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Routine self-tracking of health: reasons, facilitating factors, and the potential impact on health management practices

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Abstract

Despite a growing interest in self-tracking of one's health, what factors lead to self-tracking routinely (i.e., collecting data at regular intervals), and the effects of this behavior, remain largely understudied. Using data from the Pew Survey on Tracking for Health, we examined the patterns of self-tracking activity to understand reasons for this behavior and its impact on health management practices. We tested multiple logistic regression models to assess the influence of different predicting variables, and to find whether routine self-tracking leads to positive change to one's approaches to health management. Our results suggest that recent visits to emergency care and the type(s) of tracking tools used are significant predictors of routine self-tracking activities. Further, the results suggest that routine self-tracking, as opposed to occasional, event-triggered tracking, is more likely to result in positive changes to health management approaches. Our findings also highlight barriers to and opportunities for designing useful and usable tools to facilitate self-tracking and empower patients to become more proactive in managing their own health.

Introduction

According to a 2012 Pew Research Center survey[1], 69% of U.S. adults use tracking to manage their health or that of a loved one. Self-tracking is defined as the practice of repeatedly recording information such as behaviors, thoughts, and feelings about oneself. It encompasses collecting data and reflecting on it in order to acquire knowledge or achieve a goal, such as behavior change[2]. Self-tracking health information has been practiced for several decades using methods such as pen and paper, or just memory[12]. This practice has recently gained increased attention with the popularity of mobile technology and its ability to facilitate recording health information[3]. Self-tracking with the use of modern technology, such as smartphones and wearable devices, has been the subject of several recent studies[8–11]. The practice of tracking and the knowledge that the data tracked may provide can bring awareness and support health behaviors, thus helping in improving quality of life[4]. It can also improve patient engagement in their own care, since it allows patients to play a more active role in their disease management by better understanding their health conditions and coping with treatment and communicating with providers[5,6]. Therefore, self-tracking is also expected to improve patient-provider communication[7].

Many self-tracking studies focus on tracking diet or exercise. These studies approach self-tracking either for preventative health management, for personal curiosity, or for learning and promoting a healthier lifestyle. For example, Miller and Mynatt[13] developed StepStream, a school-based pervasive social fitness system, to encourage adolescents to improve their attitudes and perceptions towards physical activities. In another study, Cordeiro et al.[14] analyzed the challenges people face when tracking food intake in order to explore opportunities to improve the support of diet tracking activities.

Other studies have approached self-tracking by focusing on its ability to assist in chronic disease management, since chronic illnesses usually require long-term treatment and management activities. The collection and reflection on the collected data can help people suffering from these conditions in their disease management by improving their knowledge about the illness, identifying triggers, and controlling health indicators such as glucose levels or blood pressure. Studies focusing on these aspects generally aim to control or mitigate symptoms and to prevent or delay disease progression. For example, Mamykina et al.[15] developed and performed a deployment study of MAHI (Mobile Access to Health Information), a distributed mobile application to assist newly diagnosed diabetes patients in learning about their condition. Other similar studies focused on cancer[16,17], heart conditions[8,18], irritable bowel syndrome[19,20], asthma[21,22], and many others.

Collecting, registering, and reflecting on the data are the most fundamental steps of self-tracking, and the frequency with which data is captured and recorded can vary. Approximately half of U.S. adults who self-track record their data

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routinely (e.g., every day or every two weeks), and half only track when they experience changes in their health[1]. Past work has found that routine tracking is important for reflection, which is a necessary step towards common goals of tracking (e.g., behavior change)[2], and included recommendations about how often to self-track[23,24]. Li et al. describe that reflection can happen in short and long term. The former happens in a short time after collection, and helps to make users aware of their current status. The latter happens days or weeks after collection and involves deeper self-reflection, allowing users to identify patterns by comparing information from different periods[2]. Through short term reflection, routine tracking can improve self-knowledge by providing more opportunities to reflect after collecting data. Routinely tracking is also important to long-term reflection, since missing data can limit users' ability to interpret and reflect on their data. Although routinely registering personal data could influence self-tracking practices, little is known about what leads users to self-track routinely, and what are the outcomes of doing so.

In this study, we examined predictors of routine self-tracking behavior and its effects on health management based on a reanalysis of the data collected by the *2012 Pew Survey on Tracking for Health*[1]. We conducted a quantitative analysis of the data using binomial logistic regressions to understand what leads to routine self-tracking behavior and how this behavior subsequently influences health management practices. The two main research questions that we aimed to address through this study are:

Research Question 1: What factors predict routine self-tracking behavior?
Research Question 2: Is routine self-tracking associated with improved health management practices?

The rest of the paper is organized as follows. First, we describe the methods used in the research. Then, we present the findings followed by the discussion. Finally we present the limitations of the study and conclusions.

Methods

The analyses reported in this paper were based on the Pew Survey on Tracking for Health conducted between August 7 and September 6, 2012[1]. The survey was administrated through phone interviews in both English and Spanish, and involved a total of 3,014 adults living in the United States. Among them, 55.6% were female. The median age was 53.

Data

Each survey began with questions about demographic information (e.g., age, income) and health status (e.g., health rating, chronic conditions, recent changes). Then, the survey asked questions specifically about self-tracking, such as whether the respondent tracked fitness-related information (weight, diet, or exercise) or other health indicators (e.g., blood pressure, glucose). The survey then asked the method(s) that the respondent used to do self-tracking, as well as its effects, such as whether self-tracking affected their approach to self-management, or whether it led them to ask questions to physicians. The full instrument of the survey is provided on the Pew Research Center website[25].

In this study, we included all survey questions pertinent to our research objectives. They are listed in Table 1. Because we are interested in the characteristics of the respondents who used self-tracking to manage their *own* health, in our analysis, we included only those who answered "yes" to one of the following two questions: *1)* whether they tracked their own weight, diet, or exercise routine (Q24); and *2)* whether they tracked other health indicators such as blood pressure, blood sugar, sleep patterns, and headaches (Q25). Participants who tracked health data for others (e.g. family members) but not for themselves were excluded from our sample. Those participants who tracked health data both for themselves and for others were included.

Our two research questions focus on Q27, which asks the respondents, with respect to "the health indicator you pay the MOST attention to," whether they self-track this indicator routinely, or if they collect data only when something comes up or changes (see Table 1). In this study, routine self-tracking is characterized by measuring and recording data continuously at regular intervals, such as daily or weekly. Those who do not track routinely might only record events when they experience a change in their health, or adopt a new habit. We refer to the first type of behavior as "routine self-tracking," and the second type as "occasional, event-triggered self-tracking."

Data analysis

To answer the first research question, *what factors predict routine self-tracking behavior*, we analyzed the responses to questions Q3 (health problems or conditions the respondent lives with), Q4 (major health events in the past 12 months,

Table 1: Survey questions used in the analysis.

	Question	**Options**
Q2	In general, how would you rate your own health - excellent, good, only fair, or poor?	1) Excellent 2) Good 3) Fair 4) Poor
Q3	Are you now living with any of the following health problems or conditions?	1) Diabetes or sugar diabetes 2) High blood pressure 3) Asthma, bronchitis, emphysema, or other lung conditions 4) Heart disease, heart failure or heart attack 5) Cancer 6) Any other chronic health problem or condition I haven't already mentioned
Q4	In the last 12 months, have you personally…	1) Faced a serious medical emergency or crisis? 2) Gone to the emergency room or been hospitalized unexpectedly? 3) Experienced any significant change in your physical health, such as gaining or losing a lot of weight, becoming pregnant, or quitting smoking?
Q24	Now thinking about your health overall…Do you currently keep track of your own weight, diet, or exercise routine, or is this not something you currently do?	1) Yes, keep track 2) No, not something R currently does
Q25	How about any other health indicators or symptoms? Do you happen to track your own blood pressure, blood sugar, sleep patterns, headaches, or any other indicator?	1) Yes 2) No
Q26	Thinking about the health indicator you pay the MOST attention to, either for yourself or someone else, how do you keep track of changes? Do you use…	1) Paper, like a notebook or journal 2) A computer program, like a spreadsheet 3) A website or other online tool 4) An app or other tool on your phone or mobile device 5) A medical device, like a glucose meter 6) Or do you keep track just in your head? 7) Other
Q27	How often do you update your records or notes about this health indicator? Do you do this on a regular basis, or only when something comes up or changes?	1) Regular basis 2) Only when something comes up or changes
Q28	Do you share these health tracking records or notes with anyone, either online or offline?	1) Yes 2) No
Q30	In which of the following ways, if any, has tracking this health indicator affected your own health care routine or the way you care for someone else?	1) Has it affected a decision about how to treat an illness or condition? 2) Has it changed your overall approach to maintaining your health or the health of someone you help take care of? 3) Has it led you to ask a doctor new questions, or to get a second opinion from another doctor?

such as an ER visit), Q26 (tools used to track the health indicator that the respondent pays the MOST attention to, such as a notebook or a computer program), and Q27 (routine tracking or occasional, event-triggered tracking). We hypothesize that whether an individual routinely tracks the health indicator that she or he pays the most attention to (Q27) is a function of the person's health conditions (Q3); major recent health events (Q4); and the tool(s) used (Q26).

To answer the second research question, *is routine self-tracking associated with improved health management practices*, we analyzed whether the tracking behavior—routine or occasional, event-triggered (Q27)—may predict responses to Q30. Possible responses to Q30 include: (1) whether self-tracking affected the respondent's decision(s) about how to treat an illness or condition; (2) whether it changed the respondent's overall approach to health management; and (3) whether it led to asking clinicians new questions, or to looking for second opinions. We hypothesize that routine tracking, as opposed to occasional, event-triggered tracking, will more likely lead to a positive response to one or more of the Q30 options. We were not able to analyze other aspects of health management, such as those that involve family members and caregivers, as the survey did not cover them.

In both models, we controlled for age, sex, socioeconomic indicators (education, ethnicity, and income), and overall perception of one's health (Q2: excellent, good, fair, or poor). In the second model, we also included the independent variables used in the first model (e.g., Q3 health conditions, and Q4 major recent health events) as control variables.

Table 2: Descriptive statistics for routine and event-based tracking.

	Routine	**Event-based**	**Total**
N	992	949	1941
Age*			
18-29	17.9%	24.7%	21.4%
30-49	30.2%	36.8%	33.5%
50-64	29.1%	21.6%	25.3%
65+	22.9%	17.0%	19.8%
Health rating			
excellent	27.1%	31.0%	29.1%
good	51.3%	51.2%	51.3%
fair	16.4%	14.2%	15.3%
poor	5.1%	3.3%	4.2%
Chronic illness			
diabetes*	18.5%	9.3%	13.8%
high blood pressure*	33.5%	25.1%	29.2%
lung diseases	14.1%	14.4%	14.3%
heart diseases	9.9%	8.0%	8.9%
cancer	3.7%	3.4%	3.6%
Events (12 months)			
emergency or crisis*	14.2%	10.5%	12.3%
ER visit*	22.0%	16.6%	19.2%
health change	21.2%	20.2%	20.7%
Type of tracking			
Fitness	91.3%	89.3%	90.3%
Other indicators*	57.0%	41.8%	49.2%
Tool used			
paper*	42.0%	30.3%	36.0%
program*	7.2%	3.5%	5.3%
website*	2.1%	0.9%	1.5%
app*	11.9%	5.0%	8.4%
medical device*	12.3%	4.6%	8.4%
memory*	37.6%	63.7%	51.0%
sharing*	37.7%	32.0%	34.8%
Health management			
changed decision*	38.4%	30.3%	34.2%
changed approach*	53.3%	41.3%	47.2%
asked new questions	41.0%	41.6%	41.3%

* $p<0.05$

Findings

Descriptive statistics

Among the 3,014 respondents surveyed, 1,941 (64%) reported that they performed some form of health-related self-tracking activities. These 1,941 respondents are hereafter referred to as "study population."

Table 2 describes the study population (N=1,941) dichotomized into two groups based on their self-tracking style (routine vs. event-triggered). Out of the 1,941 respondents in the study population, 992 were routine self-trackers; and 949 only tracked occasionally when triggered by events.

The mean age of the respondents in the routine group was 56 years; and for those in the event-triggered tracking group it was 50.7 years. Reported health rating was not significantly different between the two groups, but a higher proportion of the respondents who tracked their health routinely reported that their health was fair (16.4%) or poor (5.1%), and a smaller proportion as excellent (27.1%), compared to the event-triggered group (14.2%, 3.3%, and 31%, respectively). This result suggests that those respondents who perceived their health to be worse were more likely to engage in routine self-tracking activities, but the differences are not statistically significant.

Most respondents with diabetes or high blood pressure self-tracked routinely ($p<.001$). The difference was not significant for those with lung diseases (e.g., asthma, bronchitis, emphysema), heart disease (including heart failure and heart attack), and cancer. This difference may arise from health providers' recommendations for patients with these conditions to use self-tracking. Both the reduced effort required for tracking using home devices, such as glucose meters, and the recommendation given by health providers may encourage routine self-tracking practices.

Among those who experienced severe health events such as ER visits in the last 12 months, a larger proportion self-tracked routinely ($p<.05$). For other health changes, such as becoming pregnant, losing or gaining a lot of weight, or quitting smoking, the difference was not significant. Experiencing a health crisis, or seeking health care from an emergency department, constitute more severe health events in comparison with other health changes, thus severe health events might be more impactful for self-tracking practices.

While there was no significant difference between the event-based tracking and the routine tracking groups regarding fitness-related indicators and activities (Q24), a significantly larger proportion of those who track other health indicators (e.g., blood pressure, blood sugar, sleep patterns, and headaches - Q25) do so routinely ($p<.001$). Most respondents who shared data collected through self-tracking also tracked routinely ($p<.01$). In addition, the two groups differ significantly in their use of self-tracking tools. Most respondents who used pen and paper, computer programs, mobile apps, medical devices (e.g., blood pressure cuff) ($p<.001$) or websites ($p<.05$) self-tracked routinely. On the other hand, a larger proportion of those who only kept data in their memory (i.e., measuring but not registering the data) only self-tracked after a health related event ($p<.001$). It is possible that those who are more diligent about tracking are more likely to track routinely, register, and share their data. But registering and sharing data could also influence users to self-track routinely.

The number of respondents who claimed that tracking activities had affected any decision about a treatment or changed their approach concerning health management was significantly higher among the group who performs tracking routinely ($p<.001$). The third option, which asked whether tracking activities led respondents to ask new questions to health providers or to look for a second opinion, resulted in no significant difference between the two groups.

In summary, routine tracking was more common amongst those who tracked indicators not related to fitness, those who shared their data, and recorded their data on paper or on a digital system. Most respondents who reported that tracking had changed a decision about health, or changed their self-management approach, self-tracked routinely. Because these variables may correlate amongst one another, we used binomial logistic regressions to learn which were significant predictors of routine tracking practices, and to find whether routine tracking influenced reported effects of self-tracking on health management.

Model testing results

In this section, we present the results from the logistic regression models, which are reported in Table 3 and Table 4.

Research Question 1: What factors predict routine self-tracking behavior?

As shown in Table 3, the model results indicate that age ($p<0.01$), recent visit to the ER ($p<0.05$), and use of a majority of self-tracking tools are associated with a higher likelihood of adopting the routine tracking behavior. When the respondent relied on memory to do self-tracking, the chance that she or he would collect data routinely is significantly decreased ($p<0.05$). Gender, chronic conditions, and recent health crises or changes do not appear to have a significant effect.

These results indicate that, regardless of other conditions, the probability of routine self-tracking is higher for those who had recent ER visits and those who use technological tools. It is possible that people become more vigilant with their health after having a severe health event warranting a visit to the ER, which leads them to become more diligent in their tracking behavior; and that the use of technological tools such as websites and tracking apps facilitates this practice.

Research Question 2: Is routine self-tracking associated with improved health management practices?

Through three binominal logistic models, we tested whether the routine self-tracking behavior leads to better health management practices. The results are reported in Table 4. Because none of the control variables have a significant

effect, they are omitted from the table.

As shown in Table 4, as opposed to occasional, event-triggered tracking, those who self-track their health routinely have a significantly higher likelihood of changing their overall approach to maintaining health ($p<.01$). Further, routine tracking is negatively associated with asking new questions from doctors, or seeking second opinions. This result may be because this population, possibly through routine self-tracking, has become more knowledgeable about coping with their illnesses or conditions. Thus, they might have become less inclined to ask new questions or seek second opinions. Finally, we found no correlation between routine self-tracking and the likelihood of altering decisions on how to treat an illness or a condition.

Table 3: Model with "routine tracking" as a dependent variable

	p-value	**OR**	**95% CI**
Age (continous)**	0.001	1.01	(1.01-1.02)
Gender			
male	0.081	1.23	(0.98-1.54)
chronic illness			
diabetes	0.058	1.52	(0.99-2.35)
high blood pressure	0.483	0.90	(0.66-1.22)
lung disease	0.051	0.70	(0.49-1.00)
heart disease	0.135	0.70	(0.43-1.12)
cancer	0.393	1.33	(0.69-2.56)
Events (12 months)			
emergency cris	0.731	0.93	(0.60-1.42)
ER visit*	0.021	1.51	(1.07-2.15)
health change	0.979	1.00	(0.73-1.38)
Tool used			
paper	0.402	1.18	(0.80-1.75)
program*	0.021	1.96	(1.11-3.46)
website*	0.042	2.66	(1.04-6.80)
app**	0.000	2.86	(1.64-4.98)
med device*	0.011	2.05	(1.18-3.58)
memory*	0.023	0.62	(0.41-0.94)

* $p<0.05$; ** $p<0.001$

Discussion

In our analysis, we investigated if factors such as the person's health conditions, major recent health events, and the tool(s) used could predict routine self-tracking. We found that having had a recent emergency visit was the only significant health related predictor of routine self-tracking. This increased use of routine tracking practices may be motivated by a need to recover from the crisis, or manage continuing health outcomes resulting from the crisis by learning how to handle it or tracking symptoms. More routine tracking suggests that these people take the practice more seriously, or have a stronger reason to engage in it. This finding suggests that it might be worthwhile to investigate the use of self-tracking by patients who are discharged after a visit to an emergency or urgent unit, both to understand their current practices and to better support their health management after being discharged. It is likely that this demographic represents an opportunity for new technology that aims to support their needs.

The results also suggest that using electronic tools might help to increase routine tracking behavior. Those who used computer programs, websites, mobile applications, and medical devices were significantly more likely to routinely register their data, while those who only kept their measurements by memory were much less likely to use tracking routinely. Concerning the non-electronic tools approached by the survey, using only memory to track health indicators actually presented a negative correlation with routine tracking, while the results for pen and paper were not significant. Electronic tools for registering the tracked data, such as computer programs, websites, and mobile applications, might encourage routine tracking activities through the use of reminders, or features that encourage higher engagement or participation (e.g., social features, and game-like features such as medals and achievements). This finding indicates that, in cases wherein routine tracking is desired or important, users should seek to utilize electronic tools such as computer software or mobile applications to measure or record their data, and avoid keeping their data only by memory. It is also important to investigate the reason for this effect, to better understand what specific aspects of self-tracking tools offer support for tracking routinely.

We also investigated whether routinely self-tracking health indicators could be associated with improved health man-

Table 4: Model with health management effects as dependent variables.

	p-value	**OR**	**95% CI**
Affected a decision about how to treat an illness or condition	0.415	1.11	(0.86-1.44)
Changed your overall approach to maintaining your health	0.007	1.38	(1.1-1.74)
Led you to ask a doctor new questions, or to get a second opinion	0.007	0.71	(0.56-0.91)

agement practices. Our results suggest that people who track routinely might become more knowledgeable about their health, and, as a result, adapt their health management approach based on their experiences with tracking, asking less questions to their clinicians. This finding indicates that, in comparison with event-driven tracking, routine tracking might better support patients' self-efficacy and better assist them to improve their self-management skills. Because both self-efficacy and self-management skills are associated with improved health outcomes[26,27], these results indicate that routinely self-tracking could have a significant beneficial impact on users' health. While the data analyzed is self-reported and cannot lead to conclusions regarding causality, our results can provide enough evidence to motivate future studies on the effects of routine self-tracking that examine such outcomes in more depth. In particular, future studies should investigate different aspects of health management that are not covered in this analysis, such as the role of caregivers and health outcomes.

In summary, the study results indicate that routinely tracking health indicators can have a significant effect on people's approaches to their health management, and that might be caused by an increase in self-efficacy. Further, we have found that electronic tools used in tracking are very strong predictors of routine self-tracking, suggesting that they may encourage measuring and recording data at regular intervals. Lastly, we found that people who have had emergency visits to a hospital in the last 12 months are approximately 50% more likely to routinely track health indicators, suggesting that the process of recovery, or learning how to handle new health developments, are situations wherein tracking might be particularly important for patients.

At the same time that routine tracking might improve the results of health management, and it should be supported and encouraged by self-tracking technologies, different users might value routine tracking more than others. For instance, our results indicate that younger people, and those who have not visited the ER recently, are less likely to routinely self-track. In these cases a system that demands routinely tracking to present valuable results may not be desired by the users. These systems should support users' priorities and capabilities.

This study has several limitations. Because the survey collected self-reported data, it is not possible to attribute causal relationships based on its analysis. The data is likely subject to bias associated with this type of data collection (e.g., social desirability bias, selection bias, acquiescence, halo effect). Additionally, because respondents might track multiple variables using different methods, and the data does not differentiate between these cases, it is possible that these instances created noise in the results. Further, the data provide limited detail regarding health outcomes, the exact variables tracked by each respondent, and the different tools used. These characteristics limit the conclusions that can be drawn from analyses. Lastly, because the survey was conducted in 2012, the influence of technologies on self-tracking activities might have changed due to the increasing popularity of mobile devices, and to new technologies that might have become available since.

Conclusion

Through an analysis of data obtained from the Tracking for Health survey[1], we have investigated what health and demographic factors influence routine self-tracking practices, and how continuously measuring and recording data at regular intervals affects health management practices. Our results indicate that older people and those who have recently experienced a health emergency are significantly more likely to self-track routinely. Utilizing electronic self-tracking tools, such as smartphone applications, also increased the probability of routine tracking. Lastly, we found that those who routinely self-track are significantly more likely to report that tracking has influenced their health management practices.

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