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Not Missing a Step: South Africans Taking Control of their Personal Wellbeing using Wearable Health Devices

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Background and Purpose: Globally, the number of people living with chronic diseases is increasing, with unhealthy lifestyles as major contributing factor. Although the benefits of preventive healthcare is documented, majority of policy makers spend only a fraction of their health budgets on preventive healthcare. There is growing evidence that increasing physical activity contributes to improved personal wellbeing and reduce chances of developing chronic diseases. Consequently, awareness of the importance of good personal wellbeing is increasing. Heightened health-consciousness has also brought along growth in wearable health device market. This study investigated the role of wearable health devices in preventive healthcare and promotion of personal wellbeing.
Methods: We employed the interpretive research paradigm to understand the role of wearable health devices in preventive healthcare and the promotion of personal wellbeing, from users' perspectives. Data was collected through a one-on-one, semi-structured interviews with 30 participants who currently own and use a wearable health device and/or a mobile fitness-tracking application.
Results: Study results showed that the use of wearable health devices can motivate users to increase their physical activity and maintain healthy lifestyle, thus promoting personal wellbeing.
Conclusions: The use of wearable health devices/mobile fitness-tracking applications play significant role in promoting personal wellbeing. Different kinds of rewards by health insurers also provide additional incentives for users to reach their monthly fitness goals. A shift towards primary preventive healthcare, where citizens are encouraged to increase their physical activity, can go a long way in reducing the high rate of chronic diseases.

Keywords: Fitness tracker, Physical activity, Preventive healthcare, Wearable health device.

1 Background and Purpose of Study

Incidence of chronic diseases, such diabetes and hypertension is on the rise across the globe primarily due to unhealthy lifestyles. This has contributed immensely to high costs of healthcare service delivery [1, 2]. As a rule of thumb, prevention is better than cure [3]. However, healthcare systems across the globe have mainly focused on curative healthcare services by providing treatment for disease conditions. Despite the fact that preventive healthcare benefits are broadly recognized, existing health systems invest only a portion of their health budgets on disease prevention initiatives [4].

Preventive healthcare involves steps taken to prevent illnesses, as opposed to treatment of disease conditions [5]. Preventive care can be classified into primary, secondary and tertiary prevention [5]. The focus of primary preventive care is on the promotion of personal wellbeing by preventing or reducing the chances of disease conditions developing. This can be achieved by maintaining healthy lifestyles, the consumption of healthy food, increasing physical activity, and so on [5]. Secondary preventive healthcare entails early detection of disease before the symptoms of the disease appears through regular screening and the treatment of such disease when it is still asymptomatic to prevent the progression of the disease. Tertiary preventive healthcare on the other hand involves the treatment of disease when symptoms are evident so as to avert complications or premature death [5]. The focus of the study reported on in this paper is primary preventive healthcare. There is growing evidence that increasing physical activity has

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paper is primary preventive healthcare. There is growing evidence that increasing physical activity has benefits in preventive healthcare and the promotion of personal wellbeing [6, 7]. Consequently, many people are becoming health conscious due to a growing awareness in preventive healthcare [8].

Associated with heightened health awareness, we have seen an explosive growth in the development and adoption of wearable health devices for monitoring physical activity [9]. Many organizations are also taking advantage of the potential benefits of using wearable health devices in the workplace as part of their employee wellness programs [10].

Globally, research focusing on the application of ubiquitous computing in the healthcare sector, termed "u-health", is on the rise. In South Africa specifically, the focus of u-health research has mainly been on applications and devices that support remote monitoring of elderly patients and the treatment of chronic diseases (for example, see [11, 12]). To address the gap in studies that focus on the use of u-health for preventive healthcare, we investigated the role wearable health devices in primary preventive healthcare and the promotion of personal wellbeing, from the perspectives of users. The research questions for the study were:

- What role can wearable health devices play in preventive healthcare and the promotion of personal wellbeing?
- In what ways do wearable health devices support users in maintaining healthy lifestyles?
- What are the perceived challenges of wearable health devices from users' perspectives?

The structure of the remaining sections of the paper is as follows: Section 2 gives a summary of literatures that are relevant to this study, while section 3 contains the materials and methods. The research results is in section 4. Finally, the discussion and conclusion is presented in section 5.

2 Related literature

In this section, we summarize the literatures that are relevant to this study. This includes an overview of mechanisms that are used in wearable fitness-tracking devices and the features that are provided in them. The section also gives a brief insight into the concept of self-quantification and its role in preventive healthcare. Finally, the benefits and challenges associated with wearable health devices are discussed.

2.1 Overview of wearable health devices

The term 'wearable' implies that such device is worn on the person's body (e.g. the wrist) or clothing. Wearable health devices are non-invasive devices that support monitoring and recording of physiological data, such as, heart rate, sleeping pattern, the level of physical activity, blood sugar levels, and so on [13]. In general, wearable health devices that monitor physical activity uses one or a combination of the following mechanisms:

- **Pedometers**: Pedometers are lightweight devices worn on various body parts to measure the number of steps taken or the distance covered by the wearer [14]. A pedometer is a useful self-monitoring and feedback tool for increasing physical activity and maintaining a healthy lifestyle [15]. One of the limitations of pedometers is their inability to measure energy being exerted accurately [16, 17]. In addition, the steps taken during a physical activity, such as for example cycling, can be inaccurate [16]. The significant growth in the penetration of mobile technology across the globe has seen an upsurge in the development of mobile applications (apps) in general and health apps in particular [18]. Of particular relevance to this study is pedometer apps that count the number of steps taken. Many of these apps are available for downloads on Android and Apple platforms free of charge. Examples of popular pedometer apps include Samsung Health, Google Fit, and Argus. Compared to dedicated wearable health devices which are generally expensive, pedometer apps could be a cheaper alternative for self-monitoring of physical activity particularly for citizens in low- and middle-income countries (LMICs). Many African countries are classified as LMIC by the World Bank [19].
- **Accelerometers:** Accelerometers are tiny wearable devices, worn on the waist, hip or thigh that measures sudden increases in speed in order to determine the amount of energy being expended [14]. Accelerometers work by detecting movement across three planes (side-to-side, up-and-down, or forward-and-backward) [20]. One of the shortcomings of accelerometers is their inability to measure steps taken in physical activities like cycling accurately [16, 20].

 J Health Inform Afr. 2019;6(2):11-18. DOI: 10.12856/JHIA-2019-v6-i2-224

- **Heart rate monitor:** Heart rate monitoring provides physiological indication of physical activity and the amount of energy being expended. This is based on the assumption that there is a direct correlation between heart rate and energy being exerted [17]. The accuracy of heart rate monitors can be influenced by factors that have nothing to do with the amount of energy being exerted. These factors include body temperature, weight, muscle mass, effect of medications, stress level, and so on [17]. Heart rate monitoring device can be combined with activity tracking mechanisms like pedometers or accelerometers.
- **Multi-sensor devices:** As the name suggests, multi-sensor devices combine multiple sensors attached on different body parts to enable a more accurate measurement of physical activity and energy being exerted [21]. Because multi-sensor devices monitor many factors at the same time (for example, heart rate, respiration, galvanic skin response, steps taken, and so forth) the accuracy of physical activity and energy being exerted is much better, compared to devices with single sensors like accelerometer [17, 21]. Weaknesses of multi-sensor devices include high cost and complex data processing [17].
- **Global positioning system (GPS):** GPS is a navigation system that can support the monitoring of physical activity. The use of wearable GPS devices for monitoring physical activity is advantageous in that it is capable of detecting the location and duration of physical activity. GPS devices are useful for monitoring outdoor physical activity due to their ability to detect and estimate the position of the wearer, accurate measurement of ground slopes, as well as the speed and distance covered [22].

2.2 Features of wearable health devices

Many of the consumer wearable health devices (for example, Apple Watch, Fitbit Charge, Garmin Vivoactive, Huawei Band Pro, Samsung Gear Fit Pro, and so on) have a range of features that enable individuals to take ownership of their personal wellbeing. These devices also come with mobile phone apps that enable users to keep track of their health and fitness activities over a period. Wearable health devices combine various techniques and strategies, including persuasion, feedback, reward, social influence, and gamification to promote positive health habits [23]. This section gives an overview of common features on wearable health devices for promoting personal wellbeing.

- **Goal setting:** Consumer wearable health devices allow users to set up personal fitness goals. Simply stated, goal setting involves providing a detailed plan of health and fitness activities, including their frequency, duration, and how to achieve the goal [24]. Goal setting is an important aspect of starting or maintaining health and fitness activities. On purchasing a new wearable health device, the owner is prompted to set up goals for daily steps, food and water consumption, weight loss, and so on [25].
- **Self-monitoring:** Wearable health devices are capable of collecting data about a user's physical activity as well as physiological data like heart and pulse rates, body temperature, blood sugar level, calories burnt, and body fat percentage, to keep track of health and fitness activities [26].
- **Performance measurement:** Wearable health devices allow users to keep track of, or count the amount of physical activity they do. Different aspects of physical activity, such as the number of steps taken, distance covered, activity duration and frequency, as well as biological data (such as, heart and pulse rates, body temperature, calories burnt, and the amount of weight lost/gained) can be measured automatically using wearable health devices [27]. For example, an associated app on a mobile phone can keep track of physical activity data over a period of time and compare the data with set goals, and compare a week's activities with the previous week's performance. Alternatively, manually tracking this type of data could be difficult, if not impossible.
- **Personalized feedback:** Feedback involves the provision of data on recorded health and fitness activities. This may include assessment of health and fitness activity against specific goals [24]. To ensure successful change in behaviour, it is important to provide relevant feedback to users. Feedback from wearable health devices and/or associated mobile phone apps can be text, tactile, or graphic. Receiving feedback about their health and fitness activity can motivate users to improve so they can attain their goals [23]. In their study on the effect of feedback on physical activity behaviour and awareness, Van Hoye et al. [28] postulate that participants that received some form of feedback will be more likely to increase their physical activity outcome than those who did not receive any form of feedback.
- **Rewards:** Another technique that is often used to promote positive health habits using wearable health device is by providing some form of reward [23]. Rewards for meeting a set target can be monetary or non-monetary (for example, vibration, sound, and images). Studies have shown that offering rewards

 J Health Inform Afr. 2019;6(2):11-18. DOI: 10.12856/JHIA-2019-v6-i2-224

can motivate people to increase their physical activity [29, 30]. However, Patel et al. [30] found that monetary reward that is framed as a loss can be more effective in motivating users to increase their physical activity. Health insurers often use monetary and non-monetary rewards to motivate their members to increase their physical activity [31]. One example of this kind of reward is the Discovery Vitality Active reward programme in South Africa, where members earn Vitality points that can be used to purchase goods and services at discounted rates at the company's partner organizations [32].

- **Virtual fitness trainers:** A virtual fitness trainer is often implemented in mobile fitness apps by incorporating the knowledge, motivation and monitoring capabilities of a personal fitness coach to encourage users to engage in physical activity [33]. Virtual fitness trainers can discover a user's strengths and weaknesses, set up an appropriate exercise plan, motivate, and assist the user to reach her/his goal [34]. Mobile apps like Nike's NRC, Endomondo, and Runtastic can be used as a stand-alone virtual fitness trainer or may be integrated with compatible wearable health device.

2.3 The role of self-quantification in preventive healthcare

The "Quantified self" is becoming a new catchphrase in the consumer wearable health device environment. Quantified self refers to continuous self-tracking of different kinds of data. This can be about physical activities, biological metrics, dietary intake, behavioural, psychological or environmental data [35]. In addition to data acquisition, users can act on the data [8, 35].

Wearable health device has the potential to motivate individuals to track and improve on their daily physical activity. For example, alerts can remind users that they have been inactive for a while and need to engage in physical activity [36]. Self-quantification is set to become the future of personalized healthcare, where individuals assume personal responsibility for their health and wellbeing [37].

One of the benefits of self-tracking is the fact that the vast amount of data generated can be used for research purposes. Furthermore, the data can enhance clinical decision making [37]. However, self-quantification is not without shortcomings. One of the criticism of self-tracking relates to lack of concrete guidance to inexperienced users on how to interpret and use the enormous data that is collected in a meaningful way. For example, Rapp and Cena [38] found that their study participants lost interest in self-tracking due to difficulty in wading through, and interpreting the large amount of data generated.

2.4 Benefits and challenges of consumer wearable health devices

In this section, we summarize the benefits and challenges of consumer wearable health devices for preventive healthcare and promotion of personal wellbeing.

As stated in section 2.2, wearable health devices enable individuals to take personal control of their wellbeing. With the aid of a wearable health technology, it is easier to keep track of physical activity and biological data automatically. Wearable health devices have the potential to help users improve their physical activity and adopt healthy behaviour [23]. Through features like goal setting, performance monitoring and personalized feedback, individuals can set up fitness goals that meet their needs, track activities against set goals, and adjust their targets as required [23, 26]. The virtual fitness trainer feature in mobile apps, often linked to a wearable health device, is capable of mimicking a personal fitness coach or trainer by showing users the correct body movements for specific exercise [33]. The benefits of virtual coach include the ability to demonstrate the correct body movements for a given exercise, targeted exercise suggestions based on a user's requirements, and motivating the user to follow a fitness program [39]. This feature is particularly beneficial in the South African context, where many people do not have the financial means to use the services of a professional fitness trainer.

Despite the highlighted benefits, wearable health devices are not without drawbacks. One of the challenges relates to privacy and security concerns [40]. Data collected by wearable health devices is often transmitted to cloud storage by means of the associated mobile app. This data is at risk of unauthorized access by people with malicious intent on the device itself, whilst the data is in transit and /or on cloud storage [41].

Health data is arguably more personal than biographical data like name, date of birth, or telephone number. The move towards self-quantification and automatic collection of health data, such as, weight, blood glucose level, calorie consumption, body fat percentage, and so on, could have negative impact if this data is linked to the owner of the data positively [41]. For example, intercepted data could be used for

 J Health Inform Afr. 2019;6(2):11-18. DOI: 10.12856/JHIA-2019-v6-i2-224

blackmail purposes. Another concern relates to manufacturers of these devices using data collected from multitude of users for purposes other than which users explicitly gave their consent [27].

3 Materials and methods

This study employed the interpretive research paradigm to understand the role of wearable health devices in preventive healthcare and the promotion of personal wellbeing, from users' perspectives. Data was collected through a one-on-one, semi-structured interviews. An important participation inclusion criterion was that potential study participants should be using a wearable health device and / or a mobile fitness-tracking app at the time of data collection. We employed a non-probabilistic, snowball sampling technique [42], where we started with three people that met our inclusion criterion to participate in the study. We then requested these participants to refer us to other people that could participate in the study. In total, 30 people participated (21 females and nine males). Each interview session lasted approximately 30 minutes. The interview sessions consisted of closed and open-ended questions. Due to page number limitation, the interview questions is not included in this paper.

Our higher education institution (HEI) granted ethical approval for the research. We explained the purpose of the study to participants and participation was voluntary. All participants signed an informed consent form as there was no identifiable risk present in them participation in the study.

4 Results

4.1 Ownership and usage of wearable health devices and / or mobile fitness apps

As stated in section 3, 30 people participated in the study. Of the 30 participants, 15 own and use a wearable health device, another 15 use one or more mobile fitness-tracking app(s), while 10 use a wearable health device and an accompanying mobile health app. Wearable health devices owned by participants include Apple Smart Watch (three people), Fitbit Charge 2 (five), Garmin device (four), Polar H10 heart rate sensor (two), and Samsung Gear S2 (one). With regard to mobile fitness-tracking apps, five participants use the Huawei Health app, four use Samsung SHealth with another four using Nike NCR app, a participant uses Google Fit app while another participant uses the Runtastic app.

Fourteen participants use their wearable health device / mobile fitness-tracking app every day, while the remaining 16 do so at least three times per week. The mean ownership duration was 20 months; one participant had been using her wearable health device for 60 months, while the shortest usage period was three months. Study participants engaged in different types of physical activities, including walking, aerobics, running, workouts at the gym, cycling, and racing. We asked participant about the types of information they got from their wearable health device and / or fitness-tracking apps. Their responses included the number of steps taken, distance covered, calories burnt, and reminders. Participants also used their mobile health apps to record their heart rates, water and food intake, and sleeping patterns.

4.2 Usage of wearable health device and / or mobile fitness apps to support healthy lifestyles

We asked study participants to share with us the ways in which their wearable health device and / or fitness-tracking apps support them to track their physical activity and maintain healthy lifestyles. The responses from participants showed that all participants were of the view that the use of wearable health device and / or a fitness-tracking app is a vital tool to their journey to healthy behaviours and disease prevention. For instance, one of the participants said, *"it motivates me, I can see how far I ran the previous day and can improve on that"*. Another participant remarked, *"For me, this is a psychological boost. When I look at my mobile app and see my workout results, I feel good"*. Yet for another respondent, *"It helps me to know when I am slacking and improve on my running activities and motivates me to be more active"*.

Eleven participants indicated that they get incentives from their medical aid by linking their wearable device to their health insurance profiles so that their physical activity is automatically tracked. A participant said, *"It keeps me focus and motivated through data records and link to Discovery Health Vitality rewards"*. Another participant remarked, *"I have certain number of active days, on average four*

 J Health Inform Afr. 2019;6(2):11-18. DOI: 10.12856/JHIA-2019-v6-i2-224

days per week. My active days amount to ten thousand steps then I get discount from my medical insurance". The use of wearable health device and / or fitness tracking apps played an important role in enabling participants that are Discovery Vitality members to reach their goals by reminding them when they are not active and providing tips on how many steps should be taken per day in order to reach weekly goals. Some of the study participants also stated that they made use of the virtual coach feature on their fitness-tracking apps. The virtual coach suggests the number of kilometres to run per day, the type of workouts to engage in, and the time intervals between workouts. Responses from two participants are quoted verbatim as follows:

"Sometimes ago when I started running I wanted to be a sprinter like Caster Semenya and I got injured. Thereafter, the app guides me on the number of minutes to run per kilometre to avoid injury".

"You can sprint and injure yourself after which you cannot run for three weeks, but with the app you get guided on how you should conduct yourself".

The preceding discussions showed that the use of wearable health device and / or a fitness-tracking app enabled respondents to be active participants in maintaining their personal wellbeing, thereby supporting the goal of preventive healthcare.

4.3 Challenges related to the use of wearable health device and / or mobile fitness apps

Participants were asked about the kind of challenges they encountered with their wearable health device / fitness-tracking apps. One of the challenges identified by participants was high data cost. Participants stated that there were times when they would abandon a planned workout simply because they do not have the funds to purchase data for their mobile phones. Without data, they could not connect to the internet to log their workouts. Some fitness tracking apps require users to connect to the internet in order for it to track physical activity automatically. This sometimes demotivates these participants, especially the ones that get incentives from their health insurers for meeting specific fitness targets. Participants' responses about high data costs was unexpected. In the last few years, many South Africans have raised concern about high data costs. This has result in campaigns like #datamustfall.

Two participants raised concern about the accuracy of data collected by their mobile fitness-tracking apps. They indicated that in some instances, the data was not the same as the one on Discovery Health's system, which could lead to increase in monthly health insurance premium. One participant expressed his concern thus, *"I worry that the information I log on my app but it did not log on Discovery will increase my monthly premiums because Discovery checks your BMI to ensure that you are not overweight or obese".* The second participant noted "*you find that you run a long distance and when you check the log on the device or app it gives you a different number*"

Another concern raised by a majority of participants relates to safety and security of their health information. Some of the safety and security issues raised by participants include the following: *"I worry and wonder about the information collected by my device and app, people are very silly, when sharing the information from the app you would share the location where you jog, which might not be safe for people you don't even know in real life"*; *"I wonder whether people will not use the information I log against me"*; and *"sometimes it has virus and it does not function well*". Participants' concerns on the accuracy, safety and security of data collected by wearable health devices and mobile fitness-tracking apps mirror the ones reported in the literature. As stated in section 2.4, health data are vulnerable to unauthorized access on the wearable device, during transmission and on cloud storage.

5 Discussion and conclusion

In this study, we investigated the role of wearable health devices and fitness-tracking apps in preventive healthcare and the promotion of personal wellbeing. Wearable fitness-tracking devices and mobile health apps can motivate users to improve their physical activity. Using automatic reminders, users can increase physical activity when they have been inactive for a specific time. Users can track the number of steps they have taken, distance covered, calories burnt, monitor heart rate and blood pressure, as well as food and water intake. Abnormal physiological data can be detected and medical help can be sought before it is too late. The different features implemented in fitness-tracking devices and / or mobile health apps support study participants in reaching and maintaining their personal fitness goals. The use of

 J Health Inform Afr. 2019;6(2):11-18. DOI: 10.12856/JHIA-2019-v6-i2-224

rewards by health insurers also provided additional incentives for participants to reach their monthly fitness goals. All study participants were unanimous in their view that using wearable health devices and / or fitness-tracking apps have had positive influence on their lifestyles and health behaviours. However, some of the concerns highlighted by participants included high data cost, discrepancies in data collected by wearable health devices and fitness-tracking apps, as well as safety and security of health data.

The results reported in this paper has implications for health policy makers. The majority of health policy makers across the globe, including South Africa, spend a significant amount of their health budget on curative healthcare. Chronic diseases form part of the quadruple burden of diseases that weigh heavily on the South African healthcare system. One of the contributing factors to high incidence of chronic disease is unhealthy lifestyles. Although the budget allocations to healthcare increases annually, the health outcomes are not commensurate with budget allocations. A shift towards primary preventive healthcare, where citizens are encouraged to increase their physical activity can go a long way in halting the high rate of chronic disease. The use of wearable fitness-trackers and apps can motivate citizens to adopt and maintain healthy lifestyles.

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