Remote health monitoring

e/MTIC

Eindhoven MedTech Innovation Center

PhD Candidate Sonja Babac   *13th Jan 2025*

Present:

- PhD Candidate @ TU/e – Philips – Catharina Hospital
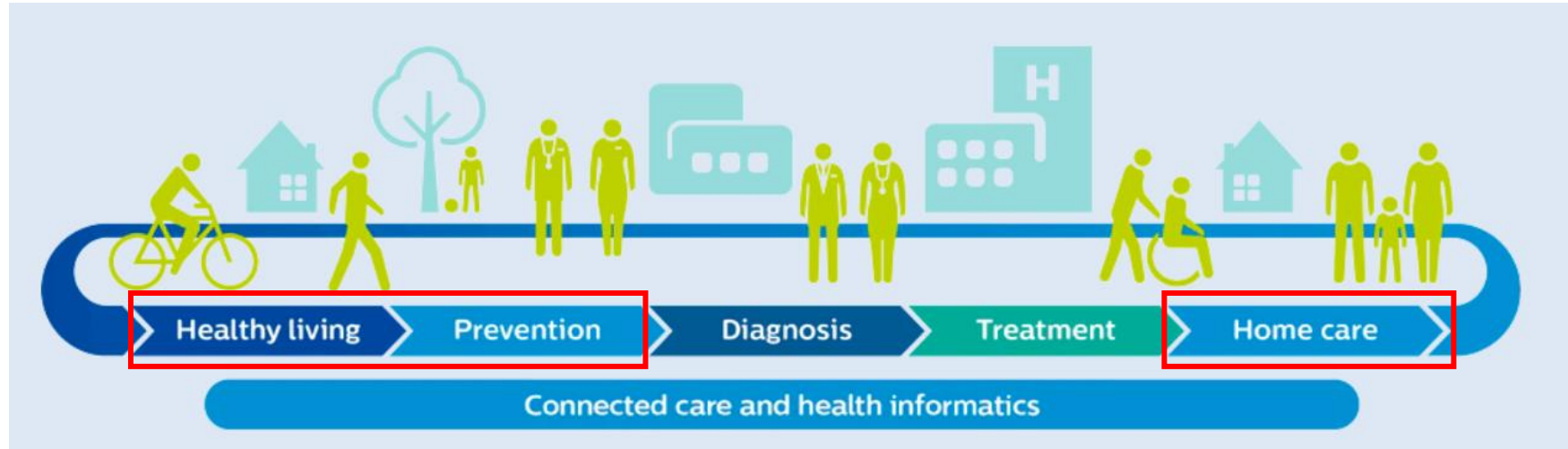- Researching AI & Signal Processing for Remote Health Monitoring

Past:

- Graduated Electrical Engineering Master @ TU/e in 2023
- Graduate Intern @ Philips - Vital Signs Camera
- Intern @ Nemo Healthcare - Remote Fetal Monitoring

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What is meant by remote health monitoring?

Health Continuum

Healthy living → Prevention → Diagnosis → Treatment → Home care →

Connected care and health informatics

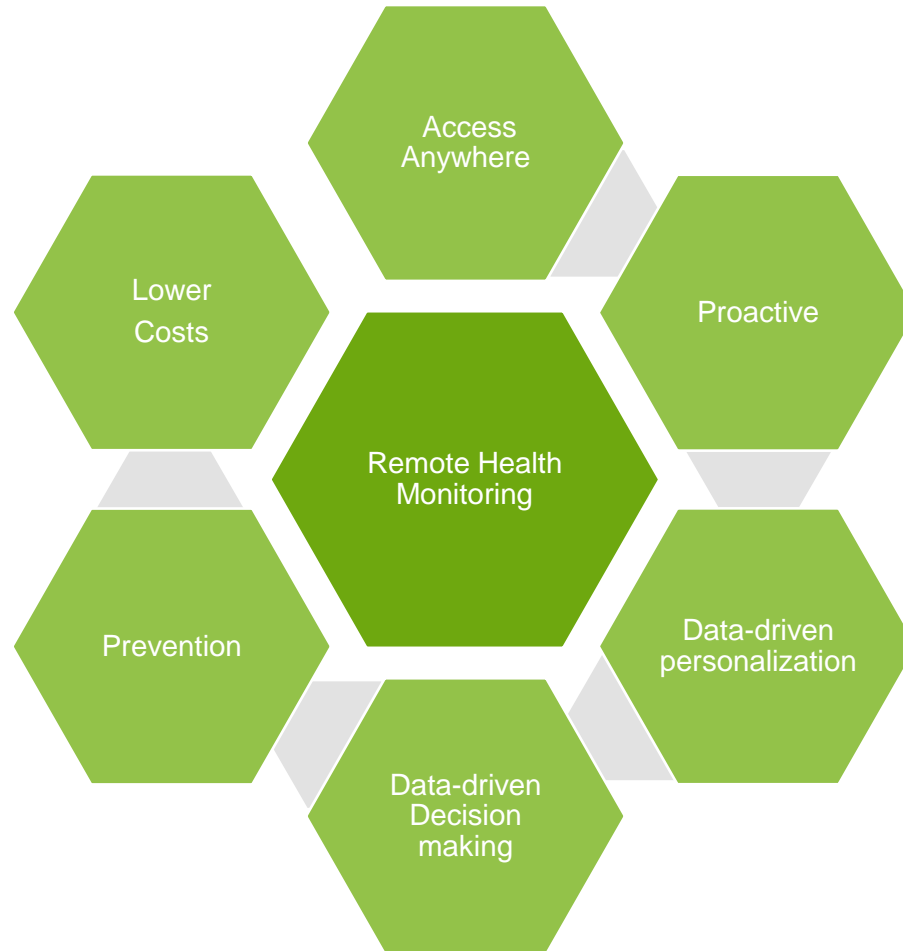# Remote Health Monitoring

Clinical Home Care:

- Patient monitoring using **_clinical-grade_** wearables

- Continuous postoperative vital signs data

- Telemonitoring for chronic diseases

- Telemonitoring for outpatient clinics

- Telehealth consultations

Fitness & prevention:

- health monitoring using **_fitness_** wearables
  - Cardiovascular health
  - Sleep
  - Recovery
  - Stress
  - Activity
  - Women's Health
  - Metabolic Health

- Health data summaries for physicians

What are the advantages of remote patient monitoring?

Remote Health Monitoring in Clinical Context

Remote patient monitoring

"The use of a device for interaction between providers and patients outside of the provider's organization "

Why remote patient monitoring?

" Many patients want to recover in their own environment. Supported by the Healthdot, we offer these people the option to go home earlier with the guarantee that the hospital is still monitoring their health. This form of continuous monitoring also offers the possibility to detect complications at an early stage. The hospital can therefore provide good care while relieving the burden on bed capacity."

Dr. Simon Nienhuijs
Bariatric Surgeon at Catharina Hospital

73% of healthcare professionals across 19 countries say connected technology is important to improving the prevention of medical issues.[22]

By 2022, **60%** of chronic disease pathways will involve remote patient monitoring.[16]

30% of all ambulatory encounters will be virtual, up from about 2% at the start of 2020.[16]

Why remote patient monitoring?

- Data-driven clinical decision making
  - Accurate vitals signs monitoring guaranteed
  - High-frequency continuous measurements
  - Early deterioration detection
- Lowering healthcare costs
  - Relieving the burden on bed capacity
  - Relieving the burden of staff shortages
- Home comfort
  - Receive health guidance @ home remotely (Telehealth)
  - Fewer commutes to the hospital
  - Lowering chances of hospital infections
  - Recover or monitor health in your own environment

Postoperative remote monitoring

Postoperative remote monitoring

Patient receives Healthdot sensor

Care provider can monitor patient at home

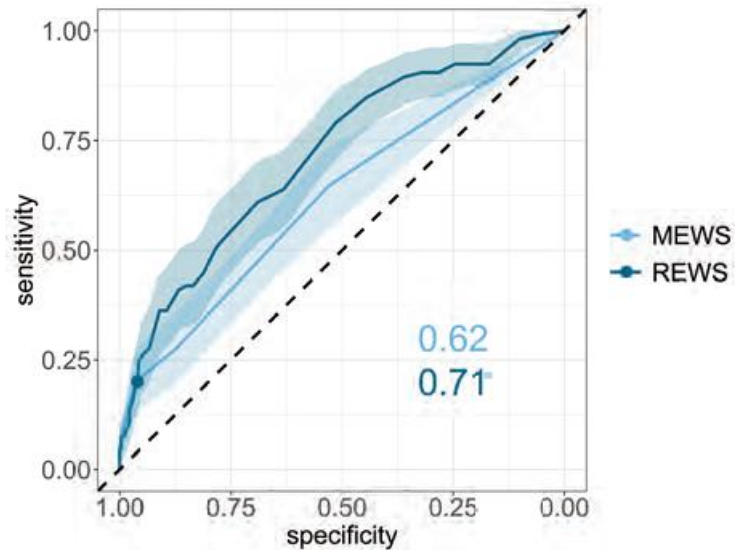If there is anything, the healthcare provider can respond

Early deterioration detection

- Cardiovascular health
  - Heart rate
  - Resting heart rate
  - Heart rate variability
  - Respiration rate
  - Cardiorespiratory coupling
- Sleep health
  - Circadian rhythm
  - Sleep quality
- Activity
  - Daily movement

Early warning score

Remote Early Warning Score

The REWS was built based solely on automatically collected HR and RR measurements from the wearable.

Receiver operating characteristic (ROC) curve for the Modified Early Warning Score (MEWS) and Remote Early Warning Score (REWS) to describe the development of a deterioration in the next 24 h. Displaced numbers are the area under the ROC-curves. Dashed line represents the random-guessing line.
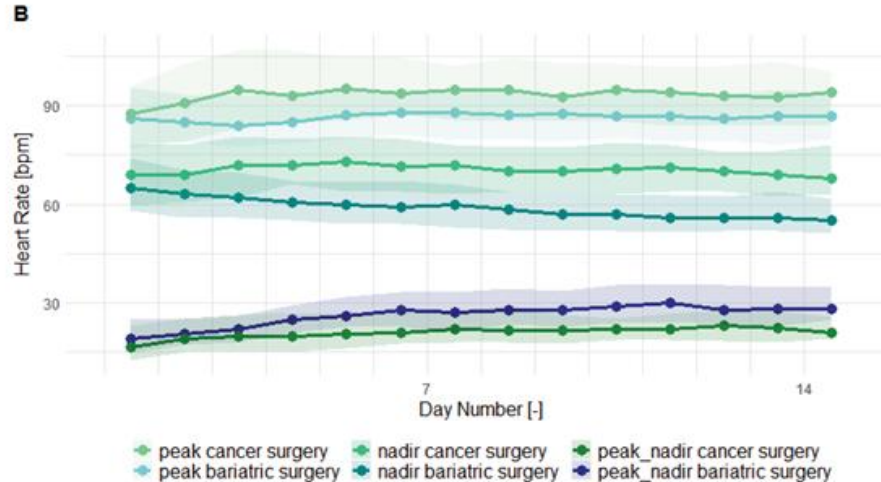
van der Stam, J. A. et al.

Circadian rhythm in postoperative patients

A Postoperative heart rate in patients without deterioration

cancer surgery ▬ bariatric surgery
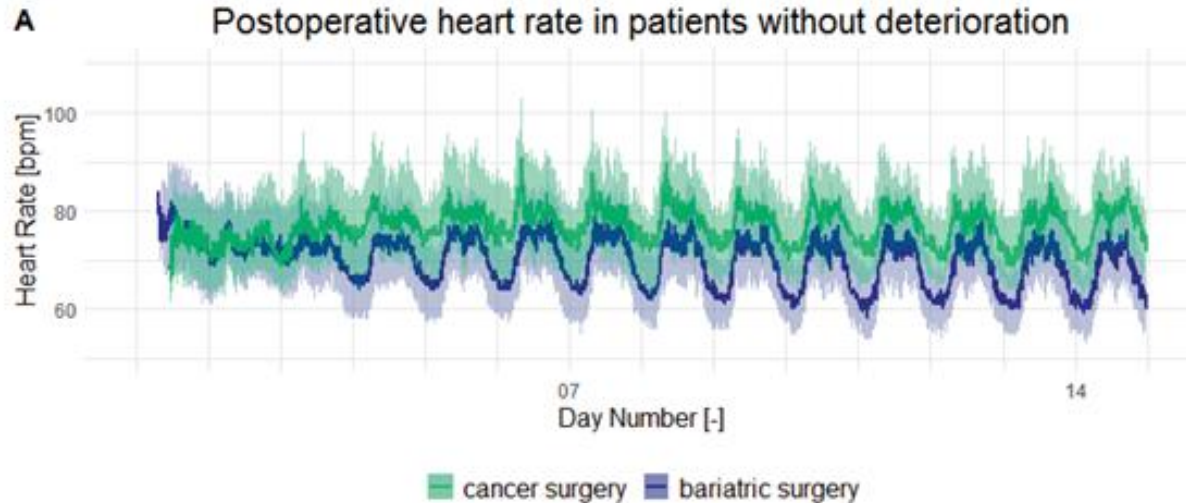
Postoperative heart rate of the bariatric (blue) and cancer surgery (green) subgroups. The line indicates the median heart rate, and the shaded area indicates the IQR.

van der Stam, J. A. et al.

Circadian rhythm in postoperative patients

Postoperative peak, nadir and peak-nadir excursions of the heart rate of the bariatric (blue) and cancer surgery (green) subgroups. Dots indicate the daily median value for the respective features, and shaded areas indicate the IQR.

van der Stam, J. A. et al.

Devices for postoperative patient monitoring

Health Dot

Accelerometry based:

- Heart rate
- Respiration rate
- Activity
- Posture

ViQtor

PPG based:

- Heart Rate
- HRV
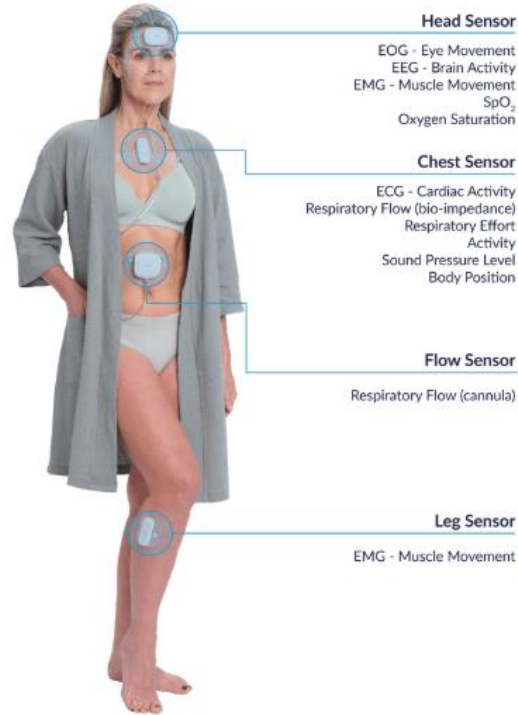- Respiration Rate
- SpO2

Accelerometry based:

- Activity

Other:

- Temperature

Other use cases of remote patient monitoring

# Clinical grade sleep monitoring @ home

Head Sensor

EOG - Eye Movement
EEG - Brain Activity
EMG - Muscle Movement
SpO$_2$
Oxygen Saturation

Chest Sensor

ECG - Cardiac Activity
Respiratory Flow (bio-impedance)
Respiratory Effort
Activity
Sound Pressure Level
Body Position

Flow Sensor

Respiratory Flow (cannula)

Leg Sensor

EMG - Muscle Movement

Sleep diagnostics and monitoring, redefined.

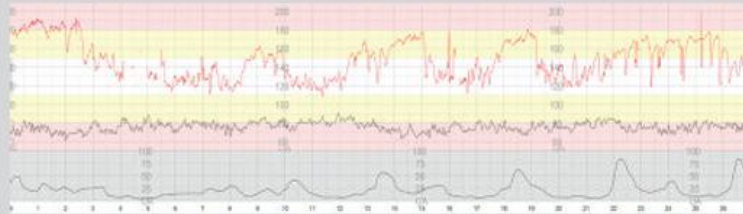The first self-applied, no-wire
Polysomnography solution.

onera

Video link

Clinical grade fetal monitoring @ home
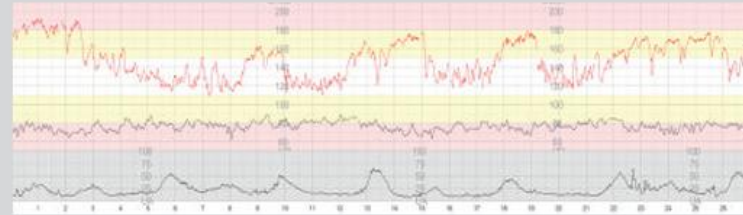
Tracing with the Nemo Fetal Monitoring System

Standard monitoring with fetal scalp electrode (FSE) and toco

"We need a non-invasive fetal monitoring system - also in a future with obesity - which provides qualitative information and allows intervention, before any damage occurs to the unborn child."

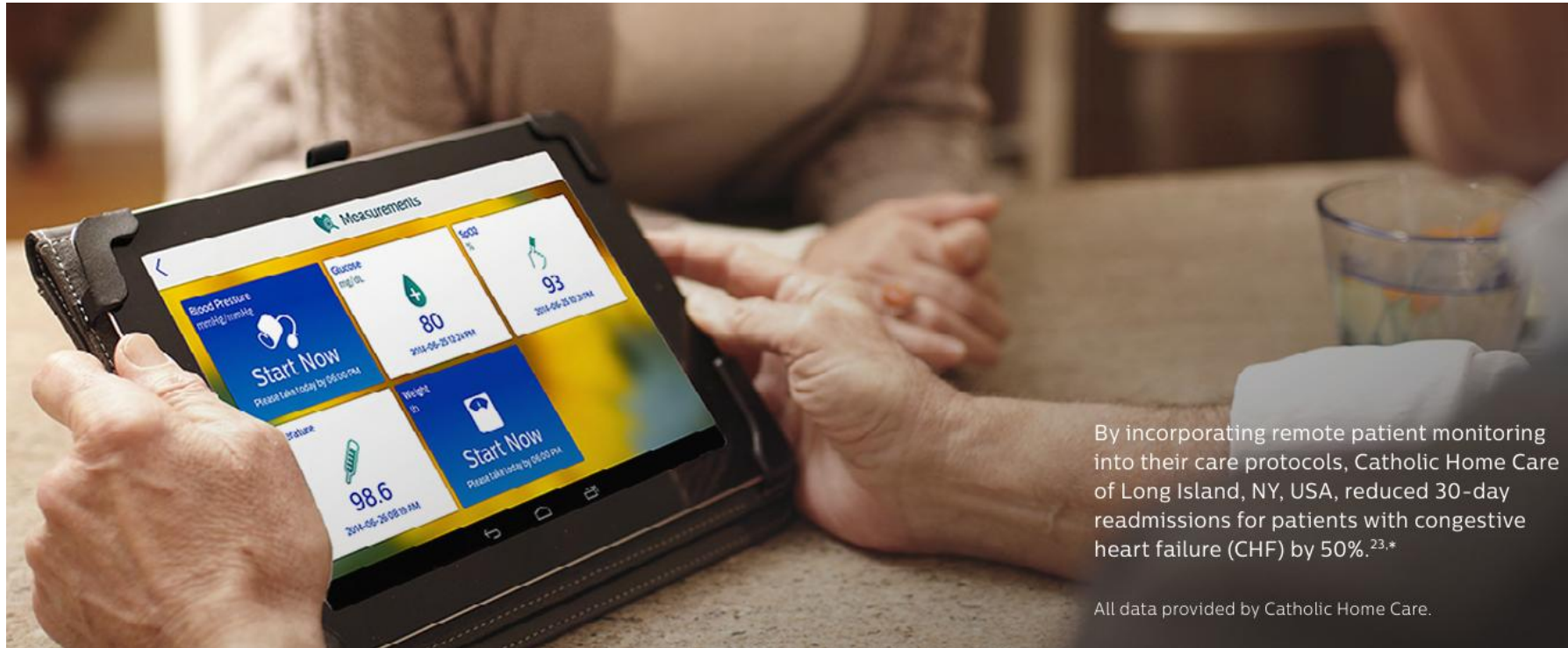Prof. Dr. Y. (Yves) Jacquemyn, UZA - Antwerp University Hospital.

Video link

Chronic disease monitoring @ home

- COPD
- Asthma
- Pacemaker patients
- Heart Failure
- Atrial Fibrillation
- Diabetes
- Obesity
- Hypertension

Luscii
an OMRON Healthcare Service

Video link

Chronic disease monitoring @ home

By incorporating remote patient monitoring into their care protocols, Catholic Home Care of Long Island, NY, USA, reduced 30-day readmissions for patients with congestive heart failure (CHF) by 50%.[23,*]

All data provided by Catholic Home Care.

Chronic disease monitoring @ home

In Canada, a pilot program is underway utilizing Philips early warning scoring to wirelessly monitor patients' vital signs in the ward and at home. [27,28,*]

Diabetes monitoring @ home

- Continuous Glucose Monitor
- App for diabetes management
  - Food intake
  - Insulin intake
  - Medication management
  - Alerts for low blood glucose
 - Alerts for high blood glucose

Vital Signs Camera

Vital Signs Camera

29

Vital Signs Camera

- Uses remote PPG (PhotoPlethysmoGraphy)

- Camera tracks rise/fall of chest and abdomen to determine respiration rate

- Tiny changes in skin color caused by HR are detected (invisible micro-blushes)

- Philips solved many challenges associated with this technique (motion, light, etc.)

- Suitable for TeleHealth consultations

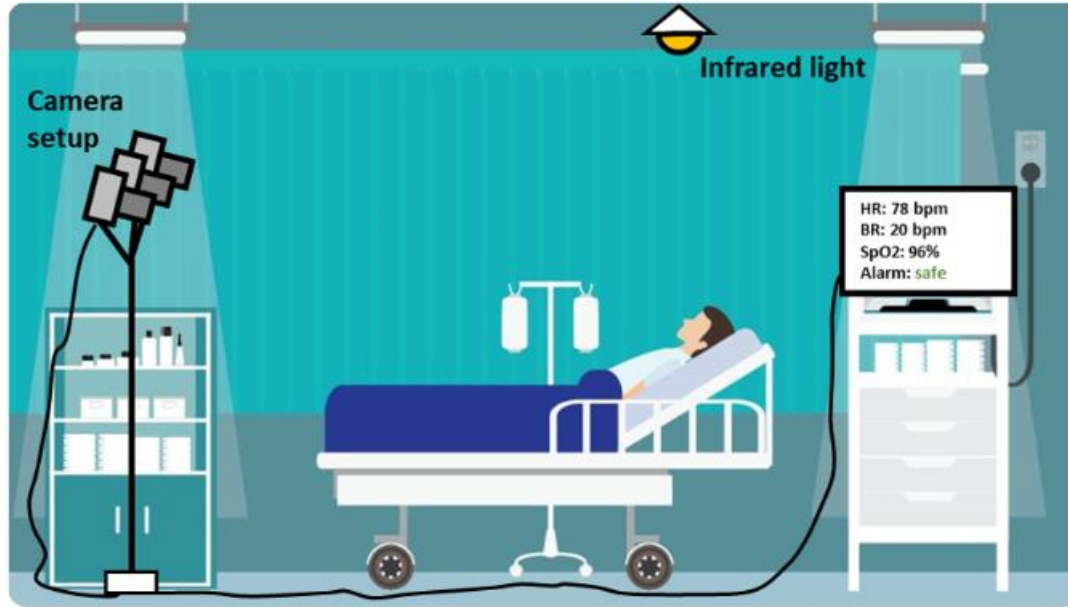- Suitable for monitoring @ lower acuity wards

Vital Signs Camera
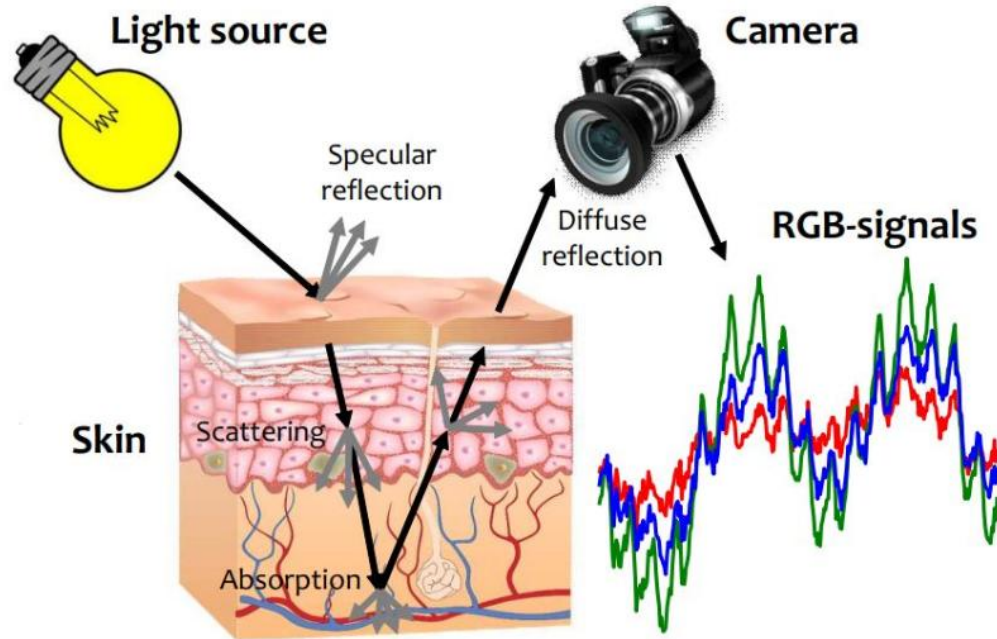
Vital Signs Camera

Video link

Vital Signs Camera

Remote Health Monitoring for Fitness & Prevention

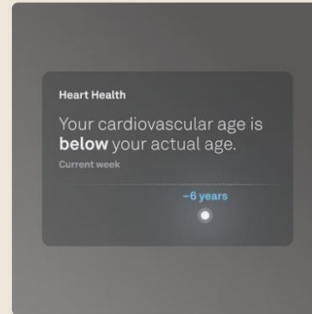# Fitness wearables: wrist watch

Fitness wearables: wrist band

Fitness wearables: smart ring

24/7 Heart Rate Monitoring
See how your heart rate changes, day and night. Learn how your body responds to daily habits, meals, stress, and environment.
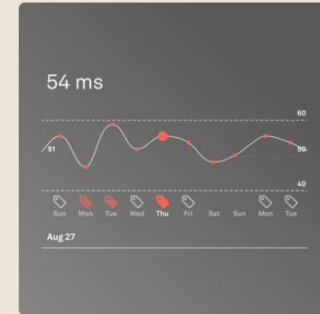
Cardiovascular Age
Quickly understand how your cardiovascular system is aging relative to your chronological age, and what that may mean for long-term health.

Cardio Capacity
Get an estimate of your VO2 Max, or how efficiently your body delivers and utilizes oxygen during intense physical effort.

Heart Rate Variability
Oura tracks your HRV to help you understand if you're stressed, sick, or need to take time to recover.
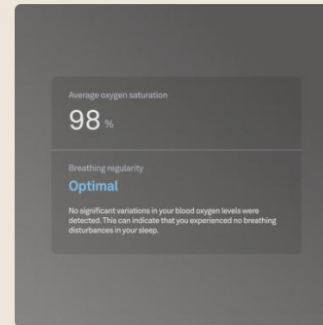
Fitness wearables: smart ring

Sleep Score

The answer to "how did you sleep last night?" Your score is based on your total sleep, heart rate variability (HRV), nighttime movement, sleep regularity, and more.
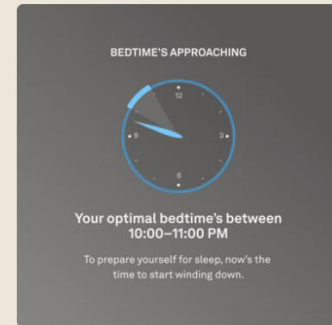
Sleep Stages

Wake up to in-depth analysis of your deep sleep, REM sleep, and light sleep from the night prior.
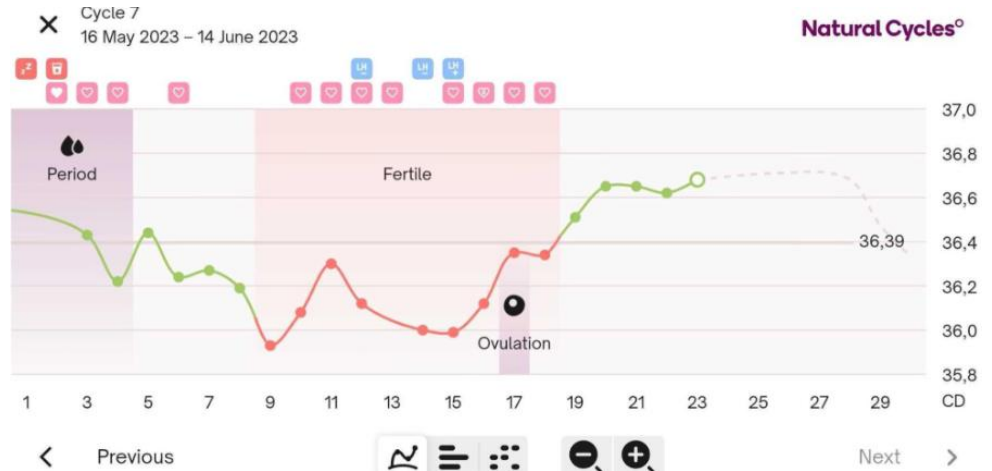
Blood Oxygen Sensing

By detecting your blood oxygen levels at night, Oura can tell if you're experiencing any breathing disturbances.

Bedtime Guidance

Oura reminds you when to start winding down so you can improve your sleep quality.

Women's Health Monitoring

Health monitoring in-vehicles

Adoption outlook of remote health monitoring

Big Data Infrastructure Costs

Data reliability

Secure Network Connection

Remote Health Monitoring CHALLENGES

Missing Data

Reliable Network connection

Patient Disobedience

Interested in an MSc internship or thesis project in Remote Health Monitoring?

Contact: s.babac@tue.nl

Thank you for your attention

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