotiation of interaction. Either an intermediary or beneficiary user would instigate a conversation that leads to interaction with the wellness app and exchange of information between an intermediary user and a beneficiary user. The phone was possessed by a beneficiary user and if negotiation for interaction is successful, the phone is passed from a beneficiary to an intermediary. If interaction was instigated by an intermediary, an intermediary would request a beneficiary to provide some information such as what food has been eaten by a beneficiary. Also an intermediary might either view information inside the app for his or her own consumption or share that information with a beneficiary user. If interaction is instigated by a beneficiary user, most of the time they request intermediaries to help them view certain information. In this scenario, there were cases where intermediaries' autonomy was violated as beneficiaries requested assistance at the time where intermediaries were either resting or occupied by other activities. In these cases, a social relationship still had to play a role in convincing intermediaries to fulfil requests from beneficiaries.

Members of a pair with a prior social relationship demonstrated improved relatedness within a pair compared to before. They mentioned that they were conversing more often to talk about what is going on inside the app. The conversation was fun in some of the participants when they made jokes about what was happening inside the app.

6.2 Motivation in Utilization of the app

Motivational strategies that were implemented in the app and those that were socially constructed as the result of engaging with information from the app, played a vital role in persuading both beneficiary and intermediary users who engaged with the application. These motivational strategies led to negotiation of interaction. We discuss in detail these forms of motivational sources below.

Sources of Motivation in Beneficiaries

The most prominent motivational factor that drove beneficiaries to seek for information derived from the app was steps comparison. Steps comparison was socially constructed as majority of the beneficiaries lived not far from each other.In cases where beneficiaries initiated the negotiation for interaction, it was for the purpose of their health and secondly it was for comparisons with other beneficiaries. This kind of comparison is referred as one form of social comparison in the context of behavior change support system [26]. This kind of comparison was not implemented in the app but it was instigated by the the existing social network. Some beneficiary users compared each other and this led to both social support, relatedness, and competition among beneficiary users. Beneficiary users who knew each other before organized themselves in informal support groups. Whenever beneficiary users met in these informal support groups, they talked about the steps walked or food they have been eating.

> *"I used to boss to others in the group like hahaha [She would giggle to the people she is interacting with] how many steps did you walk today hahaha. I am getting there. I tell them I got some encouraging messages. They would also say 'I got some too'. I tell them that I walked so many kilometres today."*
>
> —***Nokhanyo*** *(beneficiary user), 57yrs, woman, from Langa*

Through these informal discussions, beneficiary participants were encouraging each other. There was also an indication of improved relatedness among participants. People who were part of those informal support groups felt that they were more related to each other compared to before using the app.

> *"We [with other participants] didn't communicate so much before but now we communicate. Most of the time, we chat about this and we laugh."*
>
> —***Nobantu*** *(beneficiary user), 50yrs, woman, from Langa*

"

> *"I am close to other people because of the steps. They would send you messages to ask 'how many steps did you take?'. These are people that I didn't speak to here. Not to speak to, I mean others that I didn't have a really relationship with. I know them from here. It is just a hello, hello that's it. They send me messages 'how many steps did you take today? Is this app working for you?'. There is this lady next door. She would come to me like ooh 'how did that thing work for you and blah blah'. We were communicating more than before."*
>
> —***Ndileka*** *(beneficiary user), 35yrs, woman, from Langa*

Competition with others was also partially linked to competition with self of where beneficiaries challenged themselves by setting goals implicitly (without writing them down). Goal setting pushed beneficiaries to do more in steps so that they can beat others. For instance a person would ask her intermediary about the number of steps they have walked

in a particular day. Upon getting a response from their intermediaries they would say that "tomorrow I am going to walk this number of steps". But the main objective of setting these goals is to have more steps than others. Goal setting is an important aspect in health behavior change [35].

These findings suggest the role that activity and diet based social comparison can play even in resource constrained environments. With typical behavior change support systems from the west, this kind of comparison is always provided through software functionality. In our system we implemented activity and diet comparison through gamification design patterns such as points, leader board, badges, botanical gardens, and fish tanks. Through these features, each pair of users (a beneficiary and an intermediary) could be able to make comparison with other teams. But our existing gamification features appeared to be of less value to beneficiary users as they didn't really understand the meaning of motivation strategies provided by gamification although they interacted with those features through intermediaries. What they valued most was their relationship with each other(beneficiaries) within the context of the community they lived in.

Motivational Sources in Intermediaries

Each pair of users (an intermediary user and a beneficiary user) formed a team that competed with other teams. Some intermediaries pushed their beneficiary users to walk more steps or to eat healthy due to two reasons. Firstly, because they cared for the people they were helping. Secondly, because it gave them more points to win the game against other teams.In cases where intermediaries initiated the interaction, they did so to encourage beneficiaries to do more so that their pair can win in gamification. Gamification features in combination of a prior social rapport made some intermediary users to perceive themselves as partial owners of the information and value derived from the system. For instance one participant explained actions that were carried out by the beneficiary she was helping as theirs.

> *"When I saw the garden I was like yeah, our garden is looking beautiful. Lets do more. Lets take more steps. Lets eat more veges, because it is the veges and fruits that are important. One time she went to the clinic in town and she always walks to the clinic. It is up in town. That day I was motivated. She took more than four thousand steps. But mostly the garden . I like the garden. When I see the garden I say let's take more steps. Lets eat more veges."*
>
> —***Lulama**, an intermediary*

Gamification features also led to competition among intermediaries. One intermediary user explained how the badges played a role in challenging and making him to compete with others. Badges were obtained in an incremental process. Each badge had requirements that were specified by the minimum number of steps that needed to be walked by a beneficiary user, and the number of days a pair had used the system. Two intermediary participants mentioned how the badges and competition motivated them to do more with their mothers The living metaphors such as botanical gardens and fish tanks triggered social responses from some intermediary users. This phenomenon of computing systems ability to present social cues to environment that trigger social responses is discussed by Fogg [11]. For instance we asked one participant what was the size of fish in his tank and his response was as follows, *"They were medium sized because I wasn't really feeding them."* By feeding he meant recording of meals eaten by his beneficiary user. Although beneficiaries were not so much concerned with gamification still intermediaries shared that information with them as shown in the following excerpts.

> *"She saw the garden. The first day she saw just the house and brownish [Desert]. She is like 'What is this'. I told her. She said 'Aha! [Expressing dissatisfaction]. It must look green and healthy'. And then she saw the garden again and said 'It is looking good.' "*
>
> —***Lulama**, an intermediary*

> *"She doesn't understand the app. I just tell her that people are having ones twos threes and she laughs."*
>
> —***Lwazi**, an intermediary*

The above findings suggest that gamification resulted into a positive user experience on intermediaries and it had more value and meaning to them compared to beneficiary users. Most beneficiaries didn't understand the meaning of gamification functionality but upon proximate translation of output by intermediaries there were positive responses

6.3 Perceived Benefits from our BCSS

There were reported perceived benefits by beneficiary participants. For instance, the process of recording meals led to cognitive dissonance in one participant. Cognitive dissonance is where by an individual discovers that their beliefs are not consistent to their actions. Oinas-Kukkonen et al [26] discussed cognitive consistency as one of the key issues behind persuasive systems. People want their beliefs to be consistent with their actions. If there is an inconsistency, then it is likely for them to become motivated to change their attitude or behavior in order to restore that consistency.

> *"I think I like a bit everything about the app especially with food because I used to eat McDonalds. So I have to think of what I am going to eat first. I will think that I am eating big portions of carbohydrates and small portions of fruits. So now I have to balance, I have to eat fruits more than carbohydrates. With me it helps because now I can drink more water. I can eat more fruits than I used to."*
>
> —***Ndileka**, a beneficiary*

Cognitive dissonance is achieved through self-monitoring as users see discrepancy between their beliefs and their actions. The purpose of self-monitoring is to trigger individuals' consciousness to modifying their behaviour. This consciousness is fostered through behaviour recording and observation. Self-monitoring is a very important aspect in cognitive behavior therapy. Health self-management programs usually ask participants to keep records of their activities, physiological variables and other health-related data; personal informatics systems can make this process simpler and easier. [21] Some participants became more aware of their eating and walking patterns. For instance one participant described that she would always try to avoid people's lifts on her way to the bus station so that she can walk more steps. If she stays at home for the whole day then she would make an effort to go to nearby shops just to buy airtime so that she can have some steps in her pedometer.

In other cases intermediary users explained how their beneficiary users were controlling their eating habits as the result of interacting with information derived from the app. For instance the meal chart from the app helped **Nokhanyo** to reflect whether she was consuming meals that could trigger the spike of her blood sugar level i.e carbohydrates.

> *She [Nokhanyo] knows that 'I am eating too much sugar. Let me lower my sugar by 500 calories in a week.' Yah it helps her that way. And she is diabetic. So when she tests herself she sees that she ate too much of something so she knows that she has to lower it. There is a chart. There is a plate. She looks at the plate and says that 'I have eaten enough veggies but I need to eat more of this'. She doesn't eat meat that much.*
>
> —***Lulama**, an intermediary*

> *It [The app] was really good because my mother was limiting herself on stuff like pies and fat food. I would tell her don't eat this don't eat that. She wasn't eating much vegetables but I was encouraging her to eat vegetables*
>
> —***Lwazi**, an intermediary*

The application had a persuasive effect on beneficiary participants who engaged with it, hence there is a feasibility for beneficiary user to derive value from the information presented by a BCSS in our context. Without intermediaries some beneficiaries were not going to perceive the benefits of our BCSS as their consumption of information relied on intermediaries.

7. DISCUSSION

This work was developed based on existing literature of PHI and BCSS which is dominated by research from the West. Our idea was to test if a PHI works by laveraging existing intermediated technology use. As we found out during contextual enquiry, intermediated technology use was common among aged participants. So the approach attempted to utilize what already exists but this time in the context of PHI.

Our findings uncover social dynamics that are important in understanding how intermediated interactions can be leveraged to foster utilization of behavior change support systems within family settings. The two important factors to consider are (1) social rapport between an intermediary and a beneficiary as a requirement for persuasion; and (2) differences in motivation strategies between intermediaries and beneficiaries, we refer to this as parallel persuasion. We discuss these two factors in details below.

Social Relationship on Engagement with a BCSS

The motivation strategies may work provided that an intermediary and a beneficiary user have a prior social relationship. A prior social relationship makes intermediaries to value the interaction as more meaningful. One of the benefits of intermediaries valuing the interaction process as meaningful is that; we can capitalize on intermediaries to play a role of persuaders for health behavior change. We observed this phenomenon in pairs where an intermediary and a beneficiary had a prior social relationship.

> *Sometimes she (Lulama) used to shout at me. 'No no you didn't eat that thing. Tell me what you ate in the morning. I saw you eating this. It seems there is nothing for fruits, peanuts. You must remind me to check you!'*
>
> —***Nokhanyo**(a beneficiary user)*

> *I would tell her don't eat this don't eat that. She wasn't eating much vegetables but I was encouraging her to eat vegetables.*
>
> —***Lwazi**(an intermediary user), a 14 years old male from Langa*

This is an example of how intermediaries with a prior social rapport can nudge their beneficiaries to walk more steps or eat healthy. Intermediary users can become a source of intent to persuade. In the work by Fogg [10] mentioned in [26], intentions to persuade can come from three sources and these are; from the people who create or produce interactive technology; from people who give access to or distribute the interactive technology to others for which in our case could be intermediary users; and the people themselves who use or adopt an interactive technology. The approach of using people supported by technology to persuade other people is not new in the context of ICTD work. As we have seen in a study in India that equipped health care workers with mobile phones of which they could access persuasive messages and use them to persuade women on maternal health issues [29, 30]. Our approach is more innate as intermediaries and beneficiaries meet in natural settings and it can be more feasible of where persuasion is an ongoing process. Therefore, prior social rapport is one the prerequisites in laveraging intermediaries in utilization of a BCSS.

Parallel Persuasion

Prior social rapport it self may not be sufficient for sustainability of engagement. Motivation strategies are needed in conjunction with a prior social rapport. Affective persuasion strategies are important in sustainability of engagement with a BCSS. Unlike existing persuasion problems of where we design for one user; persuasion in our context is more complex as it involves both intermediary and beneficiary users. Despite of existing relationships between intermediary and beneficiary users, intermediaries, may not always be willing to help regularly and this might discourage beneficiaries and hence discontinue usage of a BCSS. Kiesler et al. [18] found out that some parents became hesitant to seek informal help from their children after they had encountered negative experiences. We encountered this phenomenon during both contextual enquiry, and preliminary interviews before evaluation II. Some of our participants shared these negative experiences. For instance one participant mentioned that sometimes it is difficult to seek help on using cellphone because their kids are sometimes annoyed when they are constantly asked to help especially if it the same task from last time. Therefore, it is important to minimize negative experiences of beneficiaries by increasing engagement of intermediaries.

We have the task of persuading intermediaries to share information with beneficiaries, and we also have the task of persuading beneficiaries to change their health behaviors. From our findings, we see how persuasion strategies

between intermediaries and beneficiaries differ. For a beneficiary, the weight is more on perceived value of the information on health benefits and informal social comparison with other beneficiaries from the same community. Intermediaries put value on game design elements and social comparison is within the context of gamification. This suggests that persuasive strategies between intermediaries and beneficiaries differ. In our context, intermediaries were young and most of them had experiences in games. A previous study on application of gamification on product advertising[4] found out that a prior gaming experience predicts higher purchasing intentions. However there is a caveat in utilization of gamification among young people. A study by Koivisto and Hamari[19] found that the usage of a gamified system is highly affected by the novelty effect and this is more apparent on younger users compared to the old ones. As time passes by younger users tend to get bored with a gamified service. Also ease of use of gamification tends to decline with age [19] with young users reporting systems to be easier use compared to their older counterparts.

In addition, we have seen from above that intermediaries can introduce an intent to persuade apart from these informal social comparisons. The persuasion strategy to be used by each set of user can be examined during analysis of persuasion context as suggested in PSD [25] and BCSS [26] models. This will determine of whether the persuasive functionality is for intermediaries layer or is for beneficiaries' layer.To engage beneficiaries we can support direct activity and diet comparison among beneficiaries through the app but implementation of this needs to address issues of privacy. An application can be configured with privacy settings to allow aggregated information of beneficiaries to be kept private or shared with other teams. The aggregated information that is shared by different intermediaries can be clustered in a bar chart to facilitate social comparison. With gamification strategies on intermediaries, and direct comparison by intermediaries we can have persuasion strategies to cater for the two sets of users.

8. CONCLUSIONS

We have explored the extent to which we can leverage on intermediaries within family settings to support utilization of behavior change support systems(BCSSs) for health. We presented the social dynamics that one needs to consider when designing a BCSS for health in the context of intermediated interactions. We also discussed how persuasive functionality might work considering the fact that we have two layers of persuasion. Our findings suggest that it is feasible to take advantage of intermediated interactions to support utilization of ICTs in health behavior change interventions.

This study has limitations in generalizations as we generated our insights based on fewer iterations of evaluations. A larger ethnography study is needed in understanding the contextual dynamics of an intermediated BCSS in detail. Secondly, it is not known to what extent gamification mediated the intrinsic motivation of both intermediaries and beneficiaries. In our current work we are carrying out a control study to evaluate the extent to which gamification has an impact on intrinsic motivation of both intermediaries and beneficiaries. We seek to understand if intermediaries' intrinsic motivation to assist in self-monitoring can be enhanced by gamification as well as an intrinsic motivation of beneficiaries in engaging in self-monitoring of health. We are comparing two systems; one with gamification; and another one without gamification.

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