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Kyle Firth: Watch renders, research, feasibility section

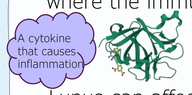
References

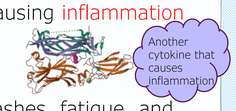
PRISM

Personalised RAIRDs Integrated Smart Monitor

What are RAIRDs and Flare-ups?

Rare autoimmune rheumatic diseases (RAIRDs) are a group of conditions where the immune system attacks healthy tissues, causing inflammation and damage across the body.





Each condition presents uniquely:

- Lupus can affect many organs, with symptoms like rashes, fatigue, and joint pain
- Scleroderma leads to thickened skin and scarring of internal organs, especially lungs and kidneys
- Raynaud's causes painful attacks of reduced blood flow to fingers and toes, often linked to other autoimmune diseases
- Vasculitis involves inflammation of blood vessels, leading to tissue damage, in places such as the kidneys, lungs, or nerves

Aneurysm from blood vessel inflammation in vasculitis

Over 170,000 people in the UK are affected by RAIRDs. There is currently no cure for RAIRDs and they can significantly impact patients' quality of life and life expectancy.

What are flare-ups?

An autoimmune flare-up is a sudden worsening of disease symptoms or the appearance of new ones. These flares are often severe and can cause inflammation, which can affect many organs. Therefore, they can hugely disrupt patients' daily activities.

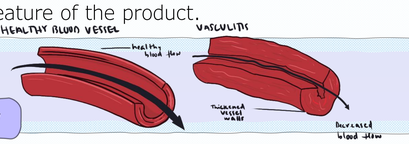
The symptoms of autoimmune flare-ups can differ by the specific condition but common ones include extreme fatigue, brain fog, depression, heightened pain and anxiety.

Giving a patient an estimate of when these flare-ups occur will provide relief, as the patient will not have to stress over when they might next encounter a flare-up – taking away from the exhaustive unpredictability of their disease. This improves overall wellbeing and reduces long term damage if the patient decides to consult a doctor prior to their flare-up.

Why a Smartwatch?

Most available devices are either too generic or not designed for real-time flare-up prediction, leaving patients to rely on symptom diaries or infrequent medical tests that fail to capture subtle day-to-day changes which can help scientists predict flare-ups more accurately. This is a major issue for those suffering from RAIRDs both medically and practically. Additionally, delays in recognising flare-ups can also lead to irreversible organ damage or worsening disease progression.

Our product helps to address these problems by allowing people to monitor their symptoms real-time, all in a non-invasive smartwatch. This is also a cost-effective solution because whilst there is the upfront cost of buying the smartwatch, it is still much cheaper than the medical care required by patients during flare-ups which our device could help prevent - this is the unique feature of the product.



Pulse Wave Velocity

Pulse Wave Velocity (PWV) measures how fast the pressure wave generated by each heartbeat travels through the arteries. It may help detect early signs of vasculitis, cardiovascular risk, or systemic inflammation in conditions like SSc (fibrosis of vessels), ANCA vasculitis (vascular wall damage), and SLE (early atherosclerosis).

The smartwatch will monitor health indicators continuously for around two months to learn the user's personal flare-up patterns. After learning, it will provide alerts when similar patterns reappear. The device also tracks PWV and flare-ups, and - with user consent - can contribute to more research on the link between PWV and vasculitis flare-ups.

Our Proposal

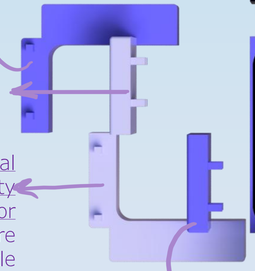
A smartwatch that constantly measures various parameters in the body to predict an incoming flare-up in a RAIRD patient, and approximately when it will occur.

A preview to the PRISM website!

PRISM APP ICON

Temperature Sensor
Detects changes in core body temperatures – an elevated core body temperature precedes a fever which could directly cause a flare-up, acting as a potential flare-up indicator.

Microcontroller Unit (MCU)
MCU in the base - collects and sends the data from the watch to the person's phone, which is then sent across the internet to servers to carry out calculations.



Accelerometer

Electrodermal conductivity sensor
Used to measure the subtle changes in the electrical conductance of the skin caused – can be used to measure stress.

UV Sensor
Exposure to a certain amount of UV light causes lupus flare-ups. A device that could detect the amount of UV light the patient is exposed to and notify the patient if they should seek shelter from the sun could prevent lupus flare-ups.

Battery

ECG and PPG
These will give readings used to calculate Heart Rate Variability (HRV) and PWV. Reduced HRV could be an indicator for Lupus flare-ups. A high PWV is hypothesised to be an indicator for a flare-up – linking this with all the other predictors can help prove this hypothesis further.

Feasibility

Based solely on the prices of stand-alone sensors (not ordered in bulk):

Sensor	Cost
UV sensor	~£5
Electrodermal conductivity sensor	~£3
Temperature sensor	~£5
PPG sensor	~£15
ECG sensor	~£20
Accelerometer	~£4
Microcontroller Unit (MCU)	~£5
Battery	~£20

This adds up to around £80. Adding the cost of assembly, straps, and any other miscellaneous factors, which should cost under £40, this would lead to a watch that costs around £120 which would be relatively economically feasible for the NHS and/or private patients. The watch is modular and can be personalised to a specific condition, so certain sensors can be taken out, making it cheaper.

Research and Pitch

The 1st step would be to conduct initial research (part of which we have already done) to hone our smartwatch-based solution whilst trying to establish the foundations of our product, such as the basic watch design, a mobile app to go along with the watch as well as the algorithms required to analyse the data collected by sensors. At this stage we will have made an initial prototype of the watch.

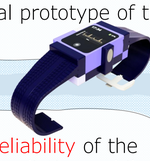
Data Collection

Provided that we have the backing of the NHS, we would be able to use their equipment in hospitals to collect as much data as possible regarding symptoms experienced by patients before flare-ups.

We would use this data to confirm the trends we already believe to be true, such as subtle core body temperature increases seen with vasculitis that come before a flare-up. We would have experienced researchers in the field look at this data, as well as train AI to help find patterns in the data we collect. The larger our sample of RAIRDs patients, the more likely this stage is to be successful.

Software Development

The 1st step would be to conduct initial research (part of which we have already done) to hone our smartwatch-based solution whilst trying to establish the foundations of our product, such as the basic watch design, a mobile app to go along with the watch as well as the algorithms required to analyse the data collected by sensors. At this stage we will have made an initial prototype of the watch.



Product Development

During this stage, we will be using an iterative development model to continuously improve upon our prototype, such as making the watch more durable, lightweight, aesthetically pleasing and most importantly making the measurements as accurate as possible to ensure that the final product is reliable.

Testing Phase

The testing of the watch is crucial to ensure accuracy and reliability of the flare-up prediction system. The aim is to maximise correct predictions while minimising false results.

Study Design:

- 1000 patients with a single condition (e.g. lupus) are selected, the sample should reflect the typical gender ratio in RAIRDs: 80 – 90% women
- Over 3 months, participants log daily symptoms, pain and stress. Weekly checkups are conducted
- When the watch predict a flare-up probability of >70%, it is treated as a positive test
- The prediction of the watch will be compared to the diagnosis of rheumatologist using clinical assessment and inflammatory markers (e.g. CRP, ESR)
- If the watch predicts a flare-up probability of >70% but no flare-up is diagnosed, it is a false positive. If a flare-up is diagnosed but the watch predicts a probability <70%, it is a false negative

Evaluation of Results:

- The results will be presented as a confusion matrix, measuring sensitivity and specificity
- The sensitivity and specificity will be plotted into a ROC curve to access the performance, a higher AUC indicates better accuracy. The performance would be considered satisfactory if AUC>0.7

Ethical Considerations:

- Informed consent must be obtained before data is collected from participants and they must be fully aware of how the data is used
- Data privacy and security must be ensured, especially sensitive health data
- Psychological impact of false predictions should be considered, as they may cause anxiety

Product Implementation

The watch can be made available to all applicable patients under the NHS for a subsidised fee such as £40. This will incur a loss but will ensure affordability for all RAIRDs patients. When working with the NHS, doctors can recommend the watch to patients to promote implementation. After distribution, the success of the flare-up prediction can be more accurately measured and to make back the loss incurred and maybe even make a profit, the technology can be sold to other countries and companies for global distribution – the UK can serve as a demonstration of the potential of the product.