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HSP: A Tool for Heat Stress Prevention for Farm Workers

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Abstract: We present the initial development of an integrated application for heat stress and heat related illness prevention in farm workers. In developing the application we have follow the OSHA guidelines and an extended project includes the social, cultural and economic factors of farm workers. Even though, our development focus is on workers in the California fields, we believe our project will be useful in multiple situations where individuals are exposed to extreme heat working conditions. This paper describes the motivation for our development, the overall approach we are following, and the first version of our application.

INTRODUCTION

In 2013, Courville, Wadsworth and Schenker (Courville, M.D., Wadsworth, G., and Schenker 2015) conducted a research about heat illness in farm workers in the Northern California fields. As a result, they found that heat stress and heat related illness results in multiple deaths in California farm fields every year, regardless of campaigns to reduce Heat Related Illness (HRI). Factors causing HRI are more complex than just a consideration of environmental, work intensity and/or physiological components (CDC, 2008). For an integral solution to HRI, we need to consider additionally the cultural and socio-economic factors unique to the largely immigrant pool of farm workers. A more complex study to reduce and prevent HRI (Schecker, 2016), includes: a socio-economic analysis with agricultural stakeholders from farm organizations and labor to develop appropriate and effective strategies to reduce the risk of HRI. Such study also includes a proposal for determine the economic cost and predict the benefits of reducing HRI in California agriculture; and a set of mobile and smart applications (or apps for short) to implement primary and secondary HRI prevention approaches.

The project presented in this paper derives from (Schecker, 2016) and focuses on the specification and development of technology solutions using smartphones and body sensors to prevent HRI.

In the following sections, we describe the overall solution we are proposing, and then we address the system specification of our project and the status, and characteristics of the first application we developed. Finally, we conclude with the follow up actions defined in our approach.

SMARTPHONE INNOVATION

Instructing agricultural workers (especially Latino workers) to rest in the shade and drink more water has proven to have a limited effect as a strategy to reduce HRI, largely because of the other forces at play; such as economic, cultural and harvest production realities. For example, workers do not want to look weak if they take a break, or they do not want to slow down others, sometimes they mistrust employer's water cleanliness or prefer other liquid than water. Some other times workers simply do not recognize HRI symptoms or the training materials are not adapted properly for low literacy or cultural needs.

We propose to use a novel engineering solution involving the development of a new smartphone application (app) that will be oriented to the specifics of their workforce, crop, location and real-time weather conditions and forecasts. This will be a major enhancement over the basic California Occupational Safety and Health Administration (Cal-OSHA, 2015) app currently available that uses the National Weather Service network and the mobile instrument's GPS to provide the current heat index, level of alert and very general suggestions for work, rest, shade and drink schedules.

Study Design:

Electronic Health or "eHealth" is the application of information technology to support, complement or provide health related services to the people (CITRIS 2014; Jennett 2005; Latifi R 2007; Macleod 2012). In particular wireless systems provide vast opportunities to deploy new services to cope with needs in underserved communities (Nadal 2007). The power of eHealth systems to prevent health problems may be augmented by the capabilities currently available in smartphones and other mobile devices. eHealth systems have been developed in urban settings where cell phone coverage is reliable (Chu 2004; Macleod 2012; Van der Velden 2008). In the case of rural areas, the use and availability of wireless and mobile technology has been increasing during the last few years (Jennett 2005; Macleod 2012; Nadal 2007; OpenSignal 2015). Creation of new applications, especially in public health and health care services is increasing exponentially worldwide. Studies of immigrant farmworkers in the US have found that over 80% of these individuals own cell phones and a large percentage of these are smart phones (Price et al. 2013). Further, the majority (81%) of farmworkers expressed a willingness to receive health related messages via their phones. Mobile messaging has been used among California farmworkers to reduce risk of pesticide illness (Versel 2013). Technologies have already been developed to integrate individual sensors and wireless networks in secure transmission systems (Challa 2008; Villareal 2013).

A set of Information Technology apps for Heat Stress Prevention (HSP), HSP-1 and HSP-2, will be described next. They will be designed to work independently but also in conjunction with each other.

HSP-1 will be used to send Informative and Periodic Recommendations Reminders to supervisors and on-site work leaders of field workers.

Concept:HSP-1 is a multiplatform application that presents information about current weather conditions and farm specific work types and computes/predicts the heat risk factor and outputs recommendations for preventing heat related illness. The application is accessible through a web portal in different devices: personal computers, tablets, basic mobile or smartphones. Additionally, HSP-1 can send text messages to mobile phones with specific preventive actions to do during the working day. HSP-1, can be viewed as an improved development to the Cal-OSHA app [Cal-OSHA] which only computes the heat risk factor and present a useful but lengthy recommendation text for actions.

Plan: Our inputs will include:

- *Current time, location local temperature and humidity which will be taken directly from the device, its GPS and public available web services or may be introduced manually.*
- *Workload categorized (low, medium, high) will be included similar to the Cal-OSHA app.*
- *Other site specific information: task, crop and demographic data such as age, gender, language (English, Spanish, other) and mobile phone number.*

Values taken from web services or sensors may be updated automatically during the working session and the corresponding outputs will be recalculated.

The output information will be:

- *HRI Risk Index We will categorize an index of HRI risk into 3 levels similar to the current Cal-OSHA Heat Index, and include additional information to individualize the risk estimation for the particular site, crop and work task(s). The index would be based on an algorithm of the input values developed from our current study. The maximal HRI index for the work day may be predicted using temperature and humidity forecasts.*
- *Scheduling recommendations for current and predicted conditions and work/task types*
    - *List of Breaks*. Timing and duration of break, and frequency of liquid intake suggestions.
    - *Reminders*. Supervisors may be sent short text reminders to alert their teams to rest or drink.
    - *General Alerts*. Considering the input information some general alerts may be issued, for example “Work should be shortened to half day”, etc.

High Risk Alerts. If for example, a heat wave is expected or weather conditions suddenly change during the day negatively affecting work conditions. If there are more vulnerable sub-groups of workers present, the app may be used to provide them with specialized instruction.

HSP-2, will be used to monitor local and Individual HRI in real-time.

Concept: HSP-2 builds on HSP-1 functionality and adds assessment of HRI evaluation of individual farmworkers using biological input data. The real time monitoring in the fields will allow the detection of signs of potential HRI in workers, and alert their supervisors. The detection of early stage HRI directly addresses requirements in the most recent heat stress standards for California, which states: “if a supervisor observes, or any employee reports, any signs or symptoms of heat illness in any employee, the supervisor shall take immediate action commensurate with the severity of the illness.” The standard, however, does not provide easily understood guidance as to what constitutes “signs and symptoms of possible heat illness”. Our HSP-2 app will provide a specific tool to assist supervisors in evaluating workers with potential heat illness. The physiologic measurements, collected by a Body Sensor Network or BSN, may include one or more of the following: heart rate, body temperature, and hydration level. In addition, simple clinical signs or symptoms can be inputted into the program such as nausea, sweating, weakness, and orthostatic symptoms. This information notify the supervisor of the probability of heat stress illness and its severity. The app will further spell out the appropriate emergency response procedures, as required by the state regulations.

Plan:_Our inputs will build on HSP-1, the additional inputs will include the acceptance range of values for vital signs, individual farm worker skin or tympanic membrane temperature, heart rate, from the BSN, farm emergency contacts from the Illness and Injury Prevention Plan (IIPP).

Regarding outputs, the acceptable ranges of vital signs for farmworkers determined using data collected in the current study will be included in HSP-2. HSP-2 will also send notification to the supervisor whether a farmworker’s symptoms suggest HRI, and if so, the severity of the HRI, the appropriate and mandated follow-up procedures including monitoring and immediate action commensurate with the severity of the illness. The data gathered by local sensors (weather stations at airports and irrigation districts) and BSN may be stored in a data repository (removing personal identifiers) for further data analysis and research.

Developmental Process:_For both applications, we will utilize mobile devices (smart phones or basic cell phones with text messaging capabilities) and a web portal base application accessible by smartphones. We will use short text message service (SMS), and cellular communication networks (3G, 4G) or WiFi if available. Otherwise Bluetooth Communication Protocol or Civil Band Radio will be used to communicate HRI related information to the supervisor. We will develop the HSP-1 and HSP-2 technologies using a mixed approach of software development methodologies. Initially, a traditional Waterfall model will be used for the first set of requirements elicitation and specification activities. Once we have specified and prioritized the first set of functional and other requirements for both applications, we will proceed with an Incremental Model to build our HSP-1 and HSP-2 apps. The Incremental Model will iterate over the phases of Design, Codification, Testing, Integration and Delivery.

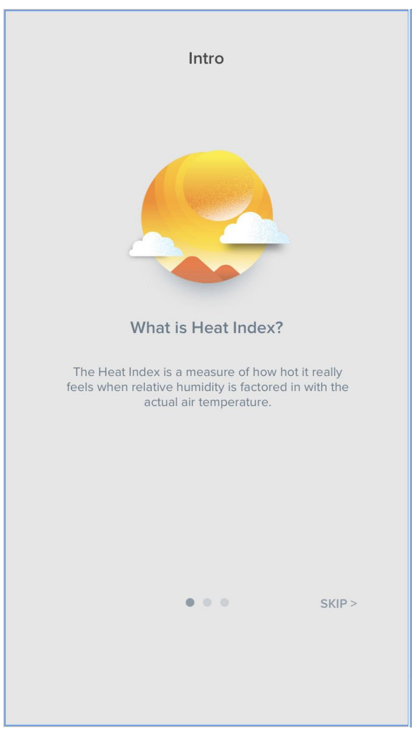
CURRENT STATUS OF THE APP AND FUTURE RESEARCH

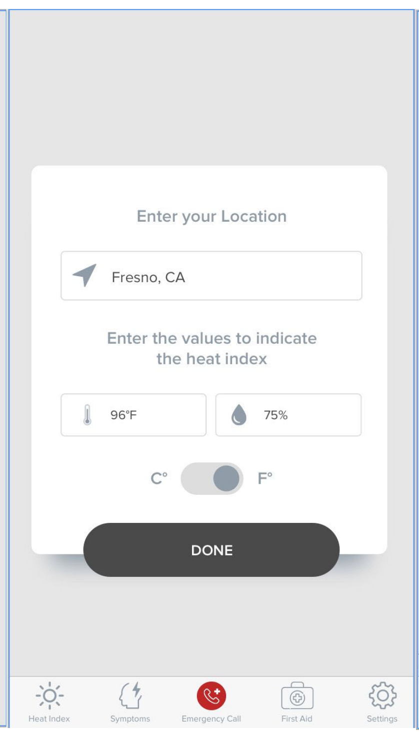
Currently we have finished our first version of the HSP 1 application that has the following characteristics. Basic functionality includes:

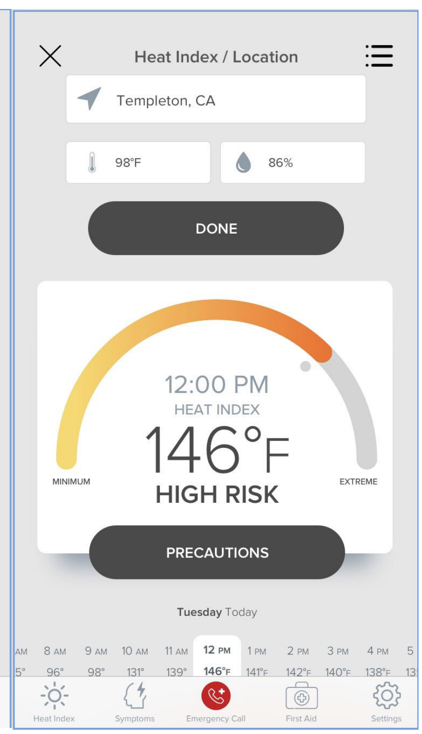
- Based on geolocation
- Shows temperature and user location
- Shows humidity percentage at user location (or to specific location input by user)
- Computes heat risk index for user location
- Provides a list of actions to follow considering heat risk index, user location, and OSHA recommendations
- Generates notifications with periodic recommendations based on the previous list
- Allows making 911 calls directly from app.
- The system is design considers the following users characterization (personas)
  - Field Worker
    - Works in the open
    - Works for long periods (sunrise to sunset)
    - She/he has access to a smartphone, we already conducted and study including a focus group to verify that most of the workers already have a smartphone.
    - Speak English, or Spanish, or both

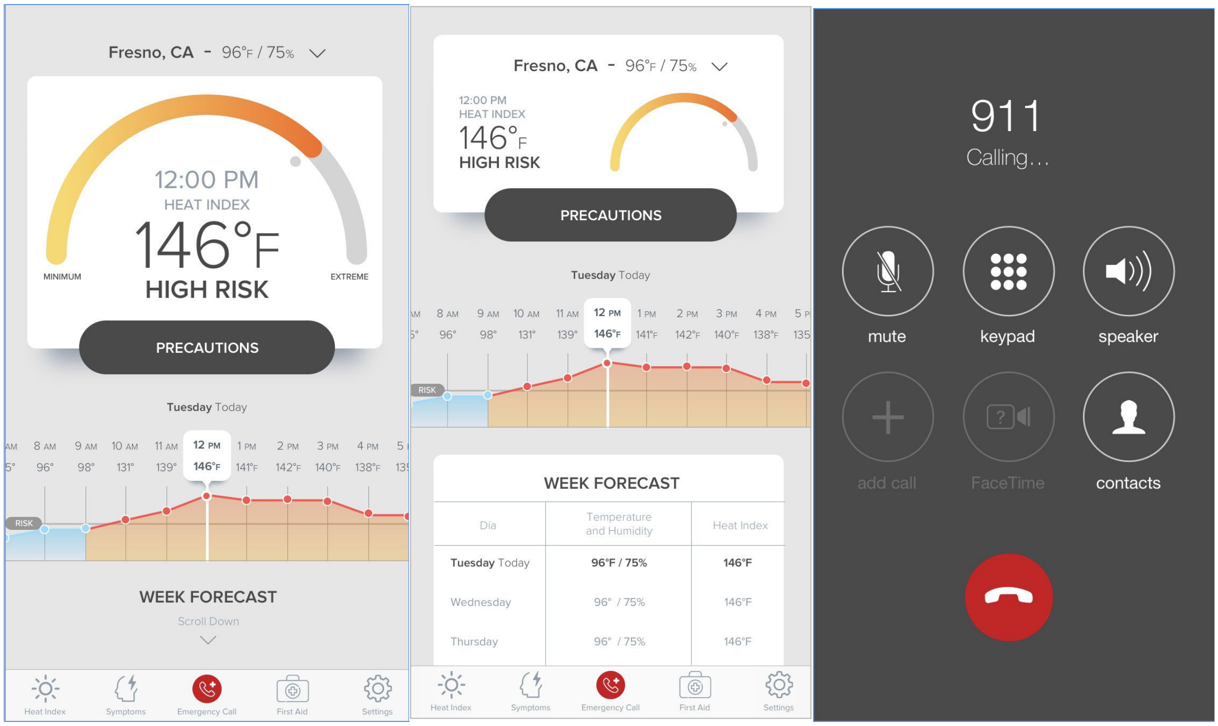
The following images illustrate some of the functionality available in the current version of our application. At this time, we have versions for the two most popular operating systems in smartphones Android and iOS.

In the following months, we will start adding body sensors for detection of humidity and temperature. This part has become difficult due to cultural aspects such as workers do not want to wear anything else besides their own clothes, and to the nature of the sensors which most of them are designed to take body measures in a controlled environment, i.e., a room with controlled temperature with people seated and not moving.









Compared with the current OSHA applications our HSP-1 adds some few features not available at OSHA app

First, our version includes a more intuitive and visual interface, heat risk indicators are present at all times, also the locator indicator and hourly heat index information are always available and updated. Currently we are using the OSHA recommendations and forms to calculate heat risk index.

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