




vito

YOUR HEALTH IN THE BLINK OF AN EYE
VITAL SIGNS AND ENVIRONMENTAL MONITORING:
TOWARDS CONNECTED HEALTH

DR. PATRICK DE BOEVER
VITO & HASSELT UNIVERSITY

VITO - VISION ON TECHNOLOGY



RTO
Research Technology Organization

Strategic research

Applied innovative technology

Health

Energy

Chemistry

Material

Land use

Industry

Government

2

vito



vito

HEALTH



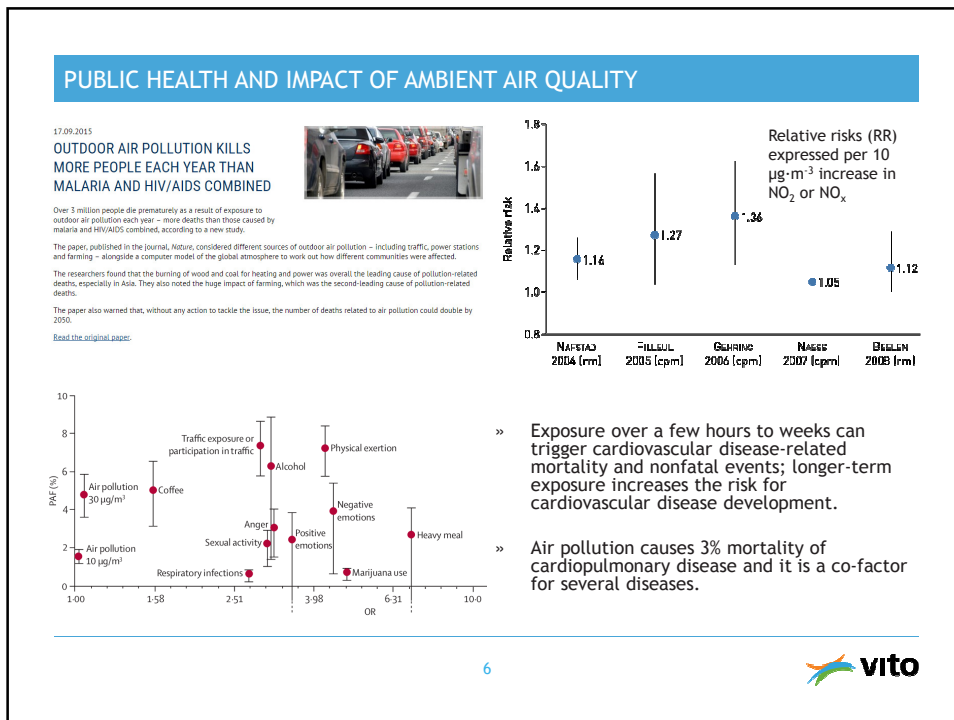
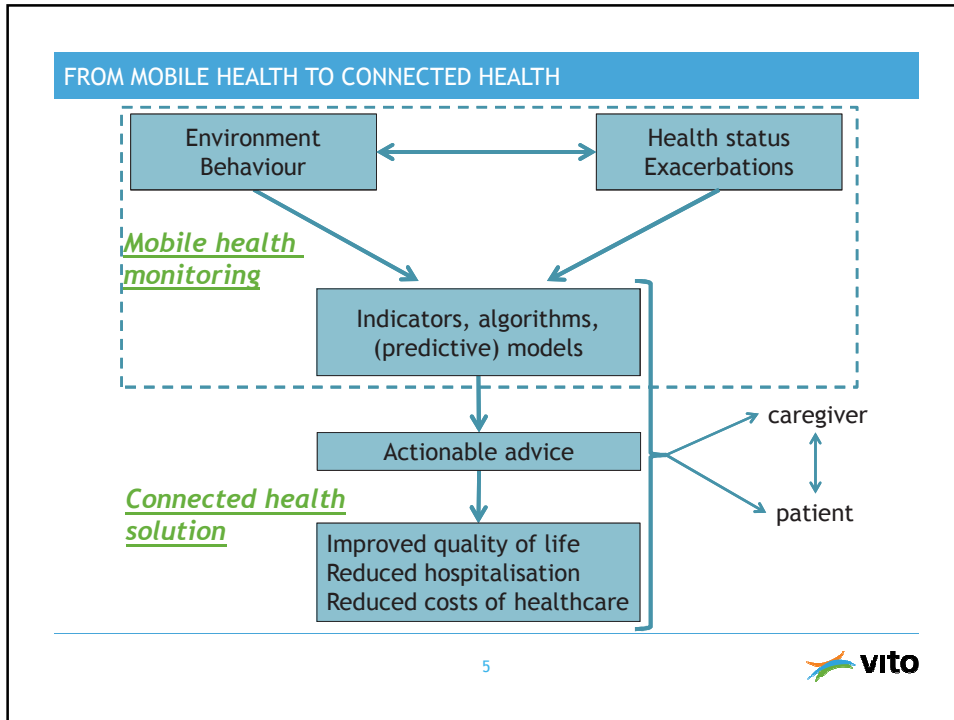
VITO-Health is at the forefront of research into precision medicine, from biomolecular research to mobile health monitoring technologies

VITO-Health is developing biomarkers for early diagnostics, screening and prognosis and is testing and integrating sensors for convenient and every day monitoring. Data science and analytics is key in all of our research

VITO-Health performs contract research with a focus on improving environment, health and safety aspects in public and private sectors

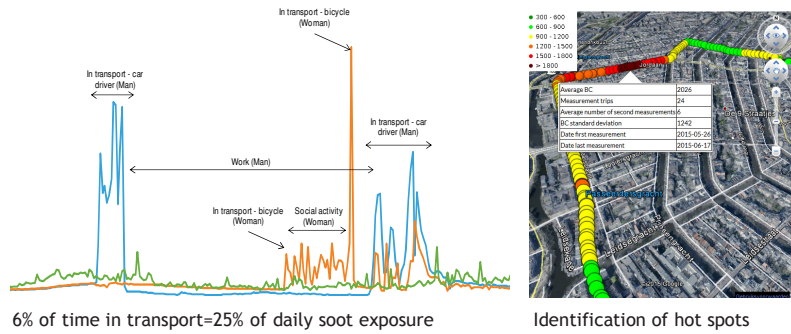
CONNECTED HEALTH CAN LEAD INNOVATION IN HEALTHCARE

- » VITO-Health is working on Connected Health solutions
- » Develop innovative services designed around the needs of patient & healthcare professional
 - » Prevention and lifestyle management
 - » Therapeutic compliance (pharmacological and non-pharmacological)
- » Collect data from patient using smart sensors and integrate with existing medical information
 - » Heterogeneous patient data
 - » Regular ambulatory measurements
 - » Patient records
- » Use data analytics to develop decision-support to predict and prevent
- » “rather than continuously developing more complex hardware without addressing their implementation and valorisation targets, ... deep integration of existing technology into innovative solutions and innovative business models are needed.”



EXPOSURE ASSESSMENT WITH PORTABLE SENSORS

- » Personalized monitoring
- » Activity levels and ventilation rates
- » Behaviour (routes, transport modus,...)
- » Whereabouts



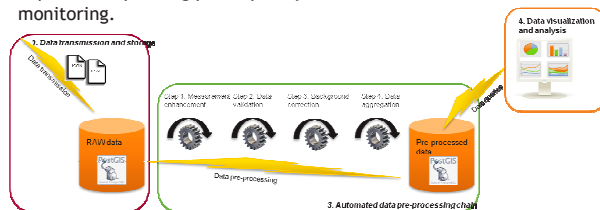
7



AIR-Q-MAP: PORTABLE APPLICATION FOR AIR QUALITY MAPPING



airQmap collects large amounts of mobile BC measurements and processes them into personal exposure maps and street-level exposure maps using participatory monitoring.



8

airQmap



HEALTHY LUNGS FOR LIFE ROUTE FOR WALKING AND CYCLING

I am amsterdam city map

HEALTHY LUNGS FOR LIFE

Exercise and air quality: 10 top tips

- 1 Consider your location and route**
When exercising in a town or city, make use of parks, public spaces and trails with low emission zones as much as possible. A growing amount of research is showing that green spaces contribute to our health and wellbeing.
- 2 Keep a healthy distance from the road**
If you are cycling, jogging or walking outdoors, it is best to avoid doing this close to roads – particularly busy ones – if possible. Studies have shown that air pollution levels are higher on busier roads, but that the amount of pollution drops in line with how far away you are from a road. For example, you will be exposed to lower levels of air pollution just 1-2 m away from the main flow of traffic. In addition, you may want to consider using a parallel road that is quieter and safer.
- 3 Move around vehicles**
When cycling, jogging or walking behind cars, scooters, motorcycles, lorries and other vehicles, you will breathe in very high levels of pollutants that can be harmful to your lungs. If it is safe to do so, move around these vehicles to try to reduce your exposure and keep your distance.
- 4 Avoid busy roads with high buildings**
Air pollution tends to get trapped within roads with tall buildings on either side, so this type of road usually has poor air quality and should be avoided for exercise. Traffic lights are another pollution hotspot to avoid, as when vehicles move away from traffic lights they give off more emissions.
- 5 Check the air quality index of the day**
Actual air pollution levels depend on the type of pollutant, the location and local weather. Many governments have monitoring stations that continuously measure and report levels of different air pollutants. Some also give forecasts, which you could use to decide when would be better to do your outdoor exercise. Try to find a source that is specific for your location. You can find Europe-wide air quality reports at <http://atmosphere.copernicus.eu/services-air-quality-atmospheric-composition>.
- 6 Check the weather forecast**
Air pollution tends to be at its highest on hot, sunny days, while the air tends to be cleaner after rainy or windy weather. If you have a pollen allergy, you may have more issues on days where pollen levels are high as pollen can interact with pollution. Check your local air quality forecast for more information.
- 7 Avoid exercising during rush hours**
Try to avoid being physically active outdoors during rush hour in busy traffic areas or other times when lots of cars will be on the roads. Choose an alternative, quieter route or another time to be active.
- 8 Choose healthy travel options**
Driving a car to get around contributes to the air pollution problem. Why not consider using public transport, or 'taking the active option' and walking or cycling? These options will help you to reach your daily physical activity goals, while contributing to a cleaner environment.
- 9 Avoid exposure to indoor air pollution and second-hand smoke**
If you exercise at a gym, at home or in another indoor space, you could come into contact with indoor air pollution and/or second-hand smoke, so it is worth considering potential pollutants in this environment and how you can protect yourself from them. Vacuuming, and using cleaning products and air fresheners may reduce air quality, so try to avoid exercise immediately after cleaning.
- 10 Be active!**
Do not be afraid to be active and exercise – environmental and lung health experts agree that the health risks associated with breathing in air pollution while exercising are less significant than those of an inactive lifestyle.

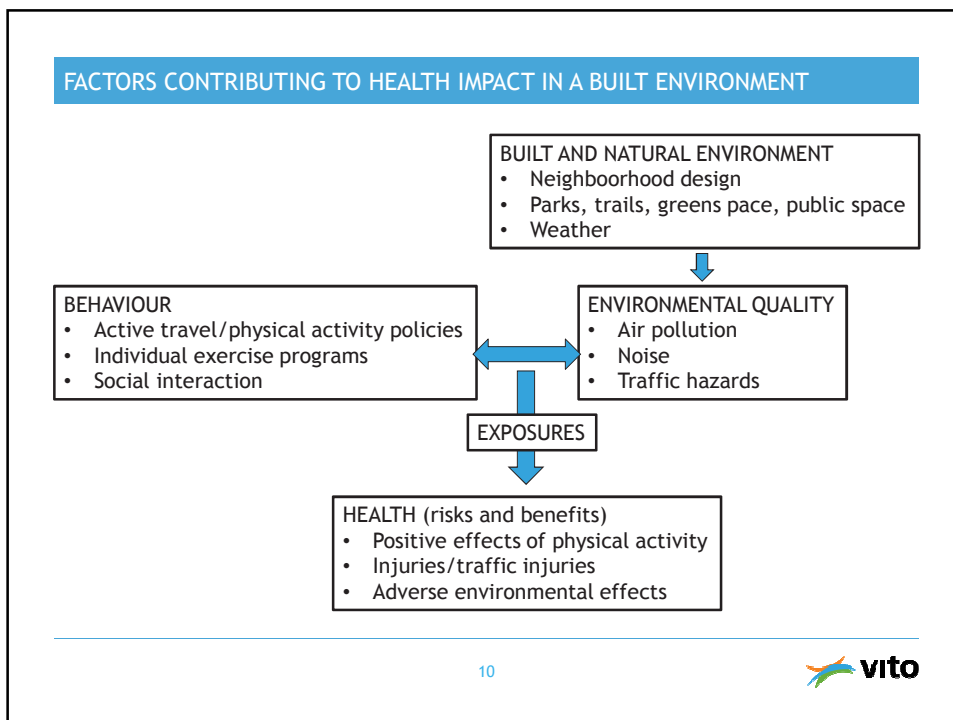
vito

LONG FONDS

TNO innovation for life

<http://www.airqmap.com/>

9

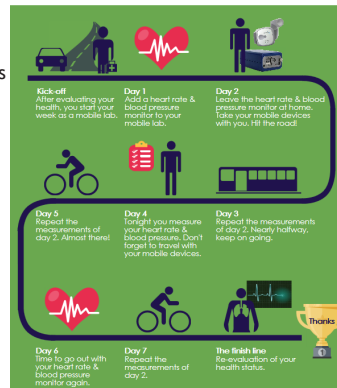


VITO STUDIES HEALTH IMPACT OF ACTIVE TRAVEL IN EUROPEAN CONTEXT

- » Field study with volunteers to better understand impact of activity and environmental quality on health
- » 120 participants; 4 seasons; 1 week/season
 - » Antwerp
 - » London
 - » Barcelona
- » Convenient monitoring with wearable and portable sensors
 - » Transport mode
 - » Activity levels
 - » Personal exposure levels
 - » Vital signs & physiological parameters
- » PASTA online survey on mobility and physical activity
 - » Crowdsourcing on 14,000 participants/7 cities
 - » What are determinants of active travel?
 - » What are good measures to promote active travel?

HOW HEALTHY ARE YOU?

The measurement week



SENSORS USED TO STUDY IMPACT OF ACTIVITY AND ENVIRONMENTAL QUALITY

- » Environmental quality and activity



μ-Aethalometer



Sensewear



GPS



Zephyr
BioHarness



Smartphone
(ExpoApp)

- » Vital signs and physiological parameters



Heart rate
variability



Blood pressure



Retinal imaging




Lung
inflammation




Lung function

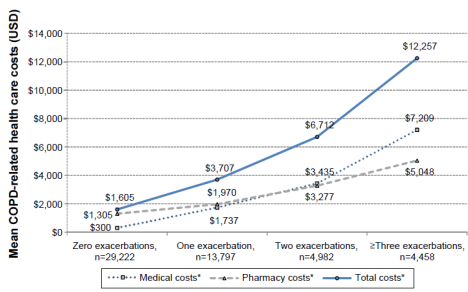
CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD) AND DISEASE FACTORS



In the adult population aged over 40 years, **moderate and severe COPD** is prevalent in 5-10% of the population and including mild cases the prevalence is **15-20%**



Every year, 300,000 Europeans die from COPD




Number of Exacerbations	Medical costs*	Pharmacy costs*	Total costs*
Zero exacerbations, n=29,222	\$300	\$1,305	\$1,605
One exacerbation, n=13,797	\$1,737	\$1,970	\$3,707
Two exacerbations, n=4,982	\$3,277	\$3,435	\$6,712
≥ Three exacerbations, n=4,458	\$5,048	\$7,209	\$12,257

Particulate matter air pollution exposure: role in the development and exacerbation of chronic obstructive pulmonary disease


An official European Respiratory Society statement on physical activity in COPD

13



WEARABLE SENSORS FOR PREDICTING ONSET OF EXACERBATION

Hurst et al. *BMC Pulmonary Medicine* 2010, 10:52
<http://www.biomedcentral.com/1471-2466/10/52>



RESEARCH ARTICLE


Open Access

Domiciliary pulse-oximetry at exacerbation of chronic obstructive pulmonary disease: prospective pilot study

John R Hurst[†], Gavin C Donaldson, Jennifer K Quint, James JP Goldring, Anant RC Patel, Jadwiga A Wedzicha

Heart rate (HR)
Oxygen saturation (SpO₂)
Peak-expiratory flow (PEF)

Pedone et al. *BMC Health Services Research* 2013, 13:82
<http://www.biomedcentral.com/1472-6963/13/82>



RESEARCH ARTICLE


Open Access

HR
SpO₂
Physical activity (PA)
Near-body temperature

Efficacy of multiparametric telemonitoring on respiratory outcomes in elderly people with COPD: a randomized controlled trial



Claudio Pedone^{1,2*}, Domenica Chiurco^{1*}, Simone Scarlata¹ and Raffaele Antonelli Incalzi^{1,3}



14

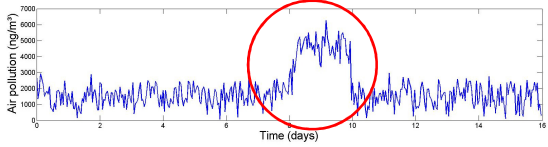
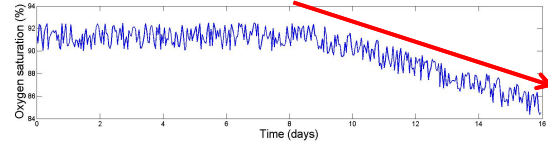


VITO DEPLOYS WEARABLE SENSORS FOR A COPD MONITORING SYSTEM

- » 20 COPD patients + 20 partners
- » Variables:
 - » O₂ saturation + heart rate: Nonin WristOx2
 - » Physical activity : SenseWear Armband
 - » Environmental quality: microAethalometer+ GPS
 - » Heart rate/ECG monitoring: Zephyr Bioharness 3





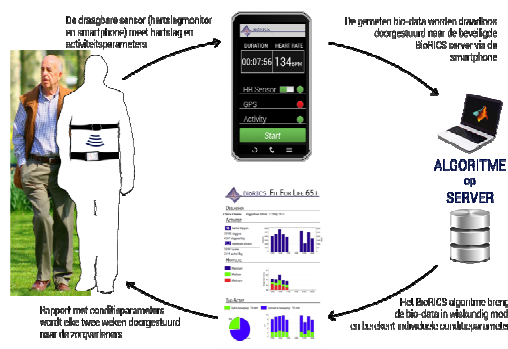
Day 16:
Patient health status ↓

15



FIT-4-LIFE 65+ PROOF OF CONCEPT STUDY FOR WEARABLE SENSORS

- » Monitor physical activity in elderly patients
- » Estimate physical activity trends
- » Predict more continuously fitness levels




De draagbare sensor (hartslagmonitor en sensortijden) meet hartslag en activiteitsparameters

De gemeten bio-data worden draadloos doorgezonden naar de beveiligde BioRICS server via de smartphone

Het BioRICS algoritme brengt de bio-data in wiskundig model en levert individuele aanbevelingen

Rapport met coachparameters wordt elke twee weken doorgezonden naar de zorgverlener

'Fit-for-Life 65+' project







Zin en doel te weten? Een jaar de mensen op maandag 11 maart en 15.00u of op 18.00u

Wat is 'Fit-for-Life 65+'? 'Fit-for-Life 65+' is een studie die het doel heeft om de invloed van beweging bij senioren te onderzoeken.


Wat houdt het project in? 40 bewoners van het Grauwekasteel nemen aan dit project deel. Een eerste groep (20 personen) krijgt vanaf april een monitor die gedurende 3 maanden meet hoeveel ellefocussen dagelijks beweegt. De tweede groep fungeert als controlegroep. Deze deelnemers krijgen hetzelfde bewegingsadvies maar dragen geen monitor.

Wat wilt men bereiken? Het onderzoek wilt vaststellen dat senioren die de monitor dragen en informatie krijgen over hun conditie, positief geïnspireerd worden om meer te gaan bewegen en dus langer fit blijven.

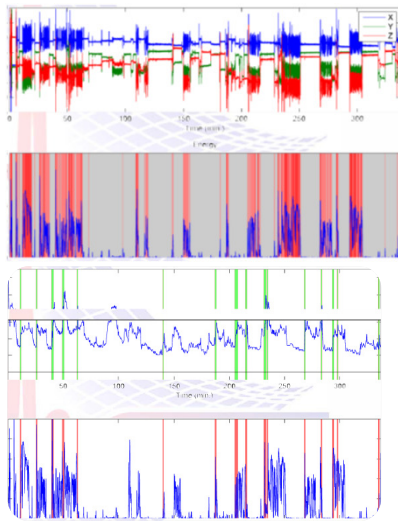
Bewegen is belangrijk: het houdt ons fit ons leven lang!

16



CALCULATED PERFORMANCE SCORE VERSUS PHYSICAL FITNESS TEST



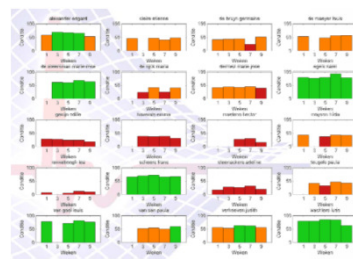
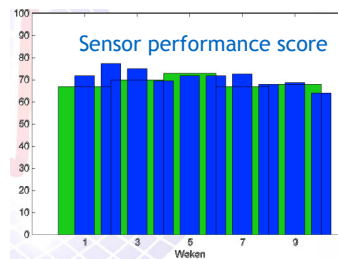
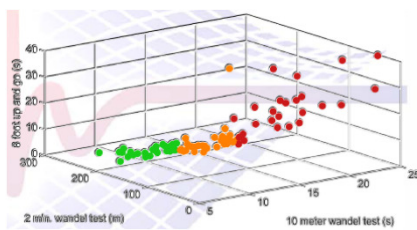
- » Strength: stand up and 8 foot up & go
- » Fitness: 10 m and 2 min walk test
- » Flexibility: backscratch and chair sit/reach



17



DAILY PERFORMANCE OF THE SENSOR IN ELDERLY HOMECARE



- » Sensor estimates fitness and discrimination between 3 fitness levels
- » With 75% correct classification, the sensor has promise as a field tool to monitor activity and performance
- » Sensor was well accepted by participants and health care professionals, but usability needs refinement

18





vito

HEALTH



iflexis
eye on health

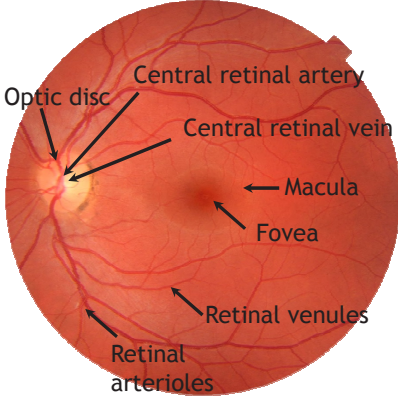
Comfortable health screening and better disease detection in the blink of an eye

Non invasive retinal imaging and data analytics

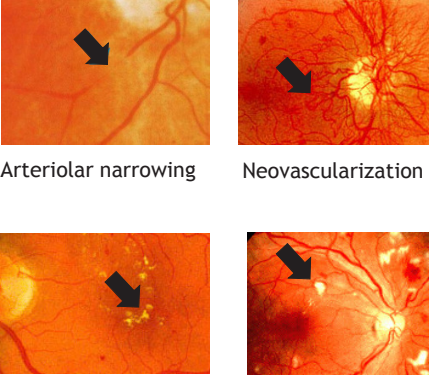
Software for quantitative retinal image analysis and algorithms for decision-making

THE RETINA IN HEALTH AND DISEASE

Healthy retina



Examples of retinal disease signs




Arteriolar narrowing

Neovascularization

Hard exudates

Cotton wool spots

20



CONVENIENT MONITORING WITH CLOUD ANALYTICS FOR HEALTH ASSESSMENT

- » Minimal client deployment
- » Interactive environment
- » Easy-to-use interface
- » Store and manage data
- » Customizable analysis workflows
- » Structured searches
- » Aggregation and reporting

Physician Researcher


Store Manage Analyze Aggregate

21

SYSTEMIC MICROVASCULATURE AND RETINAL MICROVASCULATURE AS PROXY

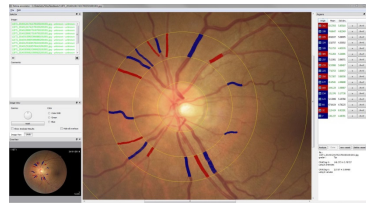
Microvasculature

- » Vessel diameter < 150µm
- » Functions
 - » Tissue perfusion
 - » Exchange O₂/CO₂ and nutrients/waste
 - » Blood flow & blood pressure
 - » Body temperature regulation
- » Retina allows visualisation of microvessels



Quantification of retinal vasculature

- » Width of blood vessels
 - » Individual blood vessels
 - » Central artery & vein (CRAE & CRVE)
- » Geometric complexity
 - » Tortuosity
 - » Branching pattern (angles, end points,...)
 - » Fractal dimension



22

EPIDEMIOLOGICAL OBSERVATIONS OF CHANGES IN RETINAL VASCULATURE

Narrowing of arterioles, widening of venules and changes in the geometric pattern leading to suboptimal blood flow

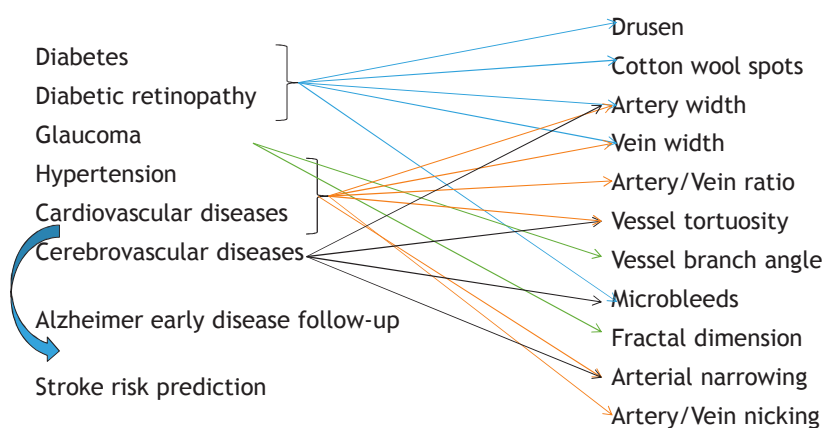
- » Disease evolution and disease severity in patients
 - » Diabetic retinopathy
 - » Hypertension
 - » Alzheimer & cognitive impairment in elderly
 - » Ischemic stroke

- » Physiological observations in healthy individuals
 - » Chronic effect of physical inactivity and time spent before TV screen
 - » Impact of carbohydrate nutrition
 - » Long term exposure to air pollution and particulate matter

23



DISEASES ASSOCIATED WITH RETINOVASCULAR PARAMETERS



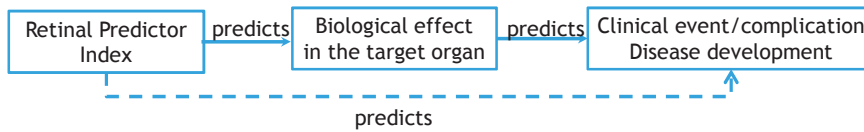
24



MODEL FOR USING RETINAL BIOMARKERS



- Need for unobtrusive and longitudinal monitoring
- Point-of-care testing systems and decentralized monitoring
- Sensitive biomarkers and decision support systems



25




CONCLUSION

- » Many technologies for monitoring physiological signals exist in the market
- » Products/services with added-value have to be created for further adoption in healthcare
- » Benchmarking is needed in terms of available standards, field application and deployment cost
- » Combination of heterogeneous data gives more insight
- » Environment & lifestyle are increasingly taken into account for mobile/connected health
- » VITO Connected Health works at interphase between technology providers and end users
 - » Environmental quality/activity for population monitoring and COPD patient monitoring
 - » Activity and fitness monitoring of elderly
 - » Retinal scanning as a convenient analysis for early disease identification & follow-up

26





vito

DR. PATRICK DE BOEVER
VITO & HASSELT UNIVERSITY
PATRICK.DEBOEVER@VITO.BE

YOUR HEALTH IN THE BLINK OF AN EYE
VITAL SIGNS AND ENVIRONMENTAL MONITORING:
TOWARDS CONNECTED HEALTH