# Using Technology to Identify Triggers for Chronic Conditions

Anne M. Faber
Indiana University
Department of Computer Science
Bloomington, Indiana
anmcleve@cs.indiana.edu

## ABSTRACT

Millions of people all over the world are currently suffering from chronic conditions. The Security for Ubiquitous Resources Group (SURG) lab is developing a toolkit that will help identify triggers for chronic health conditions. The toolkit will combine on-body sensors, nutrition monitoring, and experience sampling to record in-situ data from patients in order to determine what is causing or exacerbating their condition. While other projects have used these recording methods to gather health-related data, none have used all three together.

## Categories and Subject Descriptors

J.m [**Computer Applications**]: Miscellaneous

## 1. INTRODUCTION

Millions of people all over the world are currently suffering from chronic conditions. The prevalence of conditions like diabetes, allergies, migraines, and chronic pain is increasing year by year.[11] With any chronic condition, it is often difficult to determine what is causing it or what factors make it worse. Most often, doctors are limited to asking patients to recall what they did on a given day, how they felt emotionally, what they ate, and what symptoms they are experiencing. Sometimes, patients are asked to keep paper diaries to record their symptoms, food intake, and activities but the patients often do not keep up with the diary. [13].

Patients suffering from chronic conditions may also be asked to participate in diagnostic testing in a laboratory setting. Tests done in a laboratory might identify what is triggering a patient's symptoms but they might not. For example, a person suffering from chronic headaches might only experience symptoms when they have been sitting in front of a computer for a long time. This trigger, while not impossible to simulate in a laboratory, would be more easily discovered if the patient could be monitored at home instead.

The Security for Ubiquitous Resources Group (SURG) at Indiana University is working on a toolkit that will allow healthcare practitioners to monitor patients with chronic conditions in their daily lives. The toolkit will automatically collect data about patients as they go about their daily lives in order to help patients and healthcare workers identify triggers for chronic conditions. The next section gives a high-level overview of the toolkit and its various components.


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## 2. OVERVIEW

The toolkit will be designed with healthcare professionals and will consist of a PDA application, a desktop application, and the following recording methods:

- **personal monitoring sensors** to automatically record physiological data
- **nutrition monitoring** to easily record what the patient is eating on a day to day basis
- **experience sampling** to periodically prompt the patient for information relating to their daily activities

The three recording methods will be used together to create a rich dataset that can be used to help identify the trigger(s) for a chronic condition. After the patient has used the toolkit for a period of time to be determined by the healthcare professional, the healthcare professional can view and analyze the data on the desktop application. If, at that point, the trigger for the condition has not been determined then the healthcare professional can have the patient use the toolkit again, checking for different possible triggers. Below, each component of the toolkit is discussed in more detail and related work is reviewed.

### 2.1 Personal Monitoring Sensors

The first component of the tool consists of on-body sensors that automatically collect and wirelessly send patient data to a PDA. Sensors can be used to measure a variety of physiological conditions such as heart rate, body temperature, physical activity, and stress.[1] The toolkit will be versatile enough that healthcare workers can select which sensors they need to find the trigger for a particular condition. Several other projects which have made use of sensors for medical applications are discussed below.

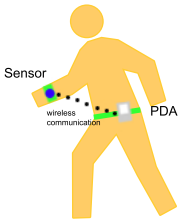


**Figure 1: Personal Monitoring Sensor**

### 2.1.1 *Wearable ECG Device*

Researchers at the University of Alabama in Huntsville created a prototype for a wearable electrocardiogram (ECG) monitoring device.[8] An ECG monitor records the electrical voltage in the heart and can be used to detect cardiovascular problems. Proactive monitoring could potentially prevent heart attacks because problems could be detected and treated before they endanger the patient.

The wearable ECG device prototype consists of a set of electrodes, an LCD Output device, a Compact Flash memory card, and a processor board. ECG readings are stored on the Compact Flash memory card and they can later be downloaded to a PC/Workstation. The researchers were primarily concerned with finding a balance between performance and power consumption. As with any small device, battery life is a concern so it is important to minimize power consumption without sacrificing performance or functionality.

### 2.1.2 *LifeMinder*

LifeMinder, developed by researchers at Toshiba Corporation is another wearable healthcare support system.[12] It includes a wristwatch-shaped wearable sensor module and a PDA. The sensor module monitors the patient's motion, pulse, temperature, and galvanic skin response (GSR). It then uses Bluetooth to communicate with the PDA.

Once the data has been transferred to the PDA, the PDA displays the data graphically for the user and attempts to identify patterns. The PDA can also give the patient advice such as, "take your medicine" or "you are putting too much strain on your body, take a break." One of the most interesting features of LifeMinder is that it can identify when the patient is eating. The researchers developed an algorithm that uses the patient's pulse rate and GSR to determine whether or not the patient is eating at a given moment. In an experiment on ten subjects, the algorithm had 90% accuracy.

### 2.1.3 *UbiMon*

The goal of the UbiMon project is to combine implantable and wearable sensors to improve healthcare by monitoring patients in their daily lives.[7] The UbiMon system consists of a network of sensors, a PDA, a central server, workstations, and a patient database. The sensors capture patient data and send it to the PDA which processes it and sends it over the wireless network to the central server. The central server then stores the data in the patient database where it can be retrieved and analyzed by healthcare providers using workstations.

Like the LifeMinder project, UbiMon is designed to use sensors for activity recognition. For example, a set of motion sensors may be used to determine whether a user is walking, sitting still, running, or going up a hill. Each of this activities requires a different amount of energy so knowing what the patient is doing and for how long would be helpful in calculating how many calories they are burning.

### 2.1.4 *Biolog*

Rather than using a variety of sensors to monitor many different conditions, the Biolog hot flash monitor is tailored to collect data for a specific symptom.[2] Used by researchers at the Indiana University School of Nursing, the Biolog uses sensors to monitor the physiological effects of hot flashes on a woman's body.

The Biolog is a small, portable device connected to two electrodes which are placed on the patient's chest. The electrodes measure skin conductance, which is a function of sweat gland activity and pore size, once every second. During a hot flash, sweat is produced and the skin conductance value increases. The Biolog also has two buttons on it that women are instructed to push when they are having a hot flash. Both the skin conductance measurements and the button presses are recorded on the Biolog with timestamps. The data can later be downloaded onto a desktop computer and displayed graphically. By comparing the change in skin conductance over time and the timing of the button presses, the researchers hope to determine what physiological changes occur before, during or after hot flashes are perceived.

## 2.2 Nutrition Monitoring

A person's diet can have a great impact on their well-being, both physical and mental. Many people with chronic conditions have dietary triggers that either cause or exacerbate their condition. These conditions may require that the patient monitor their nutrient intake in order to stay healthy. For example, diabetics must closely monitor their carbohydrate intake in order to keep blood glucose levels in a normal range. Patients with heart disease, on the other hand, must minimize fat intake to help prevent blockages in veins and arteries. A given condition may require a patient to monitor several different nutrients so it is important to create a tool that can be customized for a given patient's needs.

### 2.2.1 *Just-in-Time Decision Support Tool*

A group of researchers at MIT and the Boston Medical Center has developed a prototype for a system that will help people make more educated decisions at the grocery store.[5] The system can be used to compare two foods in terms of the nutrients they contain to help people decide which fits better into their dietary goals. It consists of a PDA and a barcode scanner which is used to scan two different food items and then nutrition information is displayed graphically on the PDA to allow the patient to compare them.

The system was designed to persuade patients to gradually improve their diet. For example, it might be hard to convince a patient to entirely give up potato chips but it might be much easier to persuade them to buy baked chips instead of fried chips by showing them a comparison of the fat content.

**Figure 2: Dietary Intake Monitoring Application (DIMA)**

#### 2.2.2 Dietary Intake Monitoring Application

Another example of a nutrition monitoring tool is the Dietary Intake Monitoring Application (DIMA) designed by researchers at Indiana University.[3] DIMA was designed specifically to monitor the nutrition needs of patients undergoing dialysis but the design could be easily adapted for other conditions. Dialysis patients must limit the amount of fluid they drink and also their sodium intake. DIMA helps them keep track of their fluid and sodium consumption by allowing them to enter their fluid or food items by selecting icons, barcode scanning, or voice recording. The application then shows the patient, graphically, how much fluid and sodium they have consumed in a given day.

DIMA saves the patient's data on the PDA, where it can later be downloaded by dietitians to a desktop application. This enables the dietitians to assess how well a patient is following their diet and to give suggestions for improvement.

### 2.3 Experience Sampling

The purpose of the Experience Sampling Method (ESM) is to collect information about users in their natural environment. By using ESM, researchers can often collect more accurate and timely information than they could obtain in a laboratory setting. ESM involves having users fill out short questionnaires periodically as they go about their day to day activities. Questionnaires may be delivered at random times throughout the day, at prescheduled times, or they may be triggered by specific events.[4][6] A PDA is an appropriate device for delivering questionnaires because it is small enough for the patient to carry around and the delivery times can be easily programmed.

ESM can be applied to the health domain by creating questionnaires that address a patient's specific complaint. For example, if a patient is having frequent headaches then a doctor might want to investigate whether stress is a trigger. A patient may receive an alert to complete a questionnaire several times throughout the day asking them to rate their relative stress level. The doctor can then use the questionnaire responses, along with reported headache occurrences, to determine whether or not there is a correlation between the patient's stress levels and headaches.

#### 2.3.1 Handheld Symptom Management

ESM was used in the Handheld Symptom Management (HSM) tool designed by researchers at the University of Glasgow.[10, 9] HSM is designed to help cancer patients undergoing chemotherapy manage their symptoms while at home. Patients enter their symptoms into a mobile phone or PDA and the information is sent to a treatment center. If the symptoms are particularly severe, a nurse will call the patient. Otherwise, the system offers symptom management advice to the patient. Throughout the day, the patient fills out questionnaires on the mobile device which ask whether they are feeling a particular symptom. If they are experiencing a symptom, they are asked to rate how severe it is and indicate whether it is affecting their ability to function. Based on the responses to the questionnaires, HSM delivers specific self-care information to the patient. HSM also includes general information about cancer and chemotherapy to educate the patient on their condition.

## 3. CONCLUSION

The toolkit being developed by the SURG lab has the potential to help many patients manage their chronic conditions. By combining on-body sensors, nutrition monitoring, and experience sampling, the toolkit can be used to test for a wide variety of potential triggers. Once the trigger(s) for a chronic condition have been identified, it is much easier for a patient to learn how to live with that condition and maximize their physical and mental well-being.

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