A Police Health Companion App

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Introduction

Police officers are regularly exposed to potentially stressful and traumatic events while on duty. Over time repetitive exposure can have cumulative effects (Silver et al., 2013), such as higher rates of negative mental health symptoms (ex., depression and posttraumatic stress disorder) (CAMH, 2018), as well as cardiovascular issues (ex., physiological overarousal indicated by heart rate (HR) measurements, hypertension, etc.) (Thayer et al., 2006). Impacted mental and cardiovascular health resulting from accumulated stress not only influence each other, but also influence performance abilities (ex., correct shooting decisions) (Violanti et al., 2006; Thayer et al., 2009). Many officers are unaware of their own health risks, with even subclinical levels of mental and health symptoms have potential negative performance effects (Dickstein et al., 2015; Covey et al., 2013). Furthermore, due to the police culture of emotional suppression and mental health stigma, officers are unlikely to seek knowledge or support without fear of direct judgement from their peers (Amaranto et al., 2003).

Sentinel is a mental and physical health tracking app designed to assist tracking police-specific health, allowing officers to be aware when they show signs of risk both on- and off-duty. *Sentinel* offers users measurements backed by research literature on police health and wellness. By providing an autonomous and confidential experience, *Sentinel*'s guided knowledge aims to encourage officers to self-regulate and prevent the exacerbation of potentially detrimental health symptoms.

Sentinel's Functionalities

Below is the main screen of the app that users will see after they log in. The top-left button links to a hamburger menu. Both buttons on the main screen and in the hamburger menu link to each functionality.
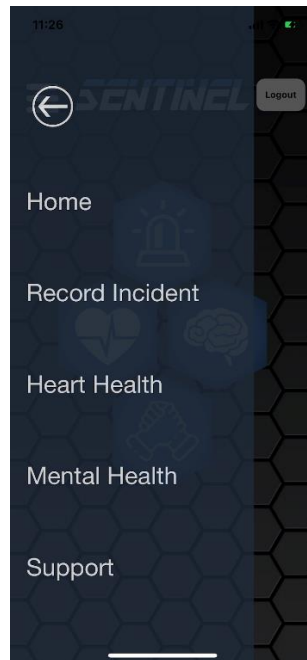

Main Menu   *Hamburger Menu*

Sentinel has 4 primary functions:

1) *Critical Incident (CI) Recording*: Record heart rate (HR) activity during CI scenarios or events encountered while on-duty
2) *Heart Health*: Track HR activity over time
3) *Mental Health*: Track mental health symptoms over time
4) *Support*: Provide police-specific support and resources

1) Critical Incident (CI) Recordings

A wearable HR chest-monitor (Polar H10) allows officers to collect active HR data second-by-second, while they experience stressful events on-duty. HR data recorded from the Polar monitor is read and collected through HealthKit. As shown below, users can signal when to begin and end CI recordings. For example, an officer could begin recording when receiving a dispatch call, leave their phone in their squad car while they resolve the incident, and end the recording after returning to their squad car. The finished recording is immediately tagged with a date, and users provide a catalogue ID/name for the CI as well as optionally provide a description of the CI itself. CI recordings are then stored in the database where visualizations can be reviewed later for analysis in *Heart Health*.
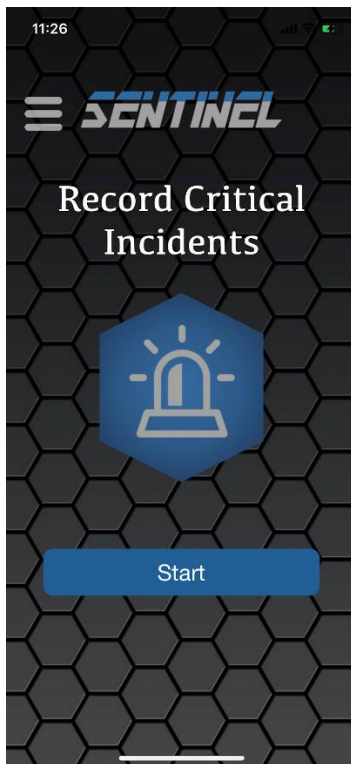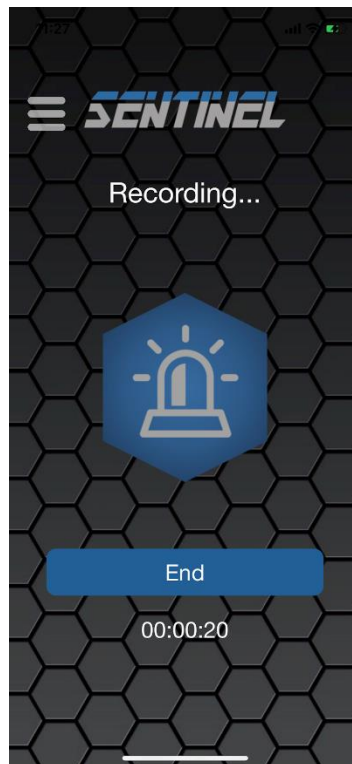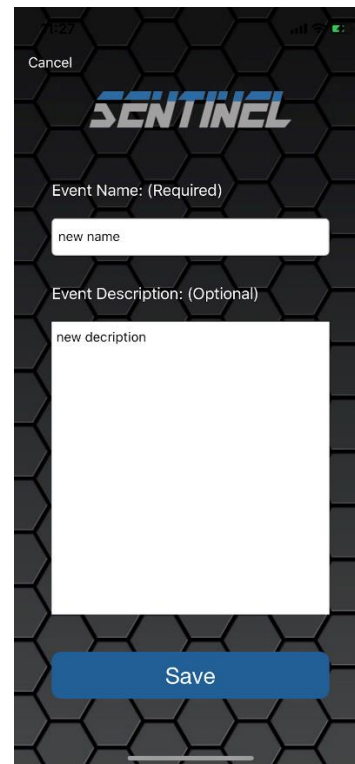
| *CI Start* | *CI End* | *CI Details* |

2) *Heart Health Tracking*

During their downtime, officers may use *Heart Health* system to track and better understand their physiological stress arousal in terms of HR variables. Research has shown that providing HR data corresponding to experienced events aids in understanding, as well paves the way for potential subsequent training for modulating stress arousal (Andersen et al., 2018; Andersen & Gustafsberg, 2016). Users can review all logged CIs arranged by recording date. Within each CI log, there is a line graph showing the users' HR every second across the CI, max and average HR, CI duration, start time, and the description users provided.

In the *Heart Health* home page, users can also find their average max HR of all recorded CIs. Finally, the *Resting HR* page allows users to measure their resting HR when they are seated and relaxed, view a line graph of resting HR measurements from the most recent five days, and a brief description about how to interpret their resting HR measure.
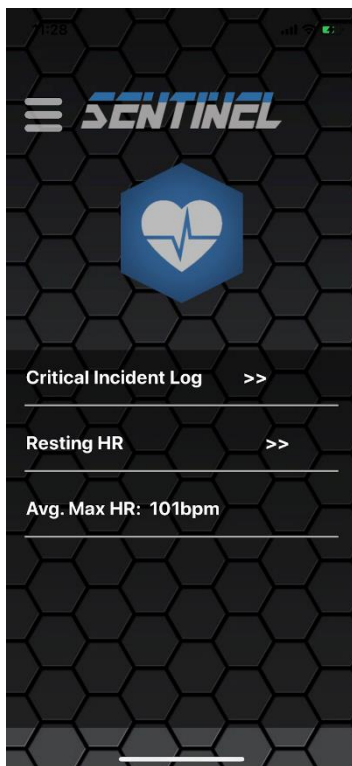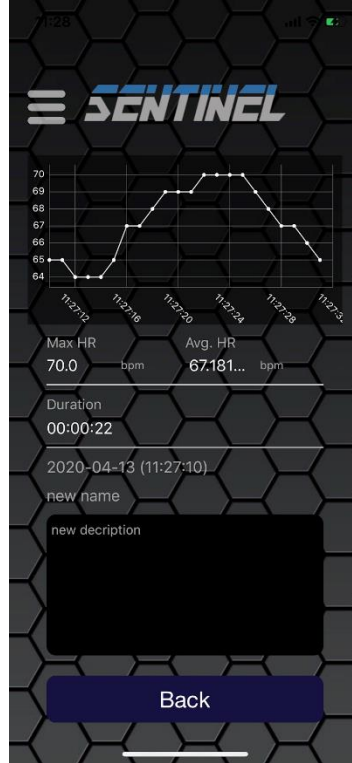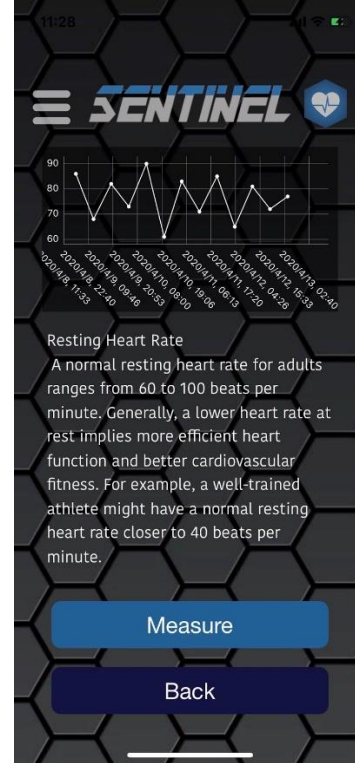

Heart Health Home

*Critical Incident Log*   *Detailed CI Log*   *Resting HR*

3) *Mental Health Tracking*

Increased physiological stress has potential long-term impacts, particularly in mental health. The *Mental Health* function allows users to record and track mental health symptoms that police are more at risk for in privacy, during their downtime. In *Sentinel*, this features literature-established surveys of police stress (PSQ), posttraumatic stress disorder (PCL), depression and anxiety (DASS-42), and social support (ISEL-12). For every symptom, users can find the symptom's description and survey information in the *About* page. In each *Assessment*, there is a quick instruction about the survey itself and users can tap "*GO*" to begin. Throughout the survey, users can refer to the top of their screen for their completion progress. After users submit their answers, they will be displayed their personal score out of a total possible score with a short explanation of how to interpret their results. Users can later refer to *Symptom History* for a line graph of that symptom's scores with dates, as well as a log list of scores. Each log is interactive, allowing the user to revisit its results page for interpretation.

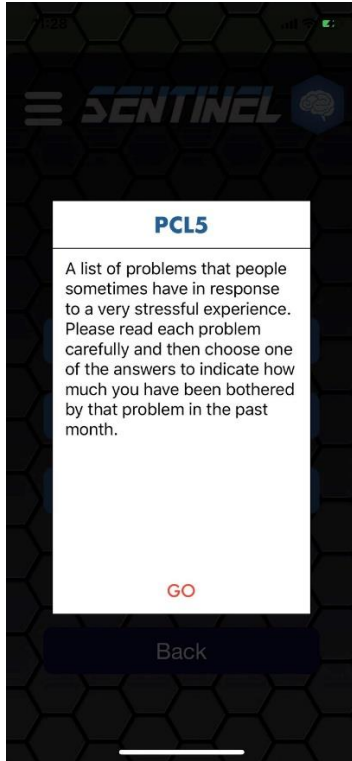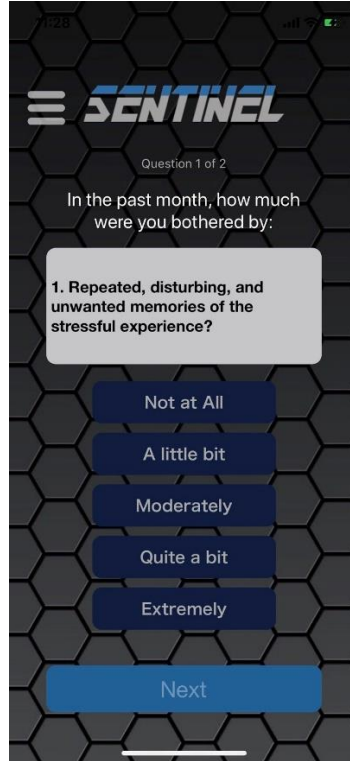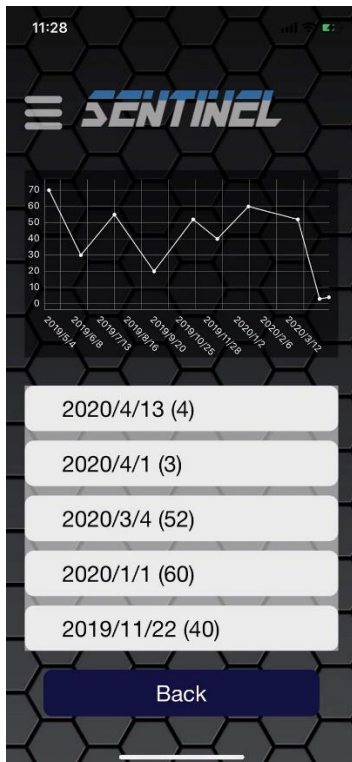|		
Mental Health Home	*PTSD Home*	*PTSD About*
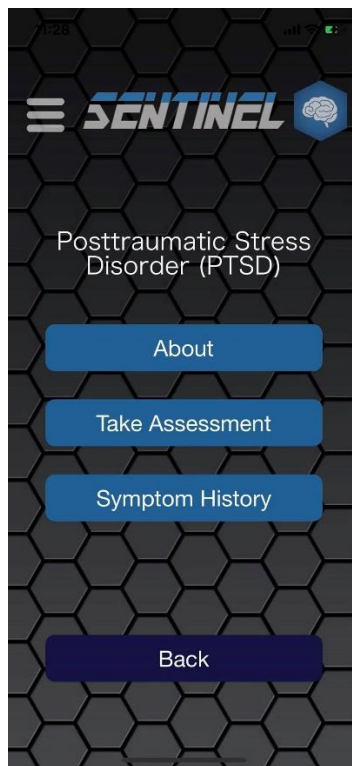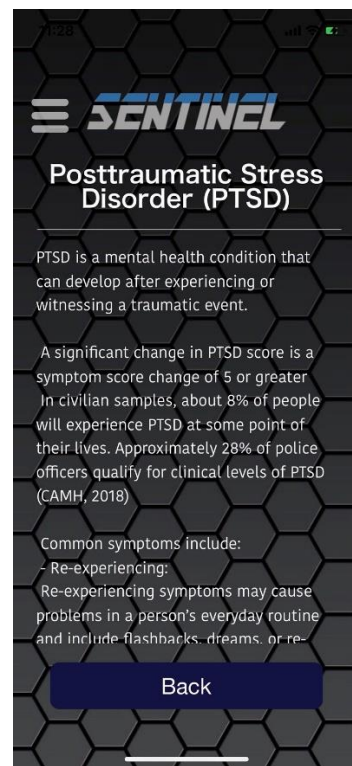
PTSD Survey Instruction   *PTSD Survey*   PTSD *Survey Result*
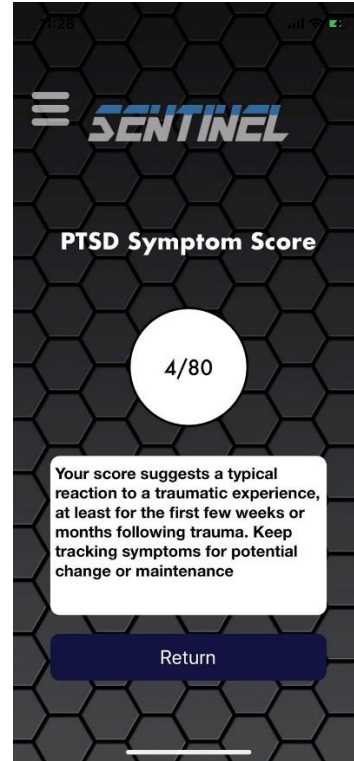
PTSD Symptom History

4) Support and Resources

The *Support* function provides users a springboard to begin seeking additional help based on their recorded health, without the need to seek resources at their occupation. In *Stats Report*, users are provided a snapshot of their current health, listing their most recent scores on each mental health survey, and the average HR data of the last month (resting HR, max CI HR, CI duration). This provides users a quick summary of their scores, aids in decisions to seek help, as well as easily share their data with a healthcare professional either in-person or with a couple screenshots. The final aspect of this function provides related further *Resources* (ex., Copline and Crisis Service Canada hotlines), in which they can directly call or text from the app using the provided hot-links.
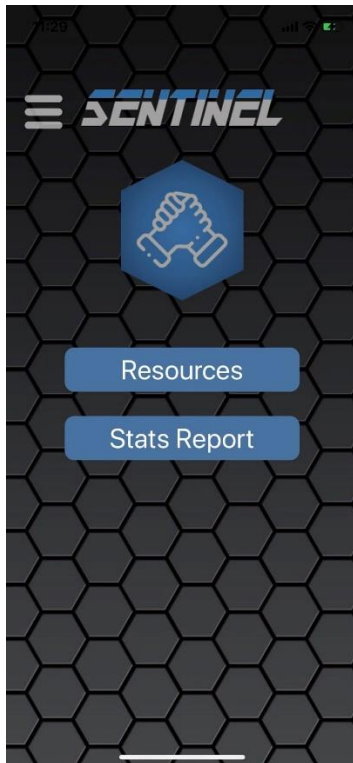
Support   *Stats Report 1.1*
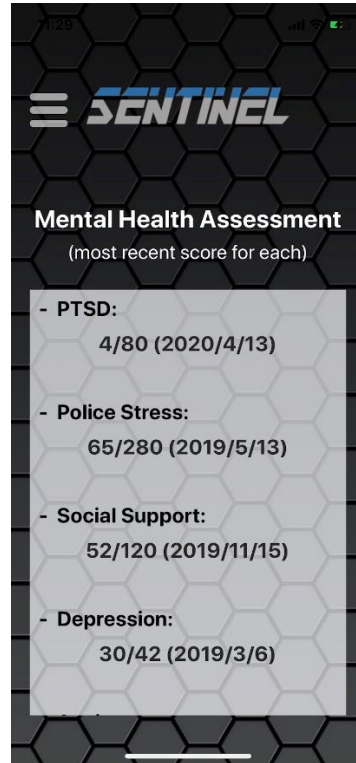
Stats Report 1.2   *Resources*

Overall Design

There are two major flows for *Sentinel*'s design. The first flow starts with the user's recorded HR data (i.e., CI/resting HR) recorded from the Polar monitor into the Apple Health Kit. While we recommend the Polar sensor for accuracy and field-use portability, *Sentinel* is desig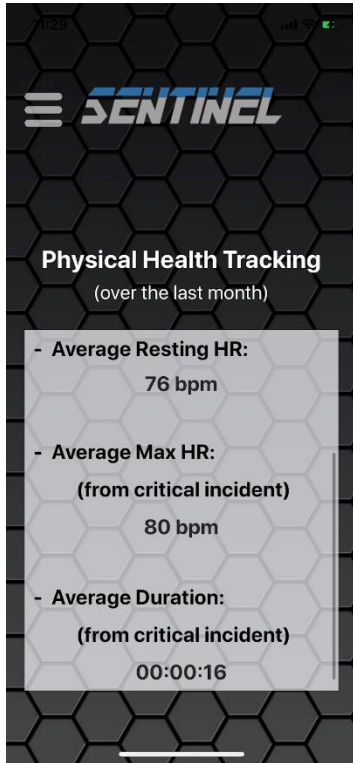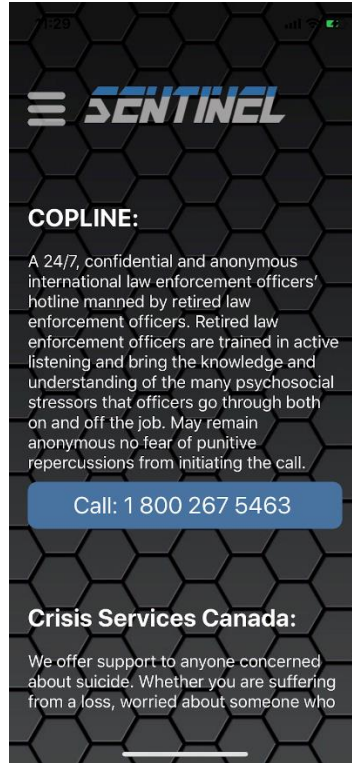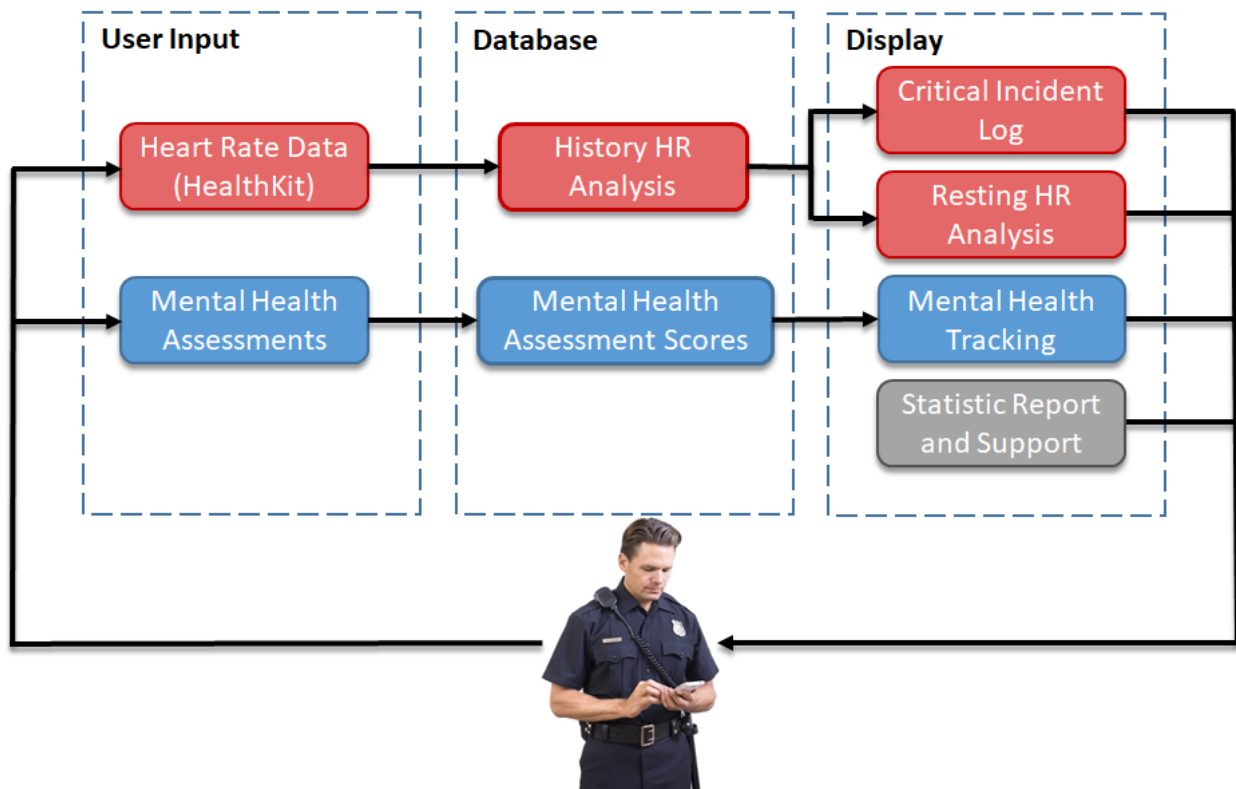ned to work with any health app-compatible HR sensor, increasing its flexibility and use. *Sentinel* stores the data into the corresponding categories (CI Log/Resting HR) in the Firebase database. With the data stored in Firebase, the application performs statistical analyses and then displays the analyzed data to the user-friendly interface. All score-tracking data is accessible and stored permanently in the database.

The second flow starts when a user completes a mental health assessment. The assessment is driven by a series of multiple choice questions. Once the assessment is complete, a total score is calculated and stored within the Firebase database. From the database, *Sentinel* generates and displays detailed mental health tracking reports (ex. current and previous total symptom scores) to the user.

In addition to two primary user-driven flows, *Sentinel* also has its *Support* functions. The statistic report pulls all recent CI/resting HR data, and mental assessment score from the database. With some statistical analysis, it displays to the user an overall view of the data collected. The resources section is predefined and hard-coded on the front end, allowing users to use hotlines via phone call or text.

Reflections: What We Learned

While the decisions of *Sentinel*'s functions were based on literature and research on police stress and performance, it would have been ideal to have receive input from the police closer to the beginning of development. This would allow an opportunity for *Sentinel* to have more direct influence from police for what they would want on an app.

During this project, we treated each function as its own independent spiral development, working sequentially on one function at a time. In hindsight from a technical perspective, we would have instead benefitted from a different spiral development approach: beginning all 4 functions simultaneously, and spirally developing from there – creating a basic dataflow prototype for a preliminary proof of concept. As a specific example, *Sentinel* was originally designed also measure heart rate variability (HRV). In the original proposal, our initial research found an abundant number of resources for importing HRV data into Health Kit. However, when we began the HR functions, we discovered recent changes in Xcode versions, restricting our original HR functionality goals by certain financial and programming permissions. If we initially built a complete preliminary prototype (i.e., simultaneous 4 function spiral development schedule), we may have earlier identified this problem, providing more time to come up with alternative solutions, rather than cutting this function completely from the final product. For example, we may have instead redirected *Sentinel* to focus on CI recording. This would have been less holistic than the current version of *Sentinel*, and instead more comprehensive in a single specialty.

Contributions of each Group Member

Jen - As the specialist, my contributions were to complete the majority of work unrelated to programming. For *Sentinel*'s interface, this included UI design such as creating screen mock-ups, as well as branding such as developing the app name, logos, and icons. For app content, this included providing and explaining to the programmers all mental and heart measurements used in the app, and mediating what could and could not be incorporated. This also included providing and writing all text descriptions seen within the app. I also was responsible for organizing the team, scheduling deadlines, meetings, and development checkpoints. Beyond immediate app development, I was the primary writer and editor for group papers, and created the majority of group presentations.

Yue - As a programmer, I did the initial UI arrangement, figured out how each functionality would be displayed, and used it to communicate with the specialist before beginning full development. During development, in the HR tracking system, my responsibilities were to figure out how to extract data from the HR monitor, as well as extracting and displaying the specific (ex., resting and max) HR variables from the data stream. In the mental health assessment system, my contributions were related to the backend, including calculating, storing, and displaying survey results. I was responsible for programming all support functionalities.

Ran - As a programmer, I contributed towards the app's main structure design and development. In the mental health functions, my responsibility was UI development and data collection:

developing user-friendly workflow for improved assessment experience, generating results based on users' input, and using results to generate score tracking (via line graphs). In the heart health functions, I focused on both frontend and backend development, including: UI experience for CI recordings, extracting data from the health app, CI database storage (CI's name and description, duration, average HR), and displaying CI summaries and tracking information to users.

Specialist Context

Sentinel has potential impacts in both scientific research fields, and police officers' occupational fields. The overall functions of *Sentinel* automate various independent measurements being done in the research literature right now. For example, HR recordings, CI event descriptions, and mental health assessments are all separate files (the latter two done by hand and then transcribed to a digital format) that are combined to create data files for analyses. Currently, *Sentinel* covers the foundation of these data within a single app, which is more efficient and less onerous. With development, *Sentinel*'s accuracy (ex., HR recording) and coverage (i.e., more variable measurements such as HRV and demographics) may improve to reach research standards. As an app, *Sentinel* has a large potential to be easily distributed and accessible to a large number of police officers. Police are a difficult sample to test and recruit, and an app format would vastly increase the amount of data that could be collected and available to researchers.

For police users, *Sentinel* could have potential impact throughout their occupational experiences. Maintaining personal health improves performance, which is critical for their own as well as the public's safety. Furthermore, maintaining health is beneficial for the police organization, reducing strain on financial resources impacted by sick days, lower productivity, burnout rates, and potential lawsuits from poorer performance that occur from accumulated stress (Tunney, 2018). Additionally, *Sentinel* will ideally contribute towards improving the current culture of mental health and support within the policing community. The knowledge gained by users will potentially normalize discussions about police physical and mental health. This would consequentially contribute towards reducing stigma, emphasizing the need for police-specific stress support, and encourage individuals to seek and receive help when they become at risk.

Future Work

There are a number of future features that would improve *Sentinel* proposed in the original concept, but were unrealistic to incorporate within the course's timeframe. The biggest would be incorporating audiovisual and GPS recording into CI recordings. This would potentially allow users to review an overlay of their exact moment-to-moment HR throughout the CI video, rather than inferring or estimating it from their written description. Another improvement that we want in *Sentinel* would be including more support features, for example, provide more specific health insights of users' mental health and HR measurements. Within the scope of this project we chose to err on the side of caution with vaguer interpretations, avoiding potential risks of providing users' recommendations regarding health decisions. Future collaboration with a trained clinician

would allow us to provide more specific health insights and suggestions to users. Additionally, we would like to include confidential user-to-user and user-to-health professional communication within the app. The support function could also be rounded out with a number of relaxation and coping exercises to reduce overall stress (ex., guided breathing, meditation, and visualization), directly contributing towards helping users address their behaviour once they form a database of health patterns. The final function that we would like to add would be several active notifications. This would include: suggestions for the user to engage in relaxation exercises if their HR has been critically high for long periods of time, reminders to take scheduled mental health assessments, and GPS-based notifications to take mental health assessments if users are located somewhere that suggests they were exposed to trauma or violence (ex., a significant amount of time near a hospital).

Statements for Future Use

All group members agree to public posting the following on the ECE 1778 course website offered by University of Toronto:

- Video of final presentation
- Final Report

At this time, group members *do not consent* to public posting Sentinel's source code on the course website, due to plans for commercialization and research purposes.

References

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