Discovering Internet of Things (IoT) Applications for Health Monitoring During the Outbreak of Infectious Disease

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Abstract. This research aims to discover the Internet of Things (IoT) technologies and applications available for health monitoring during infectious disease outbreaks. Currently studies about IoT and health monitoring are reviewed to identify applications. Then we randomly selected 100 valuable comments from top five online shops’ using reports of Internet of things devices as the basis of the data analysis. Technology acceptance model (TAM) and familiarity and trust model (FTM1) were further conducted on these using reports to value why IoT technologies and applications is ‘perceived usefulness’ and ‘perceived ease of use’ used for health management. We found IoT applications are ready widely used in health management fields. There were significant positive advantages for ease of use. IoT applications were significant positive advantages for infectious disease symptom monitoring.

1. Introduction

Monitoring of health during an infectious disease outbreak is a worldwide problem [1], the problem of risk behavior management has emerged [2]. Effective use of IoT devices and applications to monitor changes in the body's state early can detect relevant health risks in a timely manner and adopt timely response strategies [3]. While some countries advocate early detection, early isolation, and early treatment of infectious disease response methods, IoT health monitoring equipment provides the possibility of early detection of health risks [4, 5]. Symptom detection and physical parameter analysis may have a positive effect on the control of infection.

IT applications may change personal health management during infectious disease outbreaks. They can detect early symptoms of patients early and allow patients to adopt a series of self-judgments at an early stage, thereby reducing the huge risk of problems being concealed [2, 3, 6, 7]. IoT and wearable applications provide methods for health monitoring [8]. The widespread use of these applications has greatly improved healthcare services [9]. They also have the potential to reduce health risk factors.

The Internet of Things is an application that has been widely used in the field of personal health detection [4]. The concept of the Internet of Things is to equip objects with sensing, networking and processing functions so that they can interact with each other and with services on the Internet to achieve some useful purposes [5]. Devices becoming elements in the IoT include: intelligence, connectivity, sensing, expression, energy, and security [3]. The IoT is the link that connects virtual and realized objects and it develops reliable solutions and provides effective services for people and the environment. [10]. The significance of the IoT health management applications are that it can connect to the network anytime and anywhere, transmit the physiological data to the relevant docking device, and discover the health risks in time.
Wearable devices that can be used to monitor physical activity and physiological data often use IoT technology [6]. These devices with embedded sensors can track, analyze and alert users to risky behaviors during outbreaks of infectious diseases [2]. Previously, different researchers have studied IoT/wearable technology for health monitoring. However, most of them only focus on a single application area or one type of IoT/wearable device [1-11]. Therefore, there is a lack of research on the IoT application of health risk behavior monitoring.

This pilot study aims at understanding and improving measurements of risk behaviors in Internet of things (IoT) applications. The research method is based on the application of the use report for the IoT. The purpose of this test is to determine the IoT application evaluation criteria used by the research team and to evaluate the consistency of the criteria used in the early stages of infectious disease outbreaks.

In order to provide an effective explanation of the research results, the following two questions will be answered:

• Effectively using IoT (perceived usefulness and perceived ease of use) for identifying health risk factors.
• Advantages and disadvantages for IoT applications deal with health risk behaviors managements.

2. Methods

2.1. Data source
We first conduct an overall analysis of published articles on IoT/wearable technology and its application in health monitoring. Then we randomly selected 100 valuable comments from top five online shops’ using reports of Internet of things devices as the basis of the data analysis. The keywords are ‘IoT’, and ‘physiological data’, or ‘health monitoring’.

2.2. Piloting text mining method
Internet of Things (IoT) applications and usage reports are text data that can be qualitatively analyzed. Technology acceptance model (TAM) and familiarity and trust model1 (FTM1) was further conducted on these using reports to value why IoT technologies and applications is ‘perceived usefulness’ and ‘perceived ease of use’ used for health risk management. We have developed an automatic text mining tool to extract the content of some IoT applications from the report in batches. Then perform "keyword search" and "manually read content" to map the content recorded in 100 randomly selected reports to the identified IoT applications. The analysis process is shown in Figure 1.

![Figure 1. Four steps to extract and analyze data.](image)

Five Internet of Things (IoT) application reports from different stores were selected for initial analysis to build measurement reports. Then we analyze the IoT application in units of each sentence to determine the reason for describing its expected IoT application.

The two groups of authors (three authors in each group) analyzed the sentences in section IoT applications and qualitative content analysis is used to analyze each report. They read each sentence
carefully to get the exact meaning. If a sentence has several meanings, the sentence is divided into
clauses and each clause contains only one meaning to ensure that they are all extracted. We try to
maintain the consistency of clause and parent sentence structure.

For example, ‘users expressed they don’t like wearable devices because they can’t acquires
physiological data’. This sentence is divided into: no function, improper function, no effectively
communication’ preferences. We try to maintain structure and wording throughout the analysis
process. After that, all authors and qualitative text data analysis experts check the validity of the
extracted statements. They compared the semantic consistency of the extracted sentences with the
original sentences in the IoT applications. If there are inconsistencies, the authors need to reach a
consensus.

To ensure reliability, the two groups of authors continued to perform the same task of extracting
statements from the remaining four case reports. A total of 22 sentences were extracted and entered
into the excel spreadsheet, and each sentence was assigned a unique ID. The agreement between the
two results was 61%. The disagreement was regarding the number of sub-sentences that a sentence
should be broken into and how it should be broken. They discussed each of the disagreed sentences
and came to a 100% agreement. The 22 sentences were finally broken into 53 sub-sentences.

2.3. Coding the content
A process of shortening each sentence while still preserving its meaning was conducted. This led to
the first-level codes. In the example about the people given above, a sub-sentence was shortened to
‘People stated IoT applications’ physiological data was appropriate.’

The first-level codes were then constantly compared and aggregated based on their meanings. This
led to the second-level codes. Taking the same approach, the second-level codes were grouped into
three big themes: perceived usefulness, perceived ease of use and inappropriate IoT applications. For
example, the ‘users’ uncomfortable was classified to the theme of IoT applications.

2.4. Constructing statements
The sub-sentences were constructed into four IoT applications measurement statements under the three
themes: 27 items in perceived usefulness, 21 items in perceived ease of use and five items in
inappropriate IoT applications. The 53 items in the process were related to 22 IoT applications in
sentences.

Mapping 100 reports to the measurement statements. We randomly selected 100 reports Internet of
things (IoT) applications for use in the mapping process. Figure 1 described the semantic mapping
process. We developed a keyword search list of the three major measurement statements. We also
developed an automatic tool to search keywords, extract information and export information in a text
document or excel spreadsheet.

For example, we identified all the sentences in Section IoT applications in these 100 case reports
that contained the keyword ‘health management’. Then we read the selected content manually to
examine if the sentence could be semantically mapped to the statement we intended to map. If a
statement is mapped, we recorded its presence as “1” for this audit report; otherwise, “0” is recorded.

After the mapping process, we analyzed the percentage of matching for each statement to achieve
the aim of examining the consistency of use of measurements by the assessment team.

3. Result

3.1. Extracted IoT applications statements
Three major IoT applications were identified(Figure 2). Three themes (monitoring of physical activities,
physiological data and health risk behaviors) were finally grouped into four categories: perceived
usefulness or not, perceived ease of use or not (Table 1).

The IoT applications expressed are ‘perceived usefulness’ which occurs in all 57 using reports and
‘failed in perceived usefulness’ (7 reports), ‘perceived ease of use’ (44 reports), and ‘failed in
perceived ease of use’ (6 reports). The IoT applications for monitoring health risk behaviors in the remaining reports were also recorded. They are ‘fall detection’ (4 reports) and ‘emergency call’ (3reports).

| No | Knowledge of IoT applications for health risk behaviors | Percentage |
|----|--------------------------------------------------------|-------------|
| 1  | Perceived usefulness= true                             | 57%         |
| 2  | Perceived usefulness= false                            | 6%          |
| 3  | perceived ease of use= true                            | 44%         |
| 4  | perceived ease of use= false                           | 7%          |

3.2. Discovering knowledge of IoT applications

Through data mapping and discovering knowledge (Figure 2), We found that as long as we use the health monitoring function of the IoT wearable devices, we can use the Internet of things devices to detect symptoms in the early stage of the spread of infectious diseases through timely detection of health risks. All using reports show that the function is invalid, the function is difficult to use, and the communication failure is the biggest problem at present. As long as the quality of the Internet of Things devices is reliable and the health risk factors can be sensed in a timely manner, the infected person can respond in a timely manner. Of course, the use of IoT equipment provides a new method for the management of infectious diseases in the early stage.

![Figure 2. IoT for health risk behaviors management.](image)

4. Discussion

Our preliminary research methodology is dedicated to identifying relevant content in Internet of things (IoT) applications. The semantic matching ability of the mapping method between sentences and measures needs to be further improved.

Our preliminary research found that the evaluation of IoT case reports includes concurrent and coordinated evaluations of health monitoring structures, processes, and IoT applications. The mapping results also show that the case report does not have all the measurement indicators. The IoT applications’ measurement was confined to two models (TAM and FTM1) that measured IoT for health monitoring.

The strength of this measurement can be improved based on the public evaluation function, use and uncomfortable health IoT application recommendations.
The limitation of the research at this stage is the lack of experts in related fields to review the research results. Future research will expand the scale of data to verify the research results.

5. Conclusion
As part of future large-scale research, the research methods tried in this research understand and improve IoT health metrics for health monitoring in IoT applications. We analyzed 100 IoT using reports published by website between 1 January 2021 and 1 April 2021. We found that the path of acceptance is the main field of IoT applications. The most reported measurement report in the summary report of the Internet of Things includes the monitored physiological activities, physiological data and health risk behaviors.

We suggest that IoT using reports also use objective measurements of IoT applications, rather than just using measurements that people call themselves IoT applications. This experimental study confirmed that the official publication IoT applications, through the semi-automated data analysis method, promotes qualitative data analysis. Research methods can be used to understand and improve health monitoring measurements to avoid IoT applications in the context of IoT.

Knowledge discovery methods need to continually improve the measurement and reporting usage reporting standards, we extract semantic matching between bottom-up networking applications from the associated object method. Further research will improve the research methods used in other health management fields.

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