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<https://www.usenix.org/conference/soups2019/presentation/alqhatani>

**This paper is included in the Proceedings of the
Fifteenth Symposium on Usable Privacy and Security.**

August 12–13, 2019 • Santa Clara, CA, USA

ISBN 978-1-939133-05-2

**Open access to the Proceedings of the
Fifteenth Symposium on Usable Privacy
and Security is sponsored by USENIX.**

“There is nothing that I need to keep secret”: Sharing Practices and Concerns of Wearable Fitness Data

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Abstract

There has been increasing use of commercial wearable devices for tracking fitness-related activities in the past few years. These devices sense and collect a variety of personal health and fitness data, which can be shared by users with different audiences. Yet, little is known about users’ practices for sharing information collected by these devices, and the concerns they have when disclosing this information across a variety of platforms. In this study, we conducted 30 semi-structured interviews with wearable fitness device users to understand their sharing intentions and practices, and to examine what they do to manage their privacy. We describe a set of common goals for sharing health and fitness information, which then influence users’ choices of the recipients and the specific practices they employ to share that information. Our findings indicate that participants were primarily concerned about acceptable norms and self-presentation rather than the sensitivity of the information. Our results provide a set of common goals and practices which can inspire new applications and help improve existing platforms for sharing sensed fitness information.

1. Introduction

Wearable sensing devices for health and fitness tracking have become ubiquitous. Researchers anticipate that fitness devices, including smart watches, will continue to lead the wearables market in future years [18]. Such devices provide users a variety of personal sensed data, such as step count, exercise, vital signs, and sleep quality. By using these metrics, users can become aware of their activity, thus improving their healthy practices. For instance, individuals who are overweight can use accelerometers to increase their daily steps and burn more calories. People can also utilize the features within fitness trackers to monitor some medical conditions (e.g. diabetes).

Sharing health and fitness information has also become an important part of many users’ practices towards achieving their health and fitness goals. Thus, most wearable devices today have also social features that allow users to share their information and interact with different people and organizations. Some devices like Fitbit have built-in social circles where users can talk about their exercises, goals, and progress. Alternatively, users can broadcast their wearable fitness data on external health and fitness apps (e.g. Strava & RunKeeper), via common communication applications (e.g. WhatsApp), or over popular social media applications (e.g. Facebook & Twitter). In addition, users may share data with insurers or through workplace campaigns to receive rewards to further incentive healthy behaviors. Individuals may utilize several different platforms, and more than one communication channel, and switch between them to share their information online [30].

Researchers have primarily examined fitness device data sharing on social media platforms [17, 21, 24, 25] and in the workplace [3, 7, 8], revealing a range of common reasons and outcomes for sharing. Others have investigated privacy implications and concerns, including the sensitivity of various information and the lack of understanding of fitness trackers’ data practices [22, 27]. We expand upon this work by investigating users’ practices across the range of sharing that they perform. Thus, we examine both aspects of social privacy – how users disclose and interact with other people around their shared data, as well as data privacy issues that arise when they provide their data to additional organizations. As Contextual Integrity theory posits, information sharing is governed by the norms and expectations of the context, and privacy problems occur when those expectations are violated [19]. Thus, we examine those expectations to provide insight into the privacy concerns and needs of users of wearable fitness trackers.

More specifically, contextual integrity predicts that sharing preferences of people may vary based on the receiver, the information type, and transmission principle. Thus, our original goals were to examine how the design of the devices and sharing platforms, the sensitivity of certain kinds of data, and the availability of controls influence users’ disclosure behaviors and privacy concerns. However, we found that participants’ behaviors had less to do with such factors than with their sharing goals and the associated audiences

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USENIX Symposium on Usable Privacy and Security (SOUPS) 2019, August 11 -- 13, 2019, Santa Clara, CA, USA.

related to those goals. Thus, our study contributes a set of common sharing patterns, relating goals, audiences, and specific practices of participants as part of understanding users' privacy decision making and behaviors.

Specifically, we report on a qualitative study with 30 existing users of wearable fitness trackers, who have shared their information with different audiences, in order to understand their sharing practices and behaviors. Our results indicate that users' concerns about disclosing wearable fitness information are about self-presentation goals and acceptable behaviors of sharing with people on different platforms, rather than concerns over the sensitivity of data.

The contributions of our work are:

- We enhance the understanding of the sharing of wearable fitness data across the range of platforms and audiences of users.
- We provide a set of common patterns of sharing goals, audiences, and practices.
- We provide insights about users' perceptions regarding their disclosure decisions and privacy perceptions, and present implications for researchers and designers to help users share their information as desired.

2. Related Work

A number of studies have examined technologies for tracking and sharing fitness data, prior to the widespread adoption of wearable sensing devices. Such studies found that users appreciated the social aspects of sharing data within online communities and social media, and doing so encouraged them to pursue a healthy lifestyle [20, 25]. Such social interaction can provide accountability, advice, and emotional support for individuals' health and fitness goals [25]. However, users sometimes had trouble determining what to share, and with whom [15, 17]. In addition, users struggled to find desired sharing features on various platforms [15].

The introduction of wearable fitness trackers has contributed to widespread tracking and sharing of fitness information. Today, many modern wearable fitness devices have socially embedded features that allow users to share data with other people. One study found that half of their participants utilized social features of their devices to support their fitness activities [6]. Thus, a number of researchers have examined users' motivations and behaviors of sharing fitness tracker data on different platforms and within different domains [8, 9, 11, 21, 24, 31], as well as users' privacy concerns and the privacy implications of sharing this information [4, 7], which we discuss in more detail below.

2.1 Wearable Fitness Data Sharing

Multiple studies have explored the opportunities of sharing wearable fitness data with people online, primarily on social media sites [9, 11, 21, 24, 31]. Studies reveal that users' motivations for sharing include increasing motivation through accountability, finding social support, and competing with others, all in support of a user's health or fitness goals [5, 11]. Indeed, studies have linked social sharing and competing with an increased intention to exercise [31]. Some users were also motivated to share in order to help and connect with others with similar goals; however, finding the right community that satisfies sharing needs can be challenging [6].

For example, Gui et al. performed a qualitative study of a fitness plugin for the Chinese social networking service WeChat [9]. Participants preferred utilizing their existing network of social contacts, and sharing fitness data as part of their regular social networking practices. Users found increased opportunities for interaction with others who also shared their fitness information. Participants also reflected on the impressions that can be inferred by others as a result of such sharing. However, sharing using such social features may lack emotional support, or can be less effective when sharing with unknown contacts [9].

A similar study by Dong et al. focused on the Chinese site Weibo [5], and found that users shared data from the wearable sensing device Mi Band primarily to record their life and motivate oneself. In comparing users' motivations for posting on Weibo versus WeChat, their findings also provide evidence that people have different motivations for sharing on different social network sites, based on the different audiences found on different sites [9]. As a result, people may integrate different social platforms into their communication practices in order to reach a broader audience to meet their intended goals [30].

Finally, several studies have investigated sharing data from activity-sensing devices within workplace settings in order to promote physical activity [3, 7, 8]. Employees often perceive workplace tracking and sharing programs to be beneficial to their goals [3]. Financial incentives were also seen as beneficial, and could be a motivator for participation [3]. Employees generally do not feel that step count is sensitive data and are willing to share with their workplace and colleagues; however, perceptions can change over time as people gain an understanding of how details of their personal lives and activities are reflected in just a step count [7]. Employees may feel pressure to explain low step counts or change their activities to fulfill team goals, and require additional negotiation of personal boundaries with colleagues [7]. People are also concerned that undesirable decisions can be made based on the wearable fitness data they share with their employers [4].

Thus, research has so far examined the sharing of wearable fitness data primarily on social media, or within the workplace, examining users' goals and perceptions. We expand upon this work by broadening our focus to all forms of sharing, to investigate more general patterns and factors that influence users' sharing decisions.

2.2 Privacy Concerns

Collecting and sharing health related data raises several privacy risks [29]. Researchers have examined the contextual nature of sensed data, both from wearables and a variety of IoT devices. Users' comfort in sharing information obviously depends greatly on the type of information, the recipient, and the reason and benefits for sharing [16, 23]. Several studies have found that users of wearable sensing devices do not find movement data such as step count as sensitive [10, 14], and thus people are willing to share such information with many different audiences. Weight and sleep are considered more sensitive, depending on the audience [12, 23]. The primary privacy concern is with locational information captured by devices with GPS. Users fear that location data shared on social media applications can be used by strangers, or even criminals, to know where they live [10, 14].

In a survey study, Lowens et al. [13] revealed two other privacy concerns about sensed fitness data: unintended use and lack of control of personal information. For instance, users are concerned that a health insurance company could get access to their fitness data and adjust their coverage's rate accordingly [13]. Users also expressed a strong desire to retain control and ownership over their data.

In many countries, regulations protect the collection, storage, and sharing of health-related data. Yet, it is unclear how the data from wearable tracking devices is covered by those regulations [1]. For example, Paul and Irvine [22] analyzed the privacy policies of four popular wearable fitness companies. They found that some of these services did not comply with existing privacy regulations regarding informing users about the use of health-related data. In recent work, Vitak et al. found that users of fitness trackers have limited knowledge of the data practices of fitness devices' manufacturers [27].

Thus, while research has highlighted several concerns of users over sharing certain information, we seek to understand more about the privacy-related decisions and practices of long-term users of wearable fitness trackers, and how those decisions are related to users' motivations for disclosing personal sensed data.

3. Methodology

3.1 Interview Study

We conducted 30 semi-structured interviews with wearable fitness users (15 males and 15 females) to examine their sharing and privacy preferences. As our focus is on the sharing of fitness information, we restricted participation to people who have a wearable fitness device for at least three months and who have shared their information recorded by the device with other people or organizations. Participants were first prompted to fill out an online screening survey. We then contacted the participants who met our criteria to schedule an interview. All the interviews except one were conducted remotely on the phone, over Skype, or Google Hangout. Interviews lasted on average 25 minutes, and ranged from 14 to 43 minutes. Study participants were all compensated with a \$10 Amazon gift card for their time after completing each interview.

The interview questions were structured into three parts. The first part discussed the general usage of the wearable fitness devices by participants. We asked the participants how frequently they use their devices, and how and when they check their sensed data. In the second part, we focused on the users' practices and behaviors with respect to the sharing of their data. For example, participants were asked how they share their information, what information they share and with whom, and what platforms they utilize. Some participants were uncertain about their profiles, so we requested they go through their accounts to answer the previous questions. This was followed by questions about the participants' sharing practices, and the impact of sharing on their behaviors and use of their devices. In the last part, we asked the interviewees about their privacy concerns and how they manage their privacy. Participants mentioned different scenarios regarding how their information could be misused, and expressed several sharing and privacy needs. The full interview is listed in the Appendix.

3.2 Participants

Interview participants were recruited between April and June 2018. We recruited participants by posting flyers at fitness centers near our university campus, and by advertising on relevant Reddit forums. Our methods of recruitment allow us to have participants from diverse age groups and professions. The average age of our participants was 32 years old, ranging from 20 to 51. Educational backgrounds of the interviewees ranged from high school to doctorate. Table 1 reports the demographics of our participants along with the devices they have.

	Gen-der	Age	Occupation	Device(s)
P1	M	38	Software developer	Nokia
P2	M	29	Physician	Apple Watch
P3	M	34	Software Engineer	Garmin
P4	M	39	Designer	Apple Watch
P5	M	44	Self-Employed	Apple Watch
P6	M	47	Risk Manager	Apple Watch
P7	F	29	Food Services	Apple Watch
P8	F	28	Designer	OMbra
P9	M	38	Fire Fighter	Garmin
P10	M	51	Computer Engineer	Garmin; Fitbit
P11	F	25	Gerontology Researcher	Apple Watch
P12	F	27	Event Rentals	Jawbone
P13	M	47	Finance	Apple Watch
P14	F	31	Marketing	Jawbone
P15	M	32	Product Manager	Fitbit
P16	F	35	Student	Fitbit
P17	F	35	GIS Manager	Fitbit
P18	M	35	Self-Employed	Apple Watch
P19	F	22	Student	Fitbit
P20	F	26	HR Manager	Fitbit
P21	F	27	Student	Fitbit
P22	F	26	Student	Fitbit
P23	F	32	Teacher	Fitbit
P24	F	25	IT	Apple Watch
P25	M	27	Sales	Apple Watch
P26	F	20	Student	Polar M600; Polar H10
P27	M	27	Software Administrator	Garmin
P28	M	48	Journalist	Jawbone
P29	M	25	Student	Nokia
P30	F	25	IT project Manager	Motiv Ring

Table 1: Summary of the Participants' Information.

3.3 Data Analysis

All interviews were audio-recorded and transcribed. We utilized an open coding approach using a qualitative data analysis tool to identify patterns from the participants' responses. Initially, three researchers analyzed three transcripts to develop a codebook, with discussions occurring between the researchers during this process. Coding saturation was met after coding these three transcripts, after which no more codes were added. The developed codebook consists of 26 codes. Each code was conceptually assigned to one of three categories: usage, sharing, or privacy. Then, the primary investigator and another researcher independently coded the remaining 27 transcripts using that codebook. The two coders kept track of their disagreements and the calculated inter-rater agreement was 80%. The remaining disagreements were discussed and resolved by the two coders. We note that any numbers reported in the results are not

meant as quantitative analysis, but merely to indicate prevalence of themes in our sample of participants.

3.4 IRB Approval

To ensure the protection of human subjects, prior to the start of this study, our university Institutional Review Board (IRB) approved this study as an exempt protocol.

3.5 Limitations

Our study has limitations similar to many qualitative interview studies: a convenience sample of limited size that may not be generalizable to the broader population of users. The inclusion criteria for participation in our study required at least three months of device usage, which may not be enough to assess the sharing behaviors of the participants. Also, while we attempted to recruit users from diverse ages and professions and balanced participants with respect to gender, we did not consider their cultural backgrounds which may influence participants' views on sharing and privacy. Finally, in focusing on the broad range of participants' self-reported behaviors, interviewees may have neglected to report detailed or accurate sharing behaviors.

4. Results

Our participants utilize a variety of wearable health and fitness devices that have different sensors to track movements and vital signs (Table 1). The devices used in the study come in different form factors that include smart watch, chest strap, smart bra, and smart ring. Apple Watch is the most common device used by participants, followed by Fitbit. These two are the top-selling brands in the last two years [2]. A few participants have shared information from more than one wearable fitness device, but we excluded devices that have been used for less than three months. It is also noteworthy that Jawbone had gone out of business a few days before we completed our interviews. We begin with a general discussion related to participants' use and perspectives regarding their devices, before moving into more detail about sharing and privacy aspects.

4.1 Use: Motivations & Contexts

Participants reported several goals for using wearable health and fitness devices. Tracking physical activity, mainly step count, as well as being aware of general health were the primary reasons for use by all participants. Many of our interviewees have sedentary jobs, and they used the devices as a reminder to move. In addition, people make use of wearable fitness trackers to motivate themselves to exercise and to stay accountable. Aside from fitness tracking, a considerable number of participants reported using the devices for medical reasons, such as for recovery after surgery:

"I had back surgery in October, so I use it as a tool to make sure that I am maintaining my recovery from my surgery" (P11).

For many participants, the impact of using a device is measured by whether or not goals are attained or behaviors have changed. For example, four interviewees who wanted to lose body weight expressed positive attitudes toward the device because it supports them by tracking how many calories they consume and how many pounds they lose every week. Other participants used a wearable tracker to monitor vital signs, such as heart rate, or to track sleep quality. For instance, P22 has sleep apnea and she uses a Fitbit to assist her in detecting the problem. Unlike human beings, a wearable device provides unemotional facts about one's health status. P10 stated: *"The device is sort of truth because humanly you can say I have an active day, I have a busy day. In actual fact you were busy on your desk, whereas the fitness device is unemotional. It's unaware of how you're feeling. It's only aware of your physical movement."* In contrast, two participants did not find their wearable trackers to be helpful in achieving their fitness goals. For example, P6 believed that the device did not change his behavior, and he did not find features like badges and rewards within the device to be encouraging. Another participant indicated that the device was motivating when he first bought it but that impact has diminished over time, especially after his best friend who he used to exercise and share information with moved away. In general, the majority of participants were pleased about their wearable trackers and they stated several benefits that they received from their use.

We asked participants why they decided to use the device they have rather than a different device. As expected, Apple Watch was preferred due to its variety of metrics as well as its capability to integrate fitness tracking with other features, such as sending text messages and taking phone calls. Two participants who had Jawbone liked its design that encourages users to keep active by achieving scores. Other devices were chosen for other goals, such as heart rate monitoring. We also found that a single device may not fulfill some users' needs; as a result, they incorporate more than one device into their practice. For example, P26 reported using a smart watch to track her runs and to map routes during soccer games, as well as a chest strap to track heart rate. Similarly, P10 uses one device for running analytics and another one for general health data monitoring. While the wearable devices used by participants have different measurements, all have sensors to capture steps taken.

Participants also expressed different contexts for use. Most of the participants mentioned that they use their wearable tracker at all times even while sleeping. Five interviewees indicated that they use their devices at certain times, mostly when they are exercising or during an activity such as bik-

ing. Users reported reviewing regularly, either after a particular activity or in the morning or night to check regular nightly or daily statistics.

4.2 Patterns of Goals & Audiences

Participants' goals for sharing wearable fitness data are similar to those reported in other studies, such as competing with peers, mutual support, and boasting [5, 11]. However, we expand on previous research by describing a set of common sharing goals, audiences, and practices. Overall, we found that users make decisions about their audiences based on their goals, which also drive their choices regarding the way they communicate their wearable fitness data. Table 2 summarizes the common goals we found in our study.

Participants' goals were related to their choices of audience to help them with those goals. Our analysis revealed six categories of audiences: friends, family, strangers, physicians, financial incentive programs, and co-workers.

Our participants shared their information with friends (25/30), family (17/30), or both (13/30). Eleven participants indicated that they shared with strangers, mainly through different health and fitness forums. Sharing wearable fitness data with physicians for medical tracking was mentioned by seven participants; while five interviewees have their devices connected with third party applications such as insurance companies and pharmacists in order to receive financial discounts or rewards. Finally, four participants identified co-workers with whom they share data. Participants disclose more or less information depending on the recipients and their goals, with practices specific to those goals and audiences. Again, Table 2 summarizes these practices and we now discuss the details of those patterns.

4.2.1 Friends

The majority of participants shared fitness data collected by wearable trackers with friends, often on social network sites. Accountability was mentioned as a strong motivation for sharing with friends. Participants also indicated that being able to see friends' activity progress and receive notifications about others' achievements encouraged them to pursue their fitness goals. Sharing can sometimes turn into competition and the desire to outperform each other by being the most active person in the day. Moreover, individuals may feel embarrassed if they failed to meet their fitness goals:

"It's kind of partially just a motivational thing but also partially... I guess you can say it's kind of shame like that you know they see if you haven't set or hit your goals." (P15).

Another goal that emerged from interviewees' responses for sharing wearable fitness data with friends was the intention

Goals	Targeted Audience	Practices
Accountability	Friends	<ul style="list-style-type: none"> • Share common sensed data only (e.g. step count). • Sharing mostly done on social media channels. • Share after good physical performance.
Competition		
Boasting a positive self-image		
Support family maintaining a healthy life-style	Family	<ul style="list-style-type: none"> • Disclose more information to family than to friends. • Simple ways to communicate wearable data outside of platform
Mutual & emotional encouragement	Unknown people (strangers)	<ul style="list-style-type: none"> • Share using device built-in social communities, or on social media communities • Share variety of non-identifiable information related to fitness goals
Feedback from experienced individuals		
Accountability		
Vital signs monitoring	Physicians	<ul style="list-style-type: none"> • Disclose everything accurately • Compile data manually, or show doctors data in the app.
Tracking medical conditions (e.g. sleep apnea)	Insurance companies; Pharmacist; Employers	<ul style="list-style-type: none"> • Wear the device continuously to maximize the metrics • Provide permission to incentive programs to access data directly on the device, or make sure to update data regularly.
Receive financial discounts/rewards		
Competition in the workplace	Co-workers	<ul style="list-style-type: none"> • Share step count only. • Set regular step goals and interact with others to achieve.

Table 2: Participants’ Goals & Practices Based on Audience.

to boast and communicate a positive image about one’s fitness and health. For a few people, accountability can only be met if other users acknowledge good physical performance.

However, sharing with peers for accountability may also impose challenges. A few participants, especially those who may not always have the time to exercise, expressed fears about friends’ judgements of their lack of activity. Two participants also did not like to share fitness information with friends on social media because it might be perceived as bragging. Another participant decided to stop sharing with Facebook friends, and instead limited the sharing to a few friends with similar interests on the device’s platform:

“I kind of started feeling a lot of pressure when I was sharing it because I thought like, oh well if I share on Facebook and I don’t share anything for a while, what everybody will think, or they gonna think that I stopped working out. And I think that for me this is on the perfect balance that I can share with my friends on the app and my friends on the app who are active can share with me” (P22).

Others faced concerns over the broad audience on social media platforms, and limited the data they shared accordingly. For example, P12 sometimes found sharing wearable fitness data inappropriate; she stated: *“Facebook friends include co-workers or professional contacts, and it just seemed weird to share my fitness activity with people that I work with or people that I have a contact with them for professional reasons.”* Several other participants chose to

not share with friends on social media channels because of perceived lack of interest of their friends on those platforms.

All participants who shared with friends reported sharing basic sensed data, such as step count and distance covered. None of those participants disclosed more personal information with friends, such as body weight, and the majority of the interviewees were unwilling to share their eating habits. In addition, other detailed health data, such as heart rate or blood pressure, were not shared because such data was considered less interesting to friends.

Participants mostly utilized the features within their devices’ apps to hook up their data in the trackers with their social media accounts. However, participants are selective on when and what to share in order to maintain a positive self-image. For example, instead of sharing on a regular or automated basis, they only shared data after positive physical performance.

4.2.2 Family

Another audience that many participants mentioned sharing with is those they are closest to, primarily family members (e.g. spouse) and occasionally very close friends. In this case, sharing was more about mutual and emotional encouragement. Participants expressed feeling responsible to share their information or any experience they had, whether good or bad, to motivate their loved ones towards a healthy lifestyle:

“We did have bad habits when it comes to food, and so I show them look at what happened when I was going

through depression on October. Look at how I was eating and look at my heart rate, and look at it right now. You know I share with them to show them, it is like you are family, you are just like I am” (P5).

P13 commented that he does not usually workout with his wife, but he liked the challenges and notification features generated by the device, which makes it feel as if they are exercising together. However, only three participants utilized features within devices to share data with family members or a few close contacts. The majority reported using simple techniques to communicate their sensed data. For example, they simply talk about their activity goals and progress or show family members steps count in their trackers. We believe this is because family members may not have the same device to connect directly with the user.

Family members are typically aware of each other’s health conditions; thus, it is not surprising that participants disclose more information to family than to friends. They reported feeling comfortable sharing personal information, such as weight or fitness goals, with family:

“If I share it with more people, I would have chosen which specific pieces of information but I will still share everything with my wife” (P13).

4.2.3 Strangers

More than one third of the participants shared wearable fitness data with unknown people, mainly on fitness forums. Some used the communities on the device’s platform, others found forums and groups on various social media sites, such as Reddit and Facebook. By sharing on these fitness forums, participants seek to receive help and feedback from experienced people (e.g. coaches) regarding specific fitness goals, such as weight loss. Holding oneself accountable was also a primary goal, through interacting with other people with similar interests and goals.

For example, P12 described herself as “conservative” with respect to sharing personal information. She used to share her fitness information with her friends on Facebook, but later felt uncomfortable because of a mismatch between her and her friends’ interests. This participant then joined a women’s fitness group on Facebook and restricted sharing to that group of strangers with similar interests. P22 also found a fitness group on Facebook and stated such sharing can be an opportunity to build relationships with others with similar goals. Another participant even reported that she is looking for a new device with better support for fitness communities, in order to connect with others with similar goals.

Unlike with friends, participants did report sharing body weight, calories consumed, and the type of food and exercise, in addition to step count. Participants expressed will-

ingness to share because they saw little harm that could come to them:

“I guess I share more even when I don’t reach my goals because I want to... I don’t know, because they are also on the same journey so I feel like it is for accountability and they are not going to use that information in a way that would negatively affect me.” (P12).

However, interviewees were unwilling to disclose data they saw as personal, such as location information, with unknown people due to safety concerns. A few also reported putting fake information in their accounts to protect their identities. In addition, they were less interested in sharing any sensed data that were considered irrelevant to their health or fitness goals.

4.2.4 Physicians

We were surprised by how many participants also shared their data with doctors or other caregivers. Participants’ intentions were to share vital signs with doctors, often due to medical conditions. For example, P22 had been working with her doctor to lose weight by sharing steps taken. In addition, she takes medicine that affects her heart rate functions and uses the device to monitor any heart rate abnormality. She also has sleep apnea and used the sleep logs feature to show her doctor her sleep quality. Another participant (P11) had back surgery and shared her data with physicians to keep track of her walking progress afterwards.

Participants indicated they were comfortable disclosing their data openly with doctors because it would be helpful to manage their health with accurate information. For instance, P18 stated: *“Generally, it made me more diligent in my recordings. I want to get things right if I am showing my doctor the information; it is accurate, and it is not misleading to my professionals.”*

Participants expressed frustration with the methods they utilize to communicate their wearable fitness data to physicians. All those participants, except one, reported that they manually record or copy data from the device’s website into files, take a screenshot of data, or show their doctors the data in the app. They expressed desire for a centralized control where wearable device data can be integrated with other health information systems such as Electronic Health Records (EHRs) to allow medical providers to directly access their data and interact with them more easily.

“I can’t just share the data directly with my doctor. I have to compile the data and then present a report to my doctor, and that can be frustrating and time consuming.” (P18).

4.2.5 Financial incentive programs

Our results reflect those reported in other studies (e.g. [3]) that users of wearable fitness devices may disclose their

sensed data in order to receive financial discounts or rewards. Interviewees found financial incentive programs to be a great motive to increase physical activity. Participants reported different recipients of their data for this goal, including insurance companies, employers, and pharmacists. Incentives can be received as prizes offered by an employer, or discounts on purchases and insurance rates. Participants update the data, mainly step count, on a regular basis through an employer's portal. Others provided permissions to incentives programs to pull the pedometer data automatically from their devices. In order to receive financial incentives, participants make sure to have their trackers on all the time to collect the data.

Two participants admitted that their primary goal for sharing was to receive financial incentives. P28 indicated that he connected his Jawbone to a pharmacy app in order to collect points based on the number of steps taken, which then can be redeemed as discounts on purchases. Similar to most of our participants, this user had no concern about sharing this type of data. He stated: *"The sharing with the pharmacy, there has been a very motivating financial affect, maybe 20 dollars every few months. It is free money, but I never been giving away something confidential. I was giving away the number of steps or my weight. There is nothing that I need to keep secret."* He repeatedly described the sharing experience on the device as a "game" where one tries to achieve high scores.

Another participant, P15, linked his Fitbit account to his employer health insurance portal. He considered himself healthy right now but was worried about the possibility of increasing his premium based on his fitness condition in the future.

Two other participants did not share their information for any financial incentives, but expressed a desire to share if they were offered this option:

"If it is something that gives me a discount, I will definitely share information with them. I probably will be more inclined to. It gives me another reason to be active to save money on my health insurance." (P25).

4.2.6 Co-workers

Finally, a few people identified co-workers with whom they disclosed wearable fitness information as part of participating in workplace health campaigns. Some organizations offer employees the option to link their trackers' data to the employer's website. For many of those participants, sharing with co-workers is a *"friendly competition,"* although prizes can sometimes be offered to further motivate participants. P3 stated: *"When I originally started wearing it's because of the competition. You don't wanna be at the bottom of the list of your co-workers so you wanna be more active."*

However, participants find sharing fitness data with workmates as an opportunity to increase physical activity, especially because some of these participants have jobs that restrict their physical movements during the day. It can also be an opportunity to reinforce behavior change, so moving and exercising become habits rather than merely competition. Participants set daily step goals and send cheers to other co-workers who hit their step goals. To compare data with other co-workers, participants sync their daily step count to the employer's system. Although some of the workmates may not personally be known, sharing the number of steps walked every day was not something they were concerned about.

4.3 Sharing Impact

We asked participants about their perspectives regarding sharing and how it impacts their behaviors. Most of the participants (19/30) said that sharing wearable fitness data has impacted them in a positive way. It helped participants to become more aware about their health and fitness status and encouraged them to stay competitive and accountable. Similar to [23], we found that users' sharing behaviors may change over time, especially with respect to the level of information shared. For example, one participant realized that she became willing to share more data in order to motivate herself to exercise:

"I would like to share more because I noticed that the more that I'm sharing with people that I feel comfortable with I guess or with people that are having the same goal, the more I feel I exercise more" (P12).

In contrast, another participant decided to share less information with the public, mainly because of privacy concerns:

"I actually think I share publically a lot less than I used to because I become more concerned with privacy, but I have been sharing more information with some of my private connections" (P18).

Five interviewees were uncertain about the impact of sharing. These participants indicated that sharing wearable fitness data has provided some benefits, such as the desire to exercise, but it did not help them to achieve desired goals. In addition, participants with mixed feelings indicated that the impact depends on the audience's reaction and feedback.

Another six participants stated that sharing did not impact their behaviors. Some of these interviewees commented that they are self-motivated, but they shared their wearable fitness data to help others and for enjoyment:

"I just enjoy sharing the information and posting the challenge to my followers to keep up" (P10).

Finally, much of the recent research focused on sharing wearable fitness data on popular social networking platforms. We asked participants about the impact of this sharing on their behaviors and goals. Our findings contradict those reported by Chung et al. that sharing wearable fitness information on popular social media can encourage physical movements [3]. In our study, the majority of the participants (9/14) who shared their sensed fitness data on common social network sites indicated that this sharing was not all that helpful, and some are no longer sharing on such platforms. Our participants reported several reasons that include lack of interest over time, lack of interest by audience to see this type of information, unclear impact on behaviors and goals, and privacy concerns regarding third party access to their data, especially if the data is shared on Facebook:

"I don't think it's impacted me that much on Facebook because it is just kind of a general, you know people post things on there and it doesn't have much of impact on me I think" (P14).

However, the Chung et al. study was based on an existing built-in feature within a Chinese social network for sharing fitness activities. Cultural norms and expectations may explain the difference between their findings and ours. Unfortunately, we did not have the data to examine these factors.

4.4 Privacy Concerns

Finally, we explored users' concerns and perspectives regarding privacy of sharing personal and sensed data related to fitness. The overwhelming perception is that most wearable fitness information, and in particular step count, is not sensitive. Thus, few had concerns over sharing this information with any audience:

"I wouldn't really care if someone knew how many steps I have taken" (P3).

"This is not really confidential private information. I mean in some sense it is, but it is not at the level of confidence or privacy that would make think oh I better not to share this" (P28).

Some of the participants indicated that they would probably be concerned if the disclosed data contains identifiable information, or if the device stores financial information:

"If it was something from... I don't know, you have to register your ring with your address and you have to have the credit card number in file, so something like that have my personal details that's not fitness related, then I would be concerned." (P30).

Rather, participants' biggest concerns centered around the ability to manage their self-image and to comply with social norms of sharing. Norms complicate users' decisions to share wearable fitness information in different ways. For

example, participants struggled to reconcile the desire to share with their contacts on different platforms (e.g. Facebook) and to conform to what is considered normal to share on those platforms. For instance, P18 commented about sharing his sensed data on Facebook: *"I'm not going to share my blood oxygenation level with friends or in public. That would be ridiculous."* In addition, participants avoid posting too much or too detailed information in order to not bore others: *"My family and friends will kind of get annoyed if I keep sharing constantly" (P5).*

Other participants felt uncomfortable sharing fitness information with the different kinds of contacts they may have on social media platforms, such as professional colleagues. Others worried that friends may perceive sharing fitness achievements as a way of showing off. These concerns led participants to share less on social network sites, and find other platforms for sharing with people with similar goals.

Therefore, maintaining a good self-image was important for interviewees and drove sharing decisions. Users wanted to communicate a positive image regarding their fitness life to other people. Thus, they reported being selective about the information they share, sharing positive achievements for example, rather than sharing generally and automatically. Participants also chose to not disclose information related to eating and sleeping because they think it might potentially impact how they are perceived by others

Some participants (9/30) did express minor concerns over unintended use of their data. This concern was also reported in several prior studies of wearable tracking devices [13, 14]. For example, interviewees were concerned that their health insurance company could get access to their data in the trackers and tie their insurance premiums to their fitness status. Others were concerned that the devices' companies could pass their data to third parties (e.g. sport or drug companies) without their awareness. A few participants also identified that people or organizations could infer personal facts based upon the data shared, and were thus careful about what identifiable information was shared with strangers or organizations.

Finally, there were some concerns related to information security and physical safety. For example, four participants discussed a security breach as a potential risk, resulting in their data being used outside of their intentions. In addition, the GPS feature was a concern reported by four people, indicating that it can be exploited by stalkers:

"It's pretty much just the location data that bothers me the most. I don't want people knowing where I am in case there is patterns." (P26).

We asked participants what they do to protect the privacy of their wearable health and fitness data. They reported spending little or no effort on privacy protection, beyond their

choices on what and when to share information. Many of the participants were unaware of their privacy settings; and those few people who were aware about their settings had not changed them since they started to use the service. We asked the participants to go over their profiles and settings if possible, and some discovered that their platform profile was indeed viewable by the public. The remaining participants stated that they changed their controls only once, and that was when they set up the device. Despite this, many participants complained about the lack of options available in the settings to adjust the desired level of privacy.

A few participants reported other ways they protected their information. Two interviewees indicated that they disclose only basic information on their profiles – as little as possible. Another user stated that he put in fake information when he created the account. Six other participants discussed using standard security mechanisms such as authentication. For example, P3 said: *“I have a user name and a password and I just use that in the Garmin to protect my data.”*

5. Discussion & Implications

Our results reveal a set of common patterns related to users’ sharing goals, their chosen audience, and the resulting choices participants make to disclose and manage their sensed information. Our results confirm previous findings of sharing on social media [5, 11], that users are motivated by accountability, advice, and competition when sharing sensed fitness information with other people, in pursuit of their individual fitness and health goals. Participants also reported helping and providing motivation and emotional support to others. An additional goal we have not previously seen is to track and improve health by sharing with physicians. Users expressed a willingness to share if that sharing was helping them meet their health and fitness goals, and reduced sharing if it was found to not help their goals. In other words, participants were consciously making the trade-off to share information for personal health or financial benefits.

Our results also provide useful insights into users’ privacy concerns and behaviors. We found that users’ practices have little to do with concerns over the sensitivity of the data. Rather, our study suggests that norms and self-presentation are two key concerns that drive users’ choices in what information to share, and with whom. Although research suggests that sharing fitness data on popular social network sites is promising to encourage physical activity (e.g. [9]), we argue that site norms can be a barrier and drive users to find other platforms. For example, users sometimes limit the information shared with their friends in order to manage the impressions of the many different contacts they have on social network sites. Many of our partici-

pants wanted to communicate a positive image about themselves by sharing only positive fitness achievements. Thus, those who were doing well with their fitness goals found social network sites as a valuable platform to share these achievements with a broad range of friends, but those who struggled with their goals found more support on platforms where they could connect either to friends or strangers with similar goals.

Examining participants’ perspectives regarding sensitivity of wearable fitness data reveals that, for the most part, this data is not perceived as sensitive. Users have a common fallacy that there is *“nothing that I need to keep secret.”* This perspective toward sensed fitness data has influenced many users to pay little attention to protect their data, even leaving their device platform profiles with default or public privacy settings. Even though some of our participants gave scenarios of how their information could be misused, they felt that the risk was far-fetched. Additionally, the fact that a device company has been in the market for many years has made users trust that their data is safe. However, incidents have demonstrated that wearable fitness data is valuable to criminals [26]. Research has also demonstrated that very sensitive information can be inferred from seemingly innocuous fitness data [22]. While most of our participants did understand that some information could be inferred from their data, they did not express concrete examples of such sensitive information, or feel that they were very susceptible to negative consequences as a result of such inferences.

Our results also suggest that financial incentives are a powerful motive for sharing, and the availability of various wearable fitness devices today has made sharing with different incentive programs (e.g. insurance companies, employers, pharmacies) much easier. This is evidenced by the considerable number of people in our study who disclosed their information to receive discounts or rewards. For a few, the incentive was the primary driver for sharing with such organizations, rather than being in support of a health or fitness goal. However, our findings suggest that concerns over secondary use of data may discourage users from sharing with such programs long term, or as their health or fitness levels decline. Many participants commented that health insurance companies could potentially utilize fitness trackers to adjust coverage plans, although this had not happened yet.

In the light of our findings, we offer several implications for designing wearable trackers that promote sharing and privacy of fitness-related information:

Design controls and sharing features around common goals and patterns. As we noted, users’ goals for sharing fitness information vary, and this may require sharing different levels of personal information in different ways. Yet

there are a number of common practices depending on those goals, and the associated platforms used. Thus, device platforms could ease this sharing by providing designs centered around these goals and practices. For example, sharing settings could be designed to allow users to have sharing profiles with different audiences. These settings could reflect common data sharing norms, while still allowing for customization of content depending on the goals. In addition, designers should provide visualization mechanisms to help sharers focus on their goals. For example, if a user's sharing goal is to lose weight, a summary of data for this goal such as calories consumed and distance traveled could be visualized in the interface for the intended audience.

Methods for sharing with physicians. Individuals who share their wearable fitness data with physicians expressed a strong desire to directly connect their self-tracking data with health providers in some way. Thus, there is currently an unmet need in how to provide full access to, and useful views of information for health providers. For example, sharing settings could be designed to enable users to provide permission to their personal medical provider to access their data using doctors email address, for example. Such support would reduce the burden of this important sharing, facilitate conversation prior to clinical visits, and encourage long term use and tracking of sensed data in support of health goals.

Awareness of sharing policies. Generally speaking, users do not consider most of their wearable fitness data to be harmful to them. Yet, they also do not appear to be very aware of device manufacturer's data practices, and how they share their information [27]. Device manufacturers should present their data policies to users on a regular basis (e.g. semiannually), remind users about their choices, and even explain the possible risks to enhance users' awareness. Wearable fitness companies can share users' data with different external parties, such as drug and sport companies. Yet few of our participants expressed concerns over this potential and how data may be shared without their explicit interaction. And while some users acknowledged the possibility of data inference, few expressed any concerns beyond the use of locational data. Additional research is needed to determine what organizational data practices most concern users, and how to increase the awareness over such practices.

Privacy Nudges. Many of our participants discussed how their sharing and perceptions had changed over time, as other studies have also pointed out [7, 23]. Thus, designers should seek solutions that are easy to modify over time. Users should be provided with opportunities to reflect on the audiences for their sharing, and how their sharing has changed. For example, as with other forms of social media sharing, nudges could prompt users to reflect on their audience as they share [28]. Nudges could also be designed

to remind users of how their information is being shared, and revisit controls over time.

6. Conclusion

We conducted a qualitative interview study, investigating the sharing goals, practices, and privacy concerns of 30 users of wearable fitness devices. Our findings reveal that decisions to disclose information to other people and organizations are primarily influenced by the goals people have when sharing with different audiences, and how well different device and sharing platforms can support those goals. Our results highlight the need for more privacy and sharing features centered around these patterns and the sharing norms on various platforms, to support users in their ultimate goals of improving and maintaining their health and fitness.

7. Acknowledgments

We thank the anonymous reviewers for their valuable comments. We also thank Zaina Al-Jallad, Wentao Guo, and Safat Siddiqui for helping in the coding process.

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Appendix

A. Screening Survey

Part 1:

1. Please select all the wearable devices you own:

- ☐ Fitbit
- ☐ Jawbone
- ☐ Misfit
- ☐ Polar
- ☐ Garmin
- ☐ None

☐ Other, please specify: _____

2. How long have you been using the device(s)?

- ☐ Less than three months
- ☐ More than three months

3. Have you ever shared your information recorded by the device(s) with others?

- ☐ Yes
- ☐ No

Part 2:

4. What is your first name?

5. What is your age?

- ☐ 18-20 year
- ☐ 21-30 year
- ☐ 31-40 year
- ☐ 41-50 year
- ☐ 51-60 year
- ☐ >60 year

6. What is your email address?

B. Interview Questions

Demographic Questions:

- What is your age?
- What is your gender?
- What is your level of education?
- What ethnicity do you identify with?
- What is your current occupation?

Questions related to the use of the wearable device:

1. List all the wearable health devices that you own?
2. (If more than one), which do you use most frequently?
3. Have you used any other devices before? Why?
4. What are your goals of using the device?
5. How frequently and when do you use the device?
6. How and when do you look at your data on the device?
7. How has using the device impacted you?
8. What is your overall impression/satisfaction about using the device?

Sharing preferences and behaviors:

9. Have you ever shared your information with other people on the device platform?
If yes:

- a. What information do you share and why?
 - b. With whom do you share this information?
 - c. Do they also share information with you?
 - d. How do you share the information (what context, how frequently, and when)?
 - e. How does the sharing impact your behavior and use of the device?
 - f. Does sharing your information on the device help you achieve your goals? How?
 - g. Has your sharing behavior changed over time?
10. Can you walk me through your profile? Show me what type of settings you have.
 11. Did you change the sharing controls in the interface at any point?
If yes:
 - a. Why?
 - b. Did you change it for a particular person or a group? Why?
 12. Did your choice of sharing recipients affect how you shared the recorded information?
If yes:
 - a. How?
 13. Did the sharing controls in the interface allow you to set your sharing preferences easily?
If no:
 - a. Why not?
 - b. What changes/omissions/additions would you suggest to make the interface more usable?
 - c. If it had been easier to change the privacy preferences, would you have shared differently? How?
 14. Have you ever shared your wearable fitness data on popular SNSs, such as Facebook?
If yes:
 - a. Which ones, how, and why?
 - b. With whom?
 - c. What types of information and how frequently?
 - d. Does anyone share such data with you as well?
 - e. How does sharing your information on the SNS(s) impact your behavior and use of the device?
 - f. Does sharing your information on SNS(s) help you achieve your goals? How?
 - g. Do the controls on the SNS help you to share and manage your information?
 - h. Do you have any preferences between platforms (i.e. a device platform or an SNS platform) to share your fitness information? Why?
 15. Do you have any other way of sharing your information, other than what we have discussed?
 16. In general, does the device's platform support your sharing preferences and goals?

Questions related to privacy:

17. What are your concerns regarding the privacy of your information on the device?
18. Have these concerns impacted your use of the device?

19. How do you manage your information on the device?
20. To what extent are you comfortable with the existing privacy settings?
21. Do you feel that you are sufficiently protected or do you desire more protections? What kinds of protection do you need?
22. How do you think your information could be misused?
23. Are you worried that your daily activities will be monitored by another person or party when you use the system?
24. Do you have any additional comments about the privacy and sharing of the device data?
25. Would you like to say anything else before we end the interview?