



LEIDEN UNIVERSITY MEDICAL CENTER

Home monitoring in atrial fibrillation, heart failure and thoracic surgery

Roderick W. Treskes

Resident & Postdoc Cardiology



HEART LUNG
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Disclosures

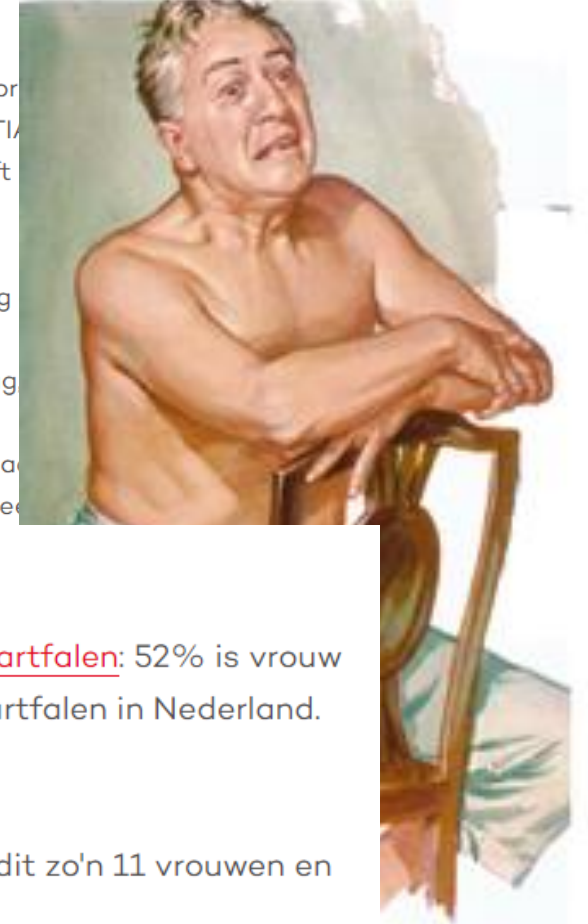
- Employment status: employed by Leiden University Medical Center
- Received speaker's fees from Boston Scientific, Pfizer, Sanofi
- No shares in Boston Scientific, Pfizer, Sanofi or other medical companies



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Home monitoring

Home monitoring: why bother?



START

HOW GREAT LEADERS INSPIRE
EVERYONE TO TAKE ACTION

WITH

SIMON SINEK

New York Times bestselling author of *Leaders Eat Last* and *Together Is Better*

WHY

MORE THAN
ONE MILLION
COPIES SOLD

Cijfers beroerte

In 2021 werden zo'n 40.000 mensen getroffen door een beroerte en ruim 53.000 door een TIA. Elke dag worden 110 mensen getroffen door een beroerte en 146 door een TIA. Ongeveer 80% van de mensen met een beroerte heeft een herseninfarct. 20% heeft een hersenbloeding.

- In Nederland leven zo'n 372.000 mensen met de gevolgen van een hersenbloeding herseninfarct.
- In 2021 stierven bijna 9.000 mensen aan een beroerte. Dat zijn 25 mensen per dag, 11 mannen en 14 vrouwen.
- Mannen zijn gemiddeld 79 jaar als ze overlijden aan een beroerte en vrouwen 83 jaar.
- Ongeveer 2 op de 3 patiënten met een herseninfarct en 1 op de 3 patiënten met een hersenbloeding.

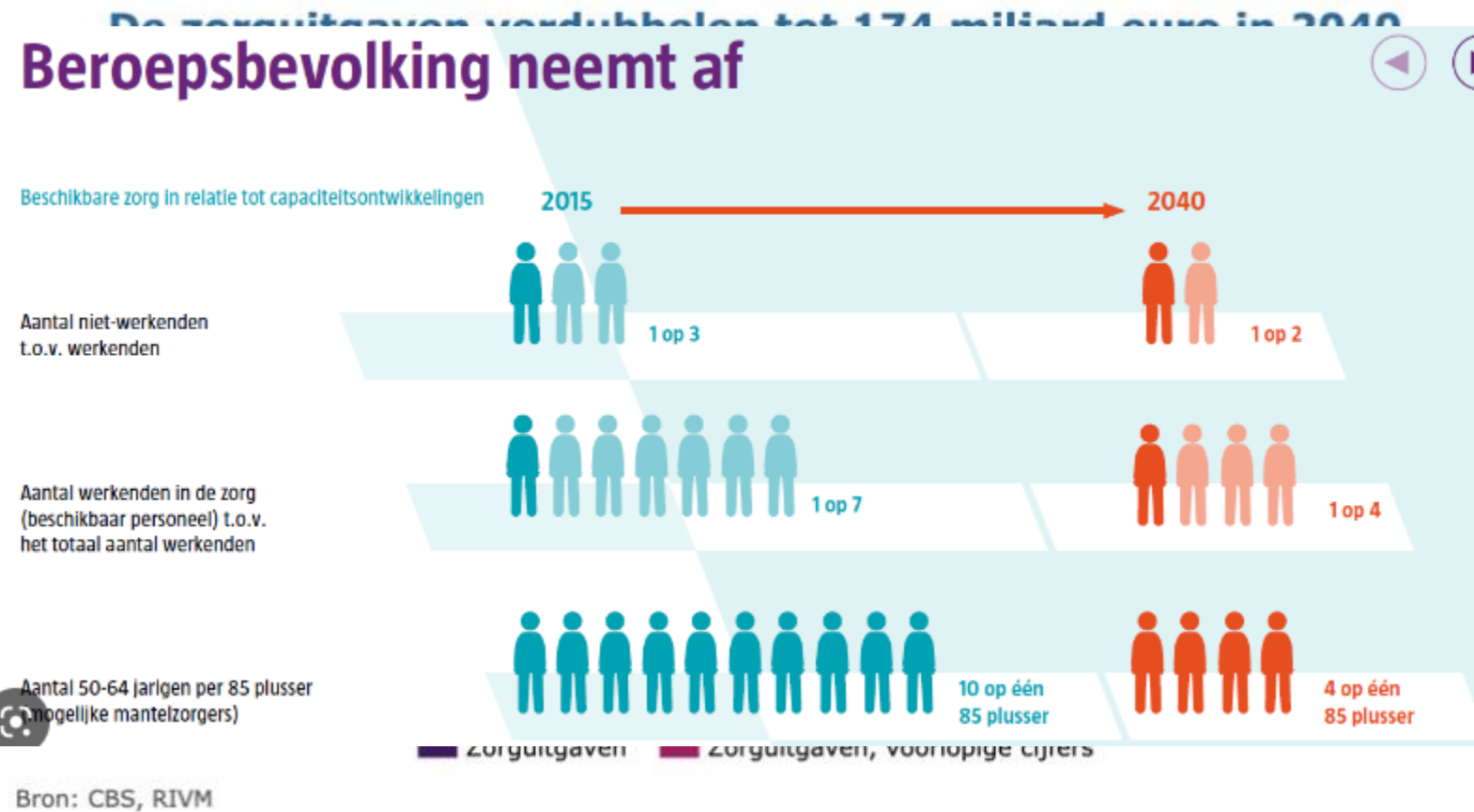
Cijfers hartfalen

Elk jaar krijgen bijna 38.000 mensen voor het eerst de diagnose hartfalen: 52% is vrouw en 48% man. Naar schatting leven er zo'n 241.300 mensen met hartfalen in Nederland. Bijna 90% daarvan is 65 jaar of ouder.

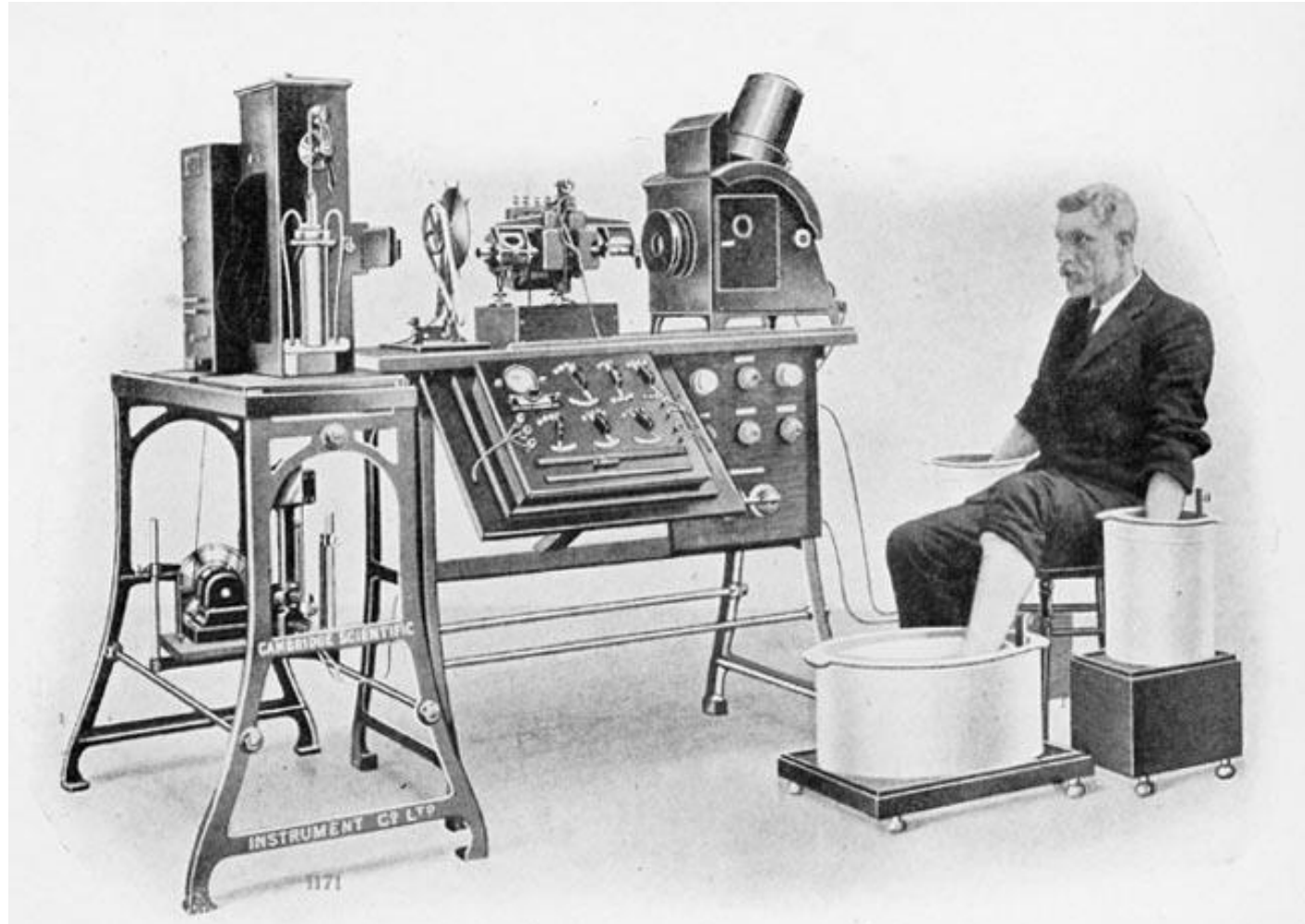
- In 2021 stierven ruim 7.500 mensen aan hartfalen. Per dag zijn dit zo'n 11 vrouwen en 9 mannen.
- Jaarlijks zijn er ruim 31.000 ziekenhuisopnamen voor hartfalen.
- Vrouwen zijn gemiddeld 87 jaar als ze overlijden aan hartfalen en mannen gemiddeld 83 jaar.

Start with why

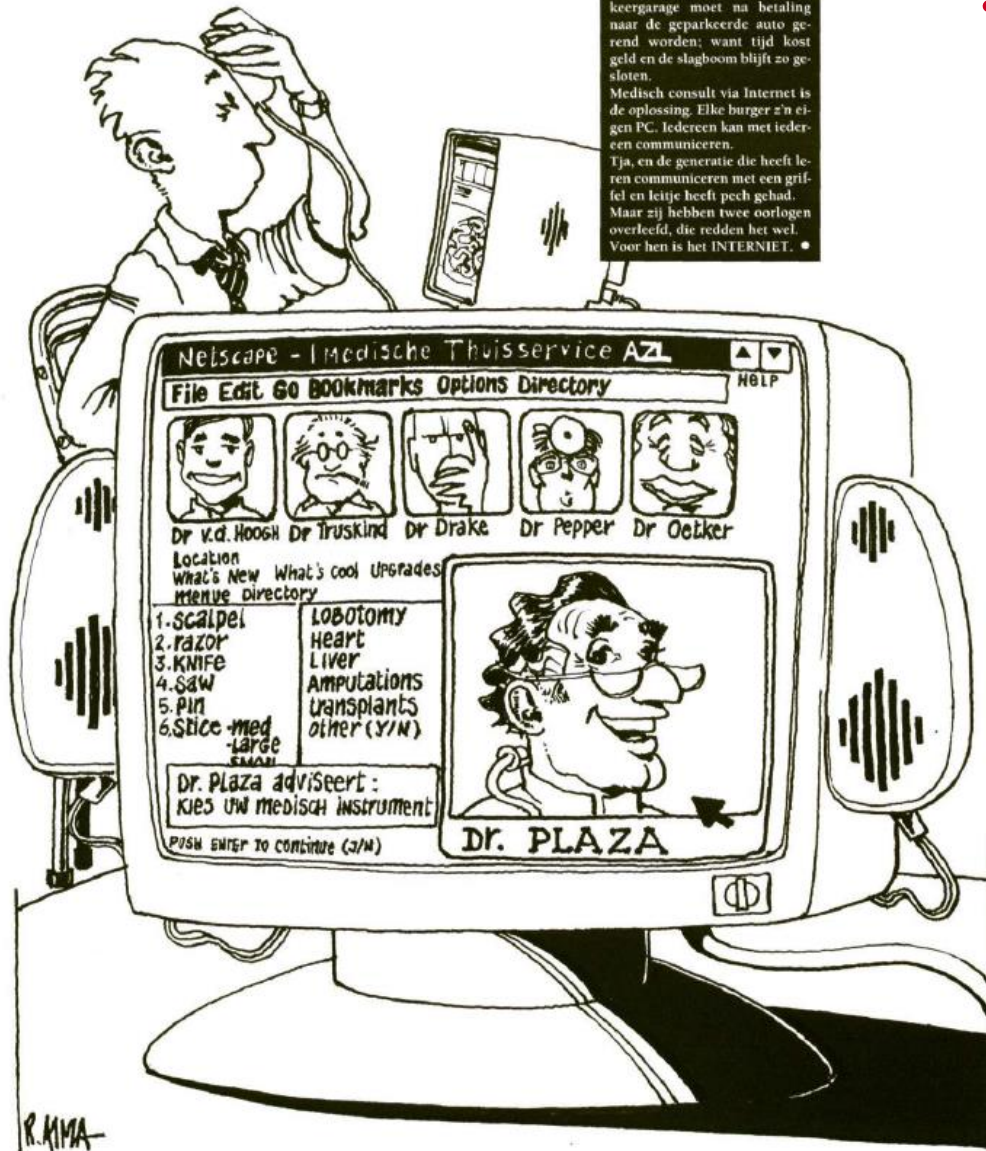
- Chronic ill
- Shortage of staff



Home monitoring (?)



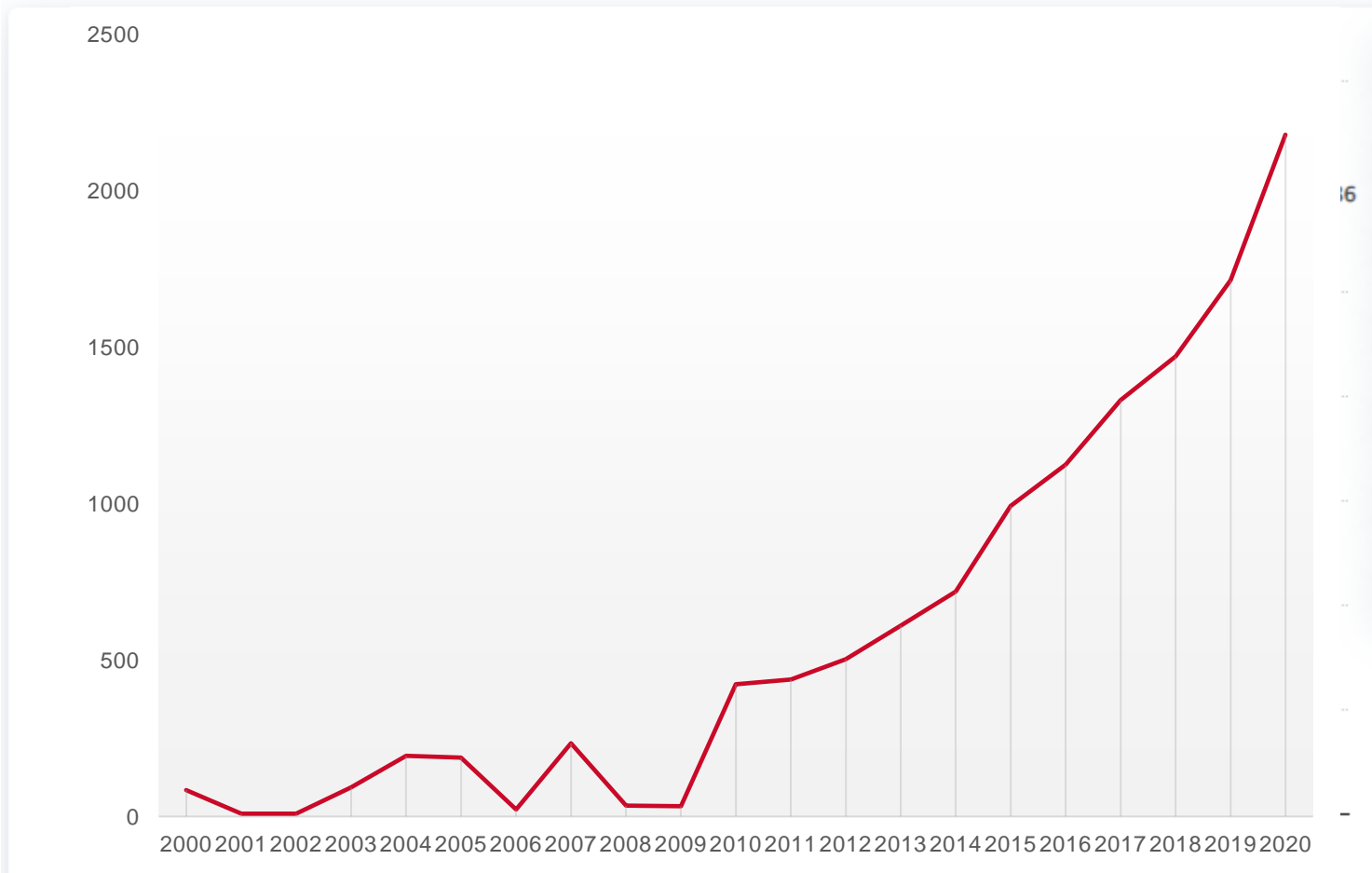
PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSSED IN JARS OF SALT SOLUTION



Via de elektronische snelweg - WWW - kom je het AZL sneller binnen dan met de auto. Patiënten die het geluk hebben om op de dertiende parkeerlaag een plekje te vinden, moeten sowieso een extra 'stief kwartiertje' bij hun reistijd optellen. En bij terugkomst in de parkeergarage moet na betaling naar de geparkeerde auto gered worden; want tijd kost geld en de slagboom blijft zo gesloten. Medisch consult via Internet is de oplossing. Elke burger z'n eigen PC. Iedereen kan met iedereen communiceren. Tja, en de generatie die heeft leren communiceren met een grif-fel en leitje heeft pech gehad. Maar zij hebben twee oorlogen overleefd, die reddden het wel. Voor hen is het INTERNET. •

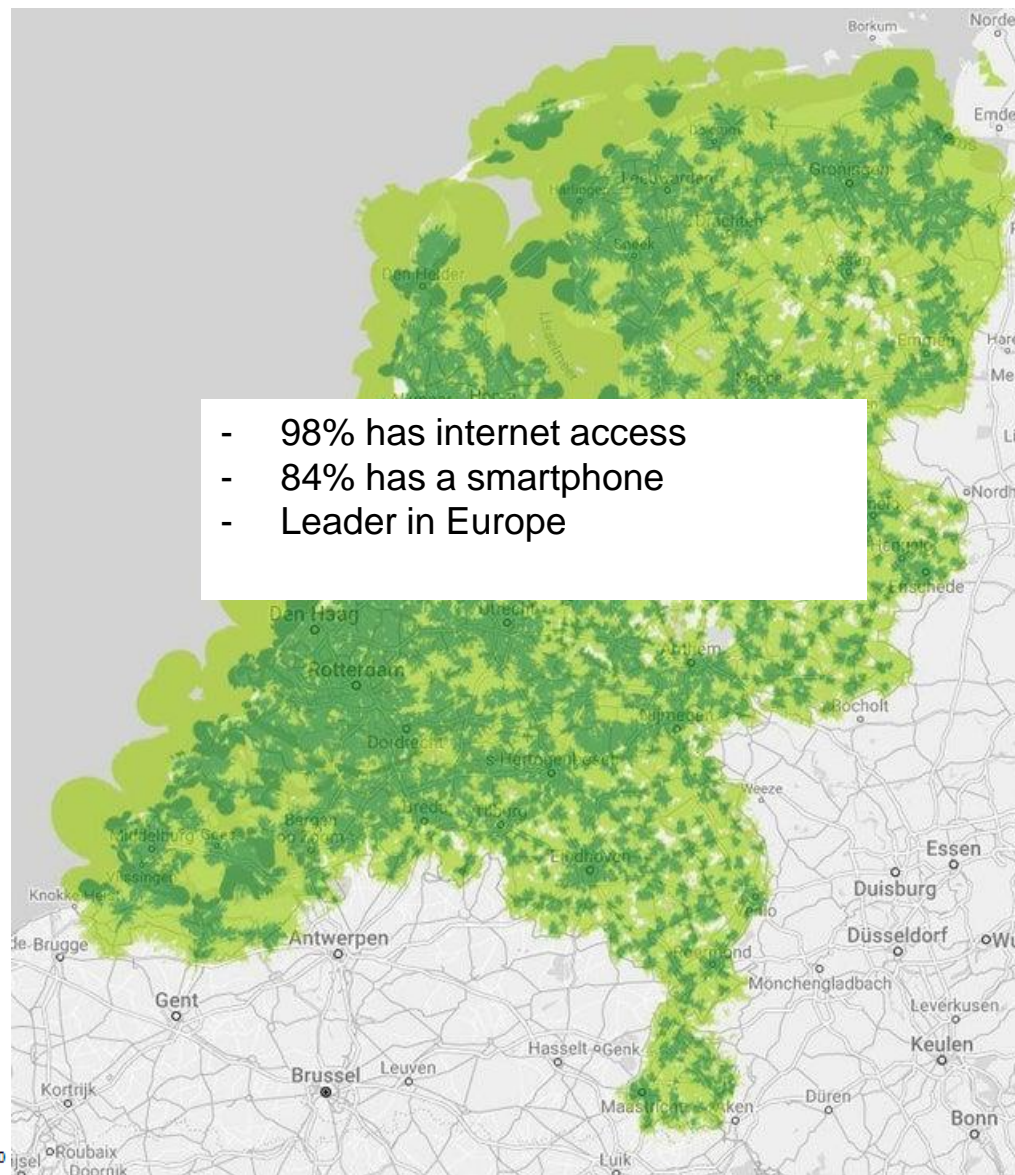
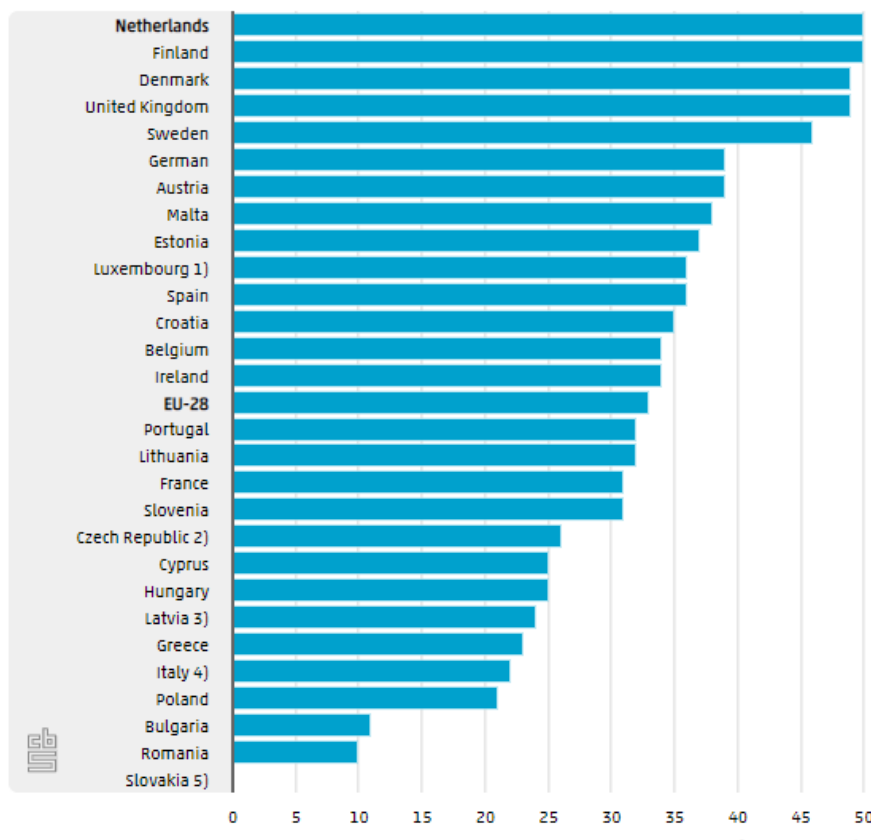
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Start of eHealth



Netherlands: eHealth utopia

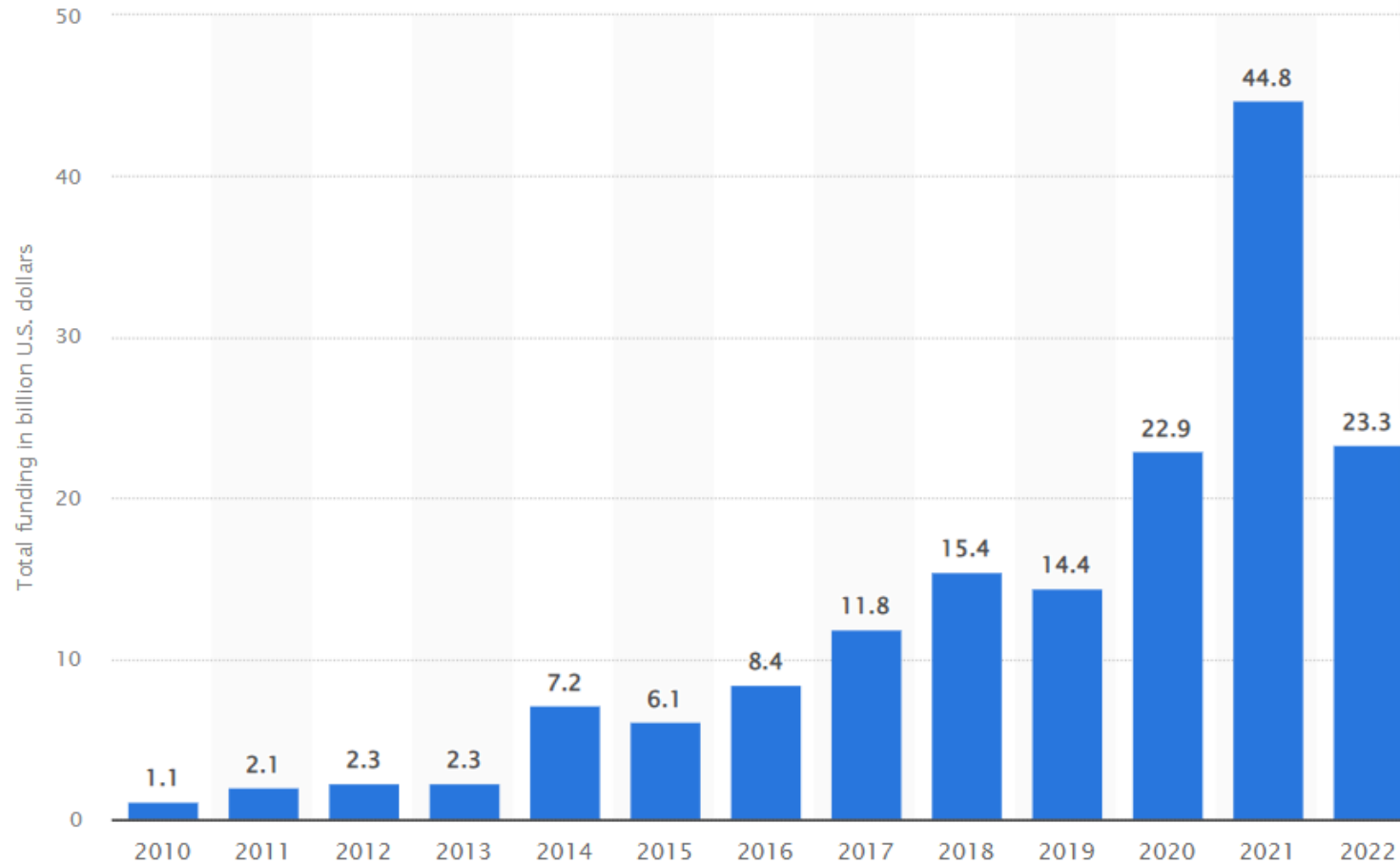
Above basic overall digital skills in the EU-28, 2019



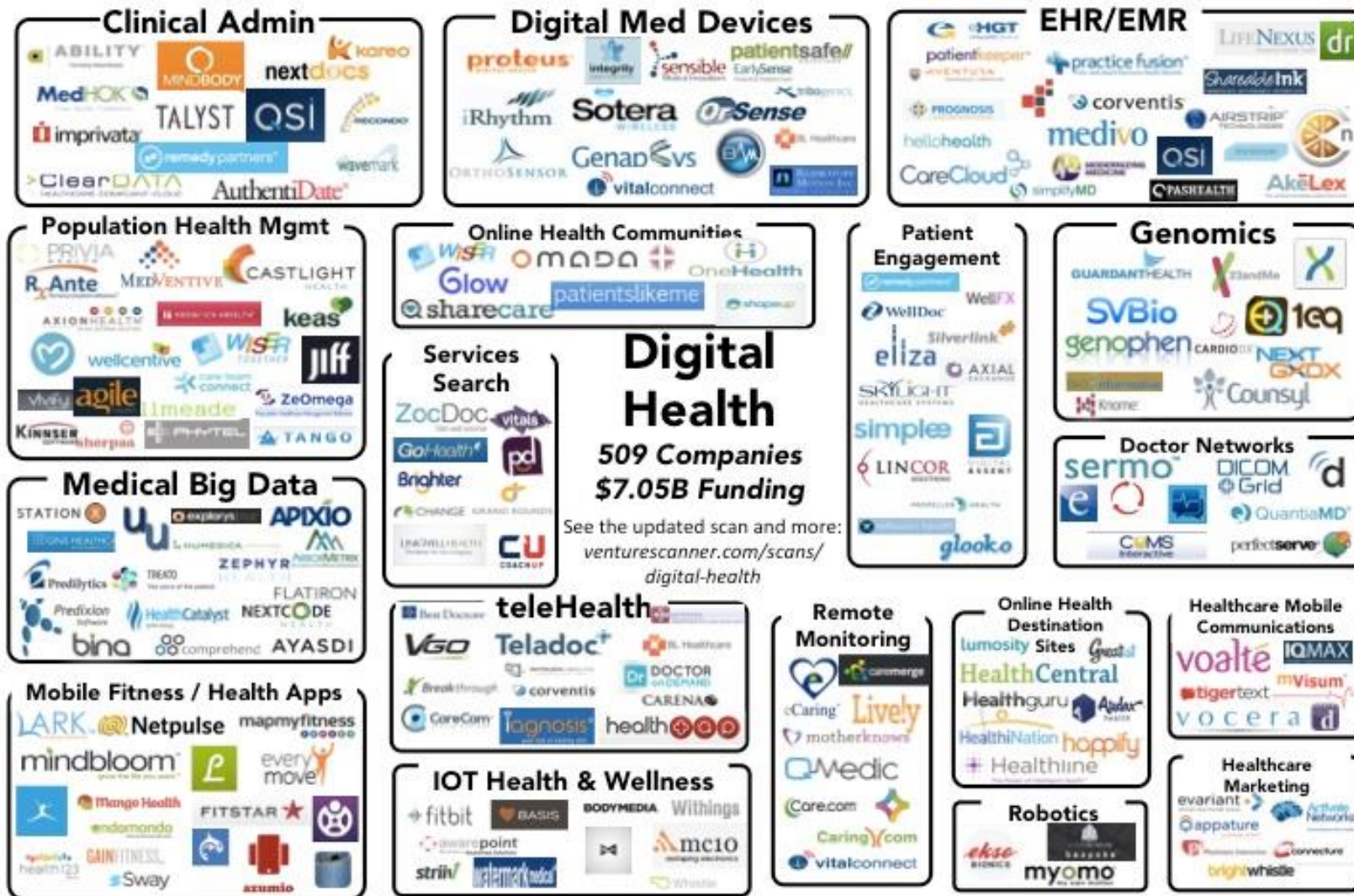
- 98% has internet access
- 84% has a smartphone
- Leader in Europe

4G: 100 Mbit/s (gem. 20 Mbit/s)
4G+: 300 Mbit/s (gem. 75 Mbit/s)

Funding of e-Health start-ups



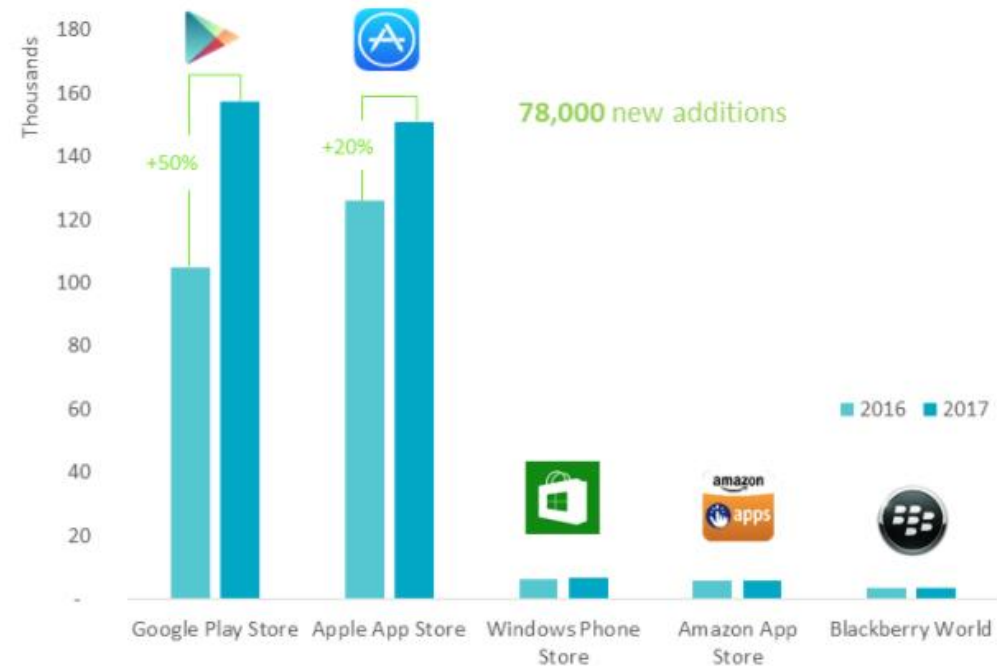
What do we get in return?



What do we get in return

325,000 mHEALTH APPS AVAILABLE – GOOGLE PLAY STORE IS NOW NUMBER ONE FOR HEALTHCARE APPS, OVERTAKING APPLE APP STORE

Number of mHealth apps displayed in App Stores



Risks

COMMENTARY

Open Access



'Trust but verify' – five approaches to ensure safe medical apps

Function of Smartphone

Paul Wicks* and Emil Chiauzzi

Tracking function	16.67 (1.71–162.56; $P = .015$)
Medication adherence tools	4.1
Device function	97.1
Informational app	0.1
App is free	23.1
Overall model significance	$P < .0001$

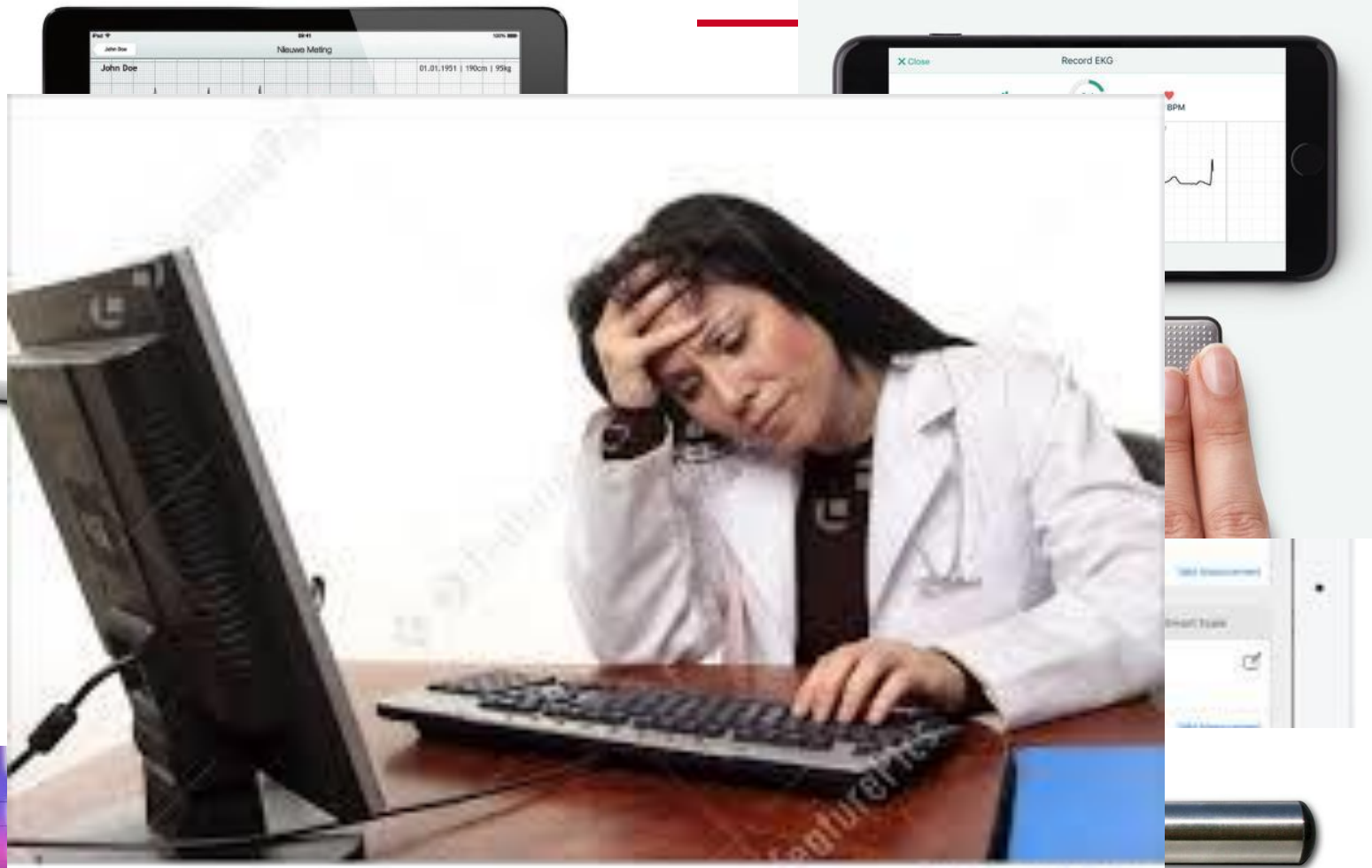
It is alarming to read that 91 % of dose calculators lack validation to check the data quality of user input and 67 % risked making an inappropriate dose recommendation. There was a disappointing lack of transparency too,

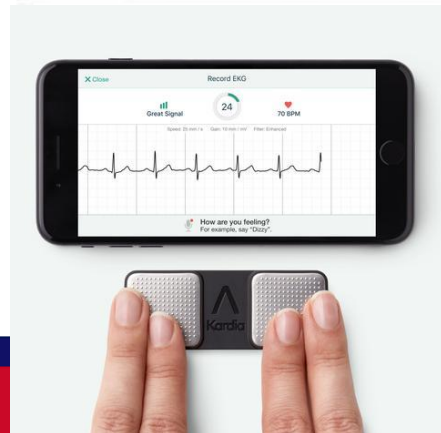
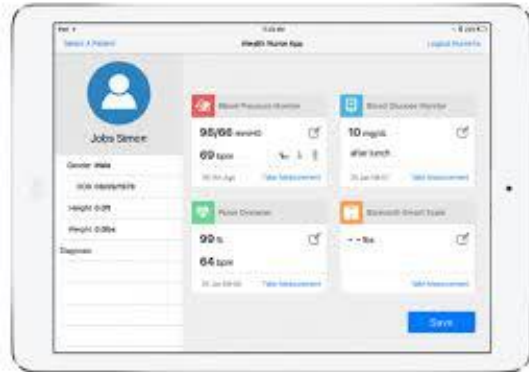
Android

Blood Pressure (My Heart)	1 million–5 million	3598	Mainly a tracking and analytical tool. Can export recorded BP data
Acc. Blood Pressure Monitor	500K–1 million	3860	Claims to measure BP within $\pm 5\%$ by placing thumb on phone screen
BP Watch	500K–1 million	6305	Mainly a tracking and analytical tool. Can export recorded BP data
Real BP Calculator	100K–500K	1584	Claims to measure BP within $\pm 10\%$ by placing finger on smartphone camera
Blood Pressure Log	100K–500K	1435	Mainly a tracking and analytical tool. Can export recorded BP data

Possibilities



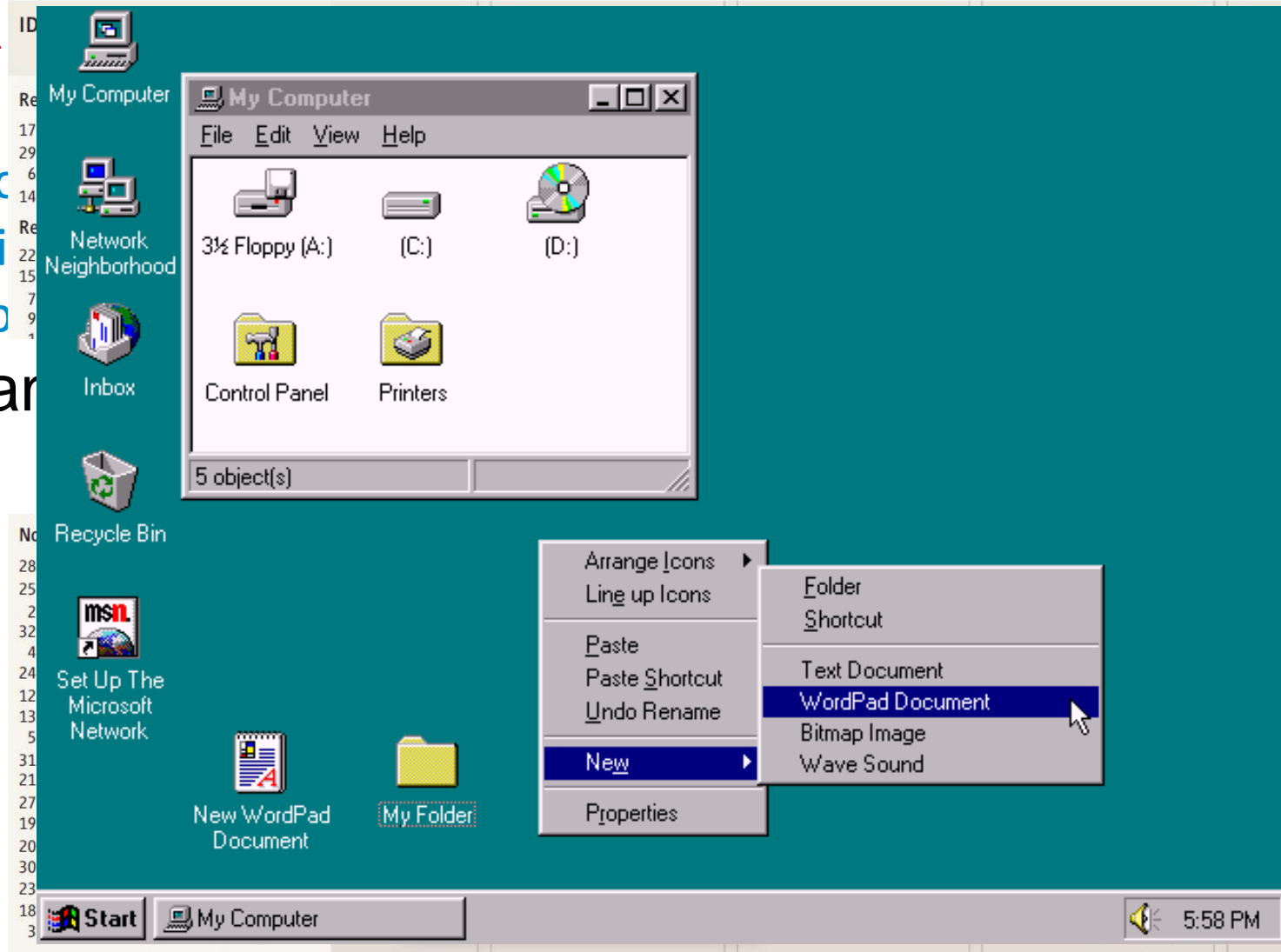




Short “slack”

- Definition slack can be delayed with the date of your presentation

Media



an task can
completion

ation

COVID-19



The elderly and tech?



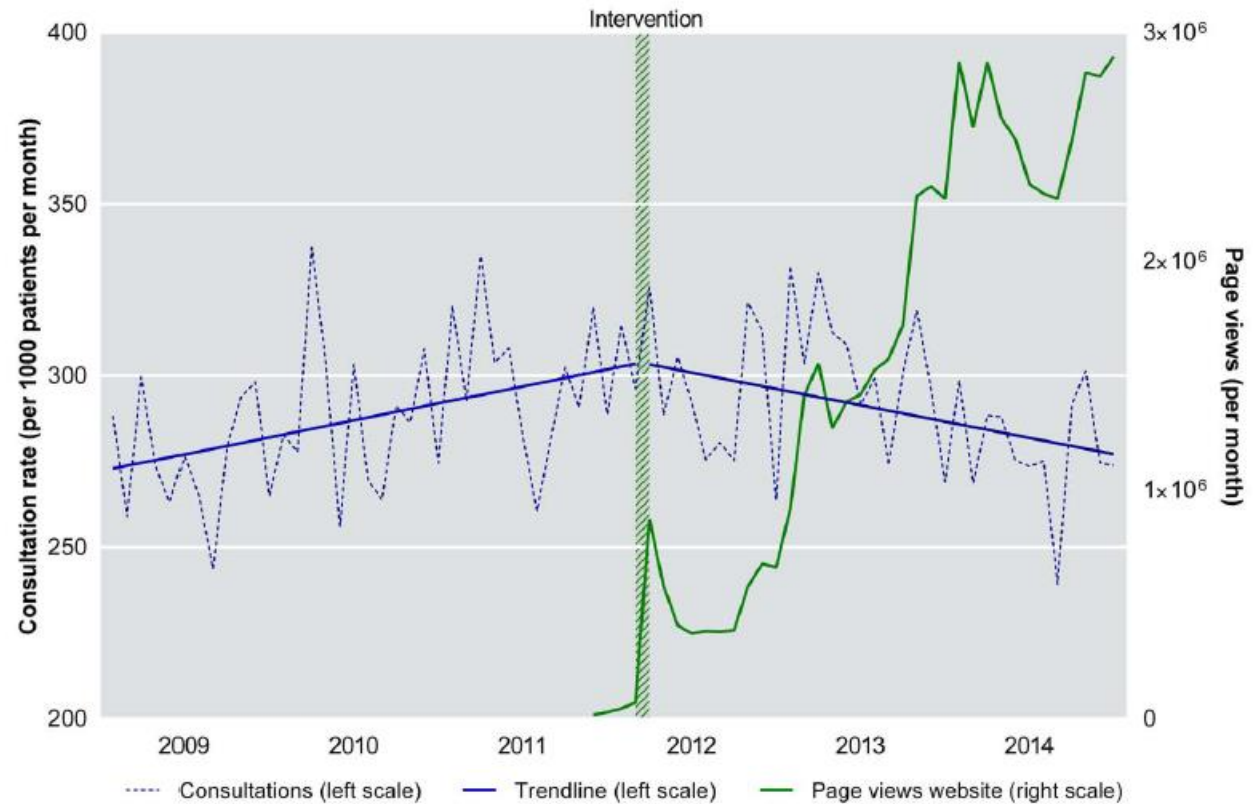


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Applications, atrial fibrillation

The forgotten one

Figure 1 Rate of primary care consultations and page views of the website. Consultation rates with trend lines are displayed on the left y-axis. The number of page views of the website is displayed on the right y-axis and shows a step increase in March 2012, which represents the launch of the website.



Overzichten  Onderwerpen A-Z  Videos  Afbeeldingen



Blood pressure monitor



Systole gemiddeld **111** mmHg
 Diastole gemiddeld **66** mmHg

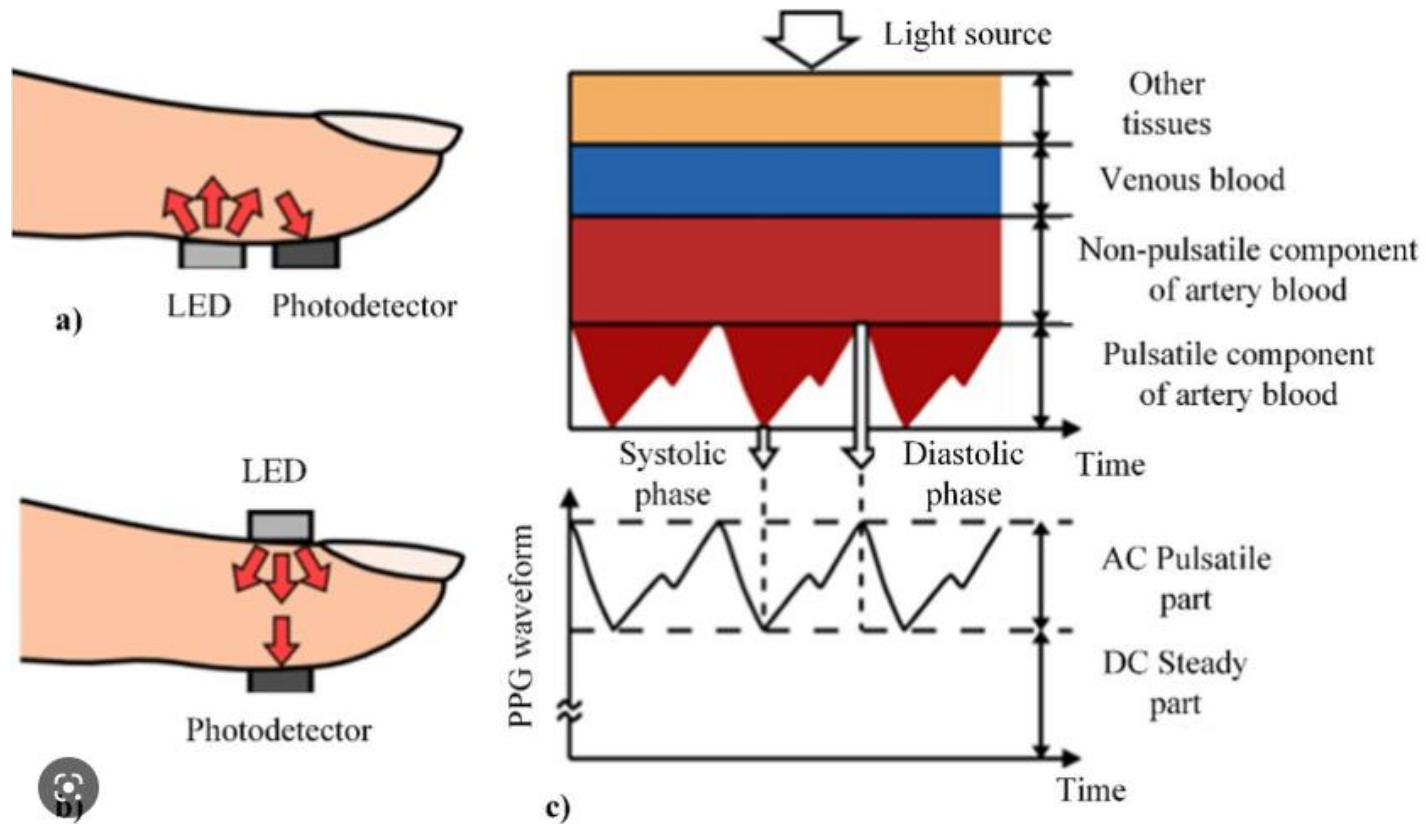
Systole max 125/66 mmHg

Week Maand



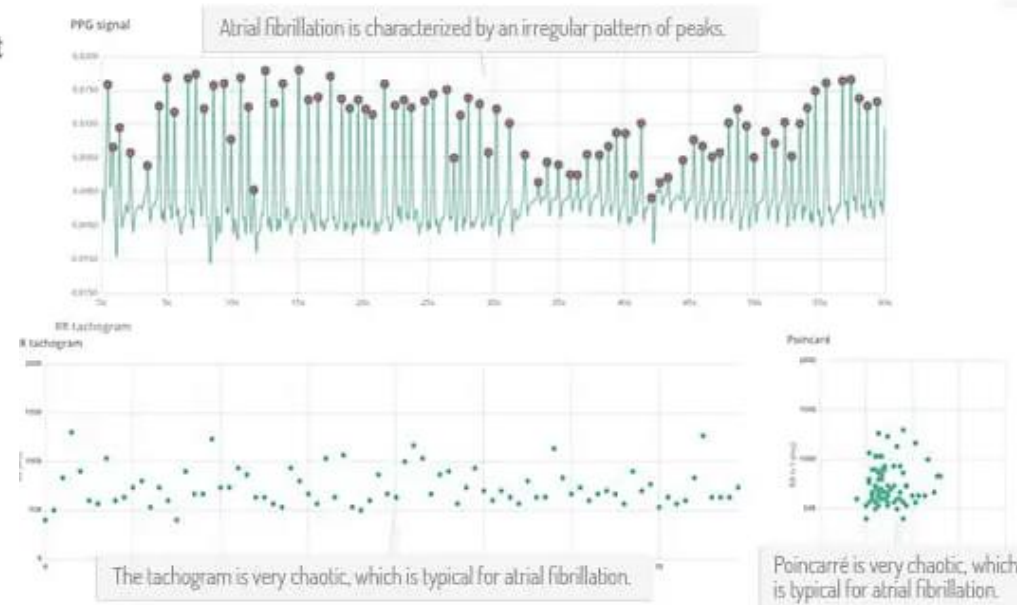
FibriCheck®

Photoplethysmography



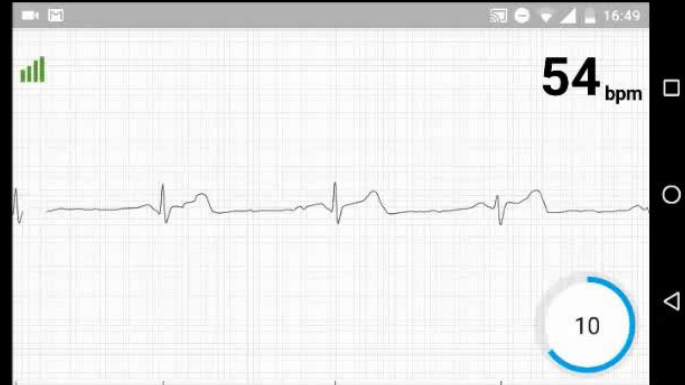
l Fibrillation

ial fibrillation

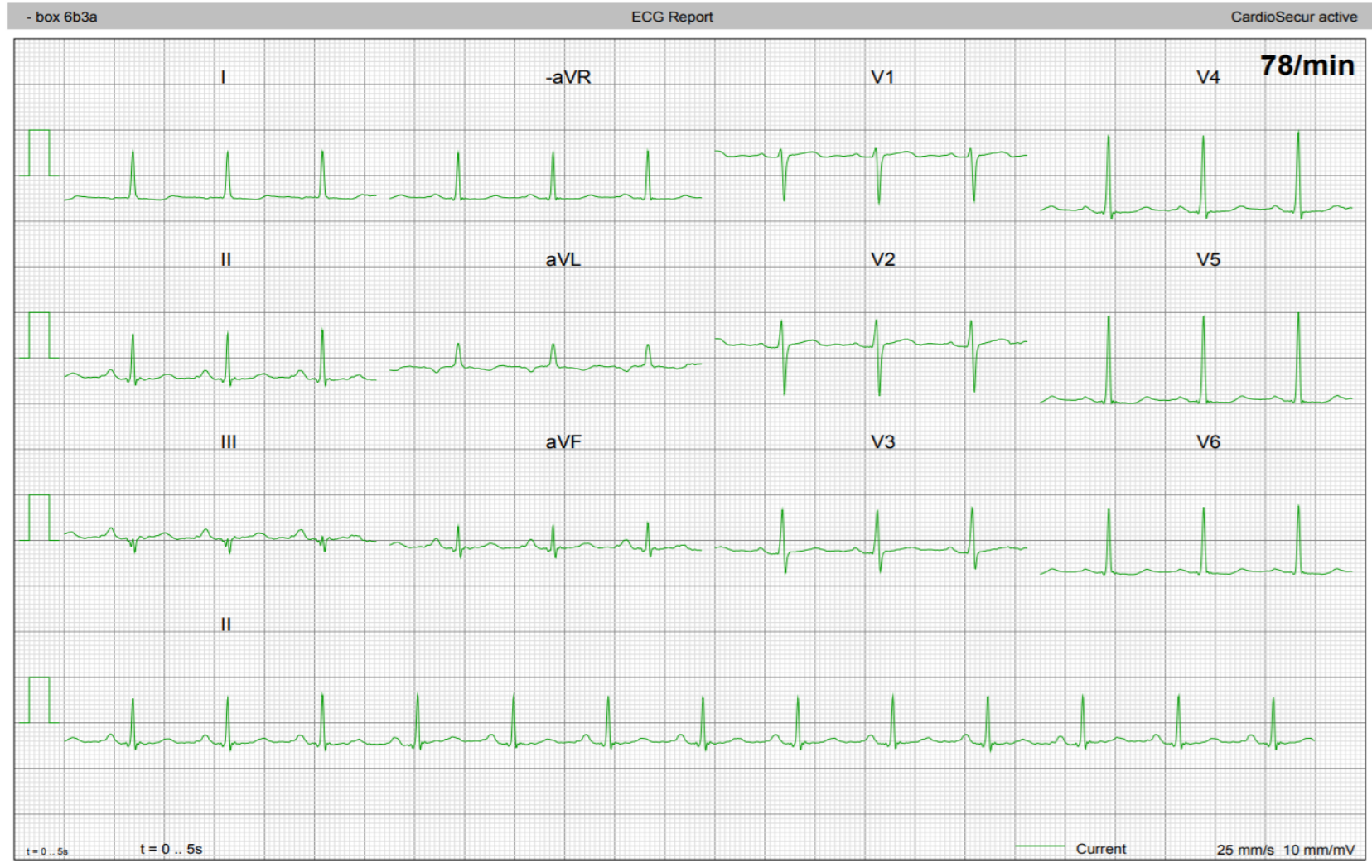
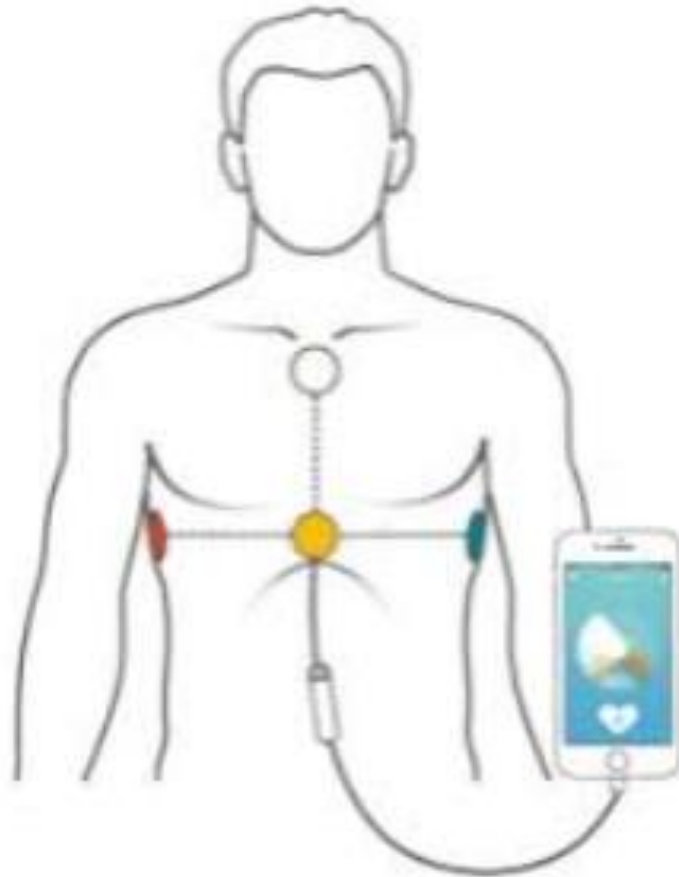


Single lead ECGs





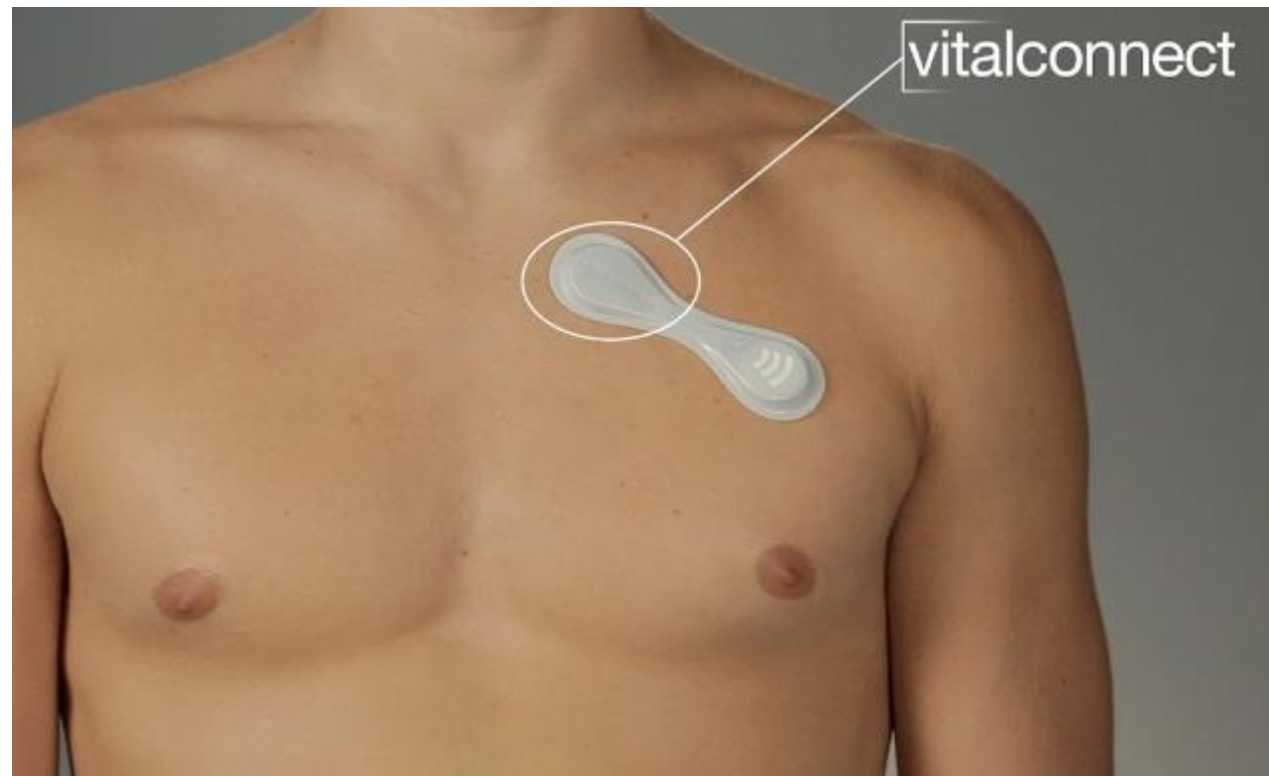
Multiple lead ECGs



Watch



Patches



Electronic Medical Record

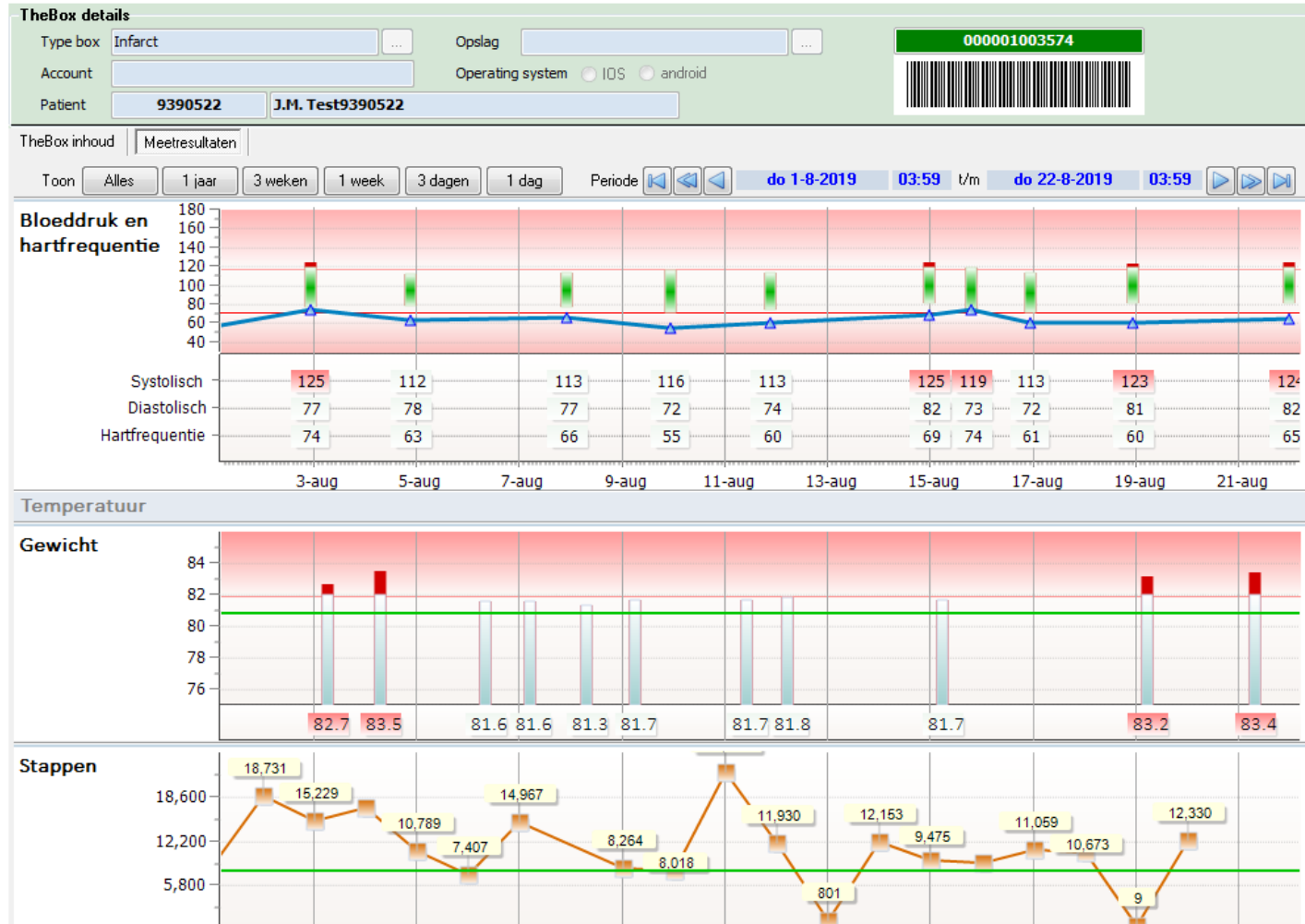


Table 4 Factors to consider when choosing screening mode**For the choice of screening mode take into account:****Age**

- ≥ 65
- ≥ 75

Comorbidities

- Hypertension
- Sleep apnoea
- Prior MI
- Obesity
- Diabetes
- Heart failure
- COPD
- CKD

Biomarkers

- NT-proBNP ≥ 125 ng/l

Consumer screening

- PPG indicating irregular rhythm

Screening opportunities

- Systematic
- Opportunistic

Digital competence of the patient

- Limited
- Full

Device available

- PPG-based
- ECG-based

Screening strategies:**Single time**

- Pulse taking
- BP monitor
- PPG
- Single-lead ECG
- 12-lead ECG

Intermittent

- 30-60s:
 - pulse
- 1-4x per day:
 - BP monitor
 - PPG
 - Single-lead ECG
- Every 1-4 weeks:
 - 12-lead ECG

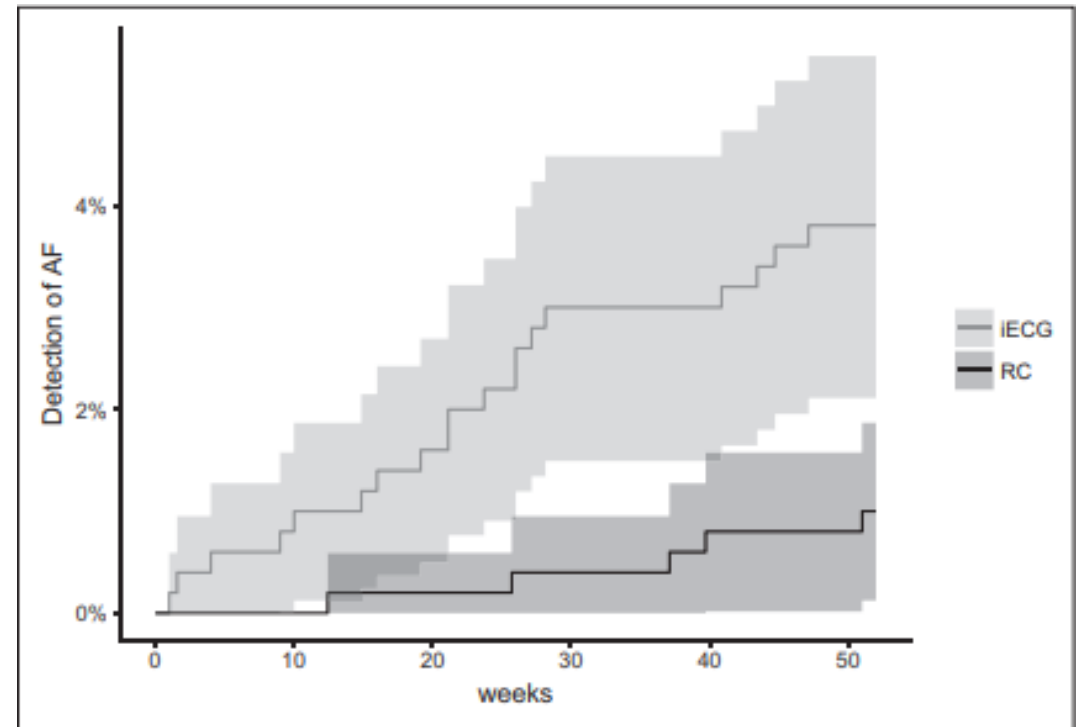
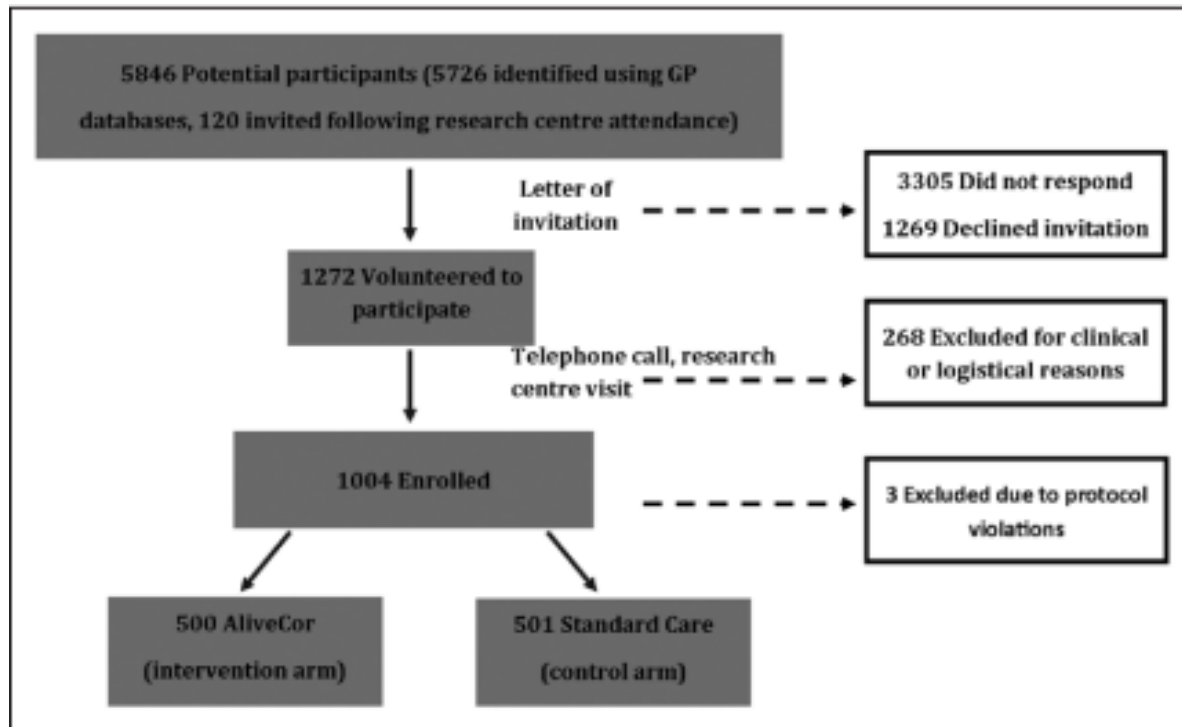
Continuous

- ECG patch
 - 7-day
 - 14-day
 - 2x 14-day

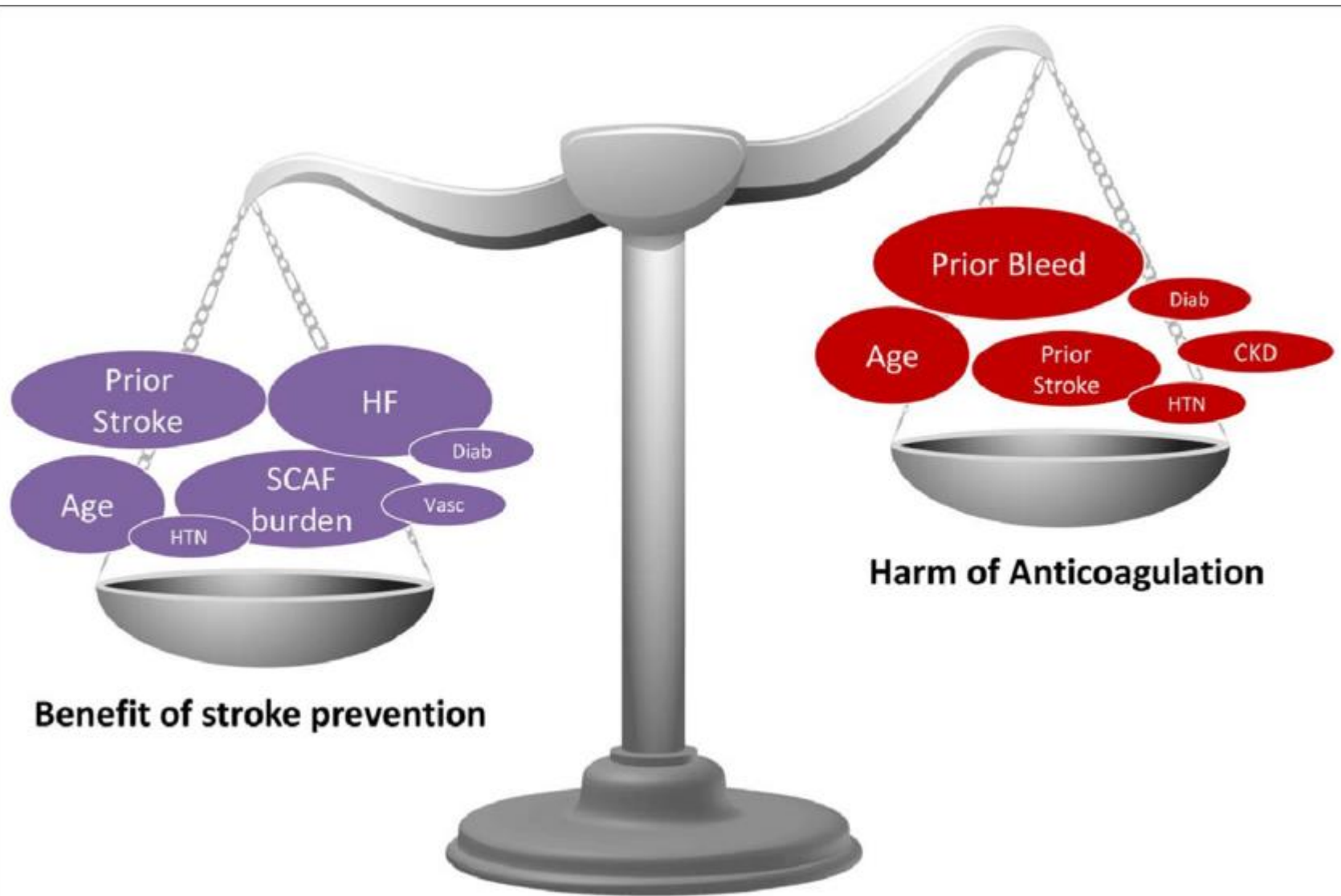
Continuous long-term

- ILR

Rehearse AF



The Big Question



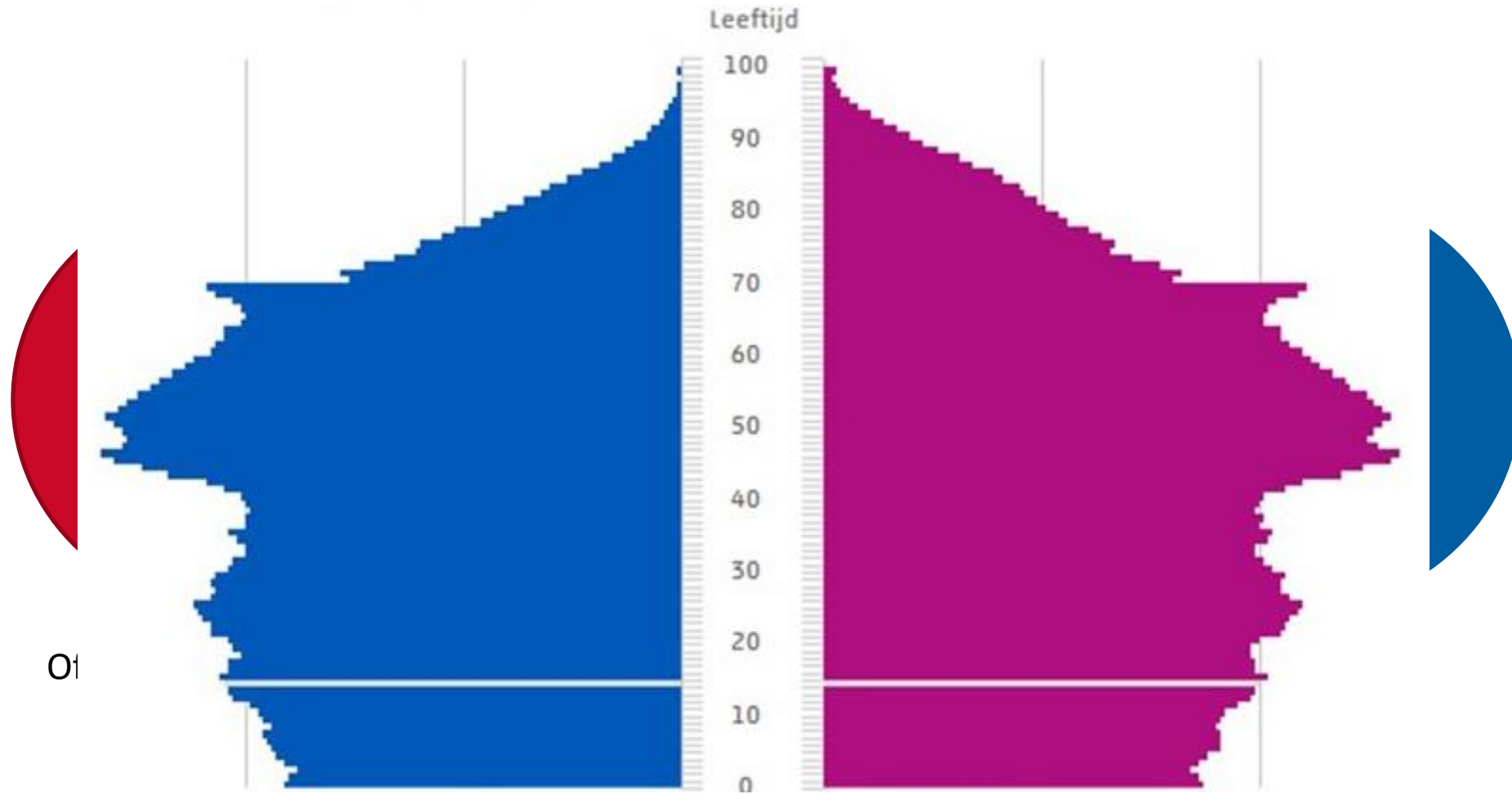
and Atrial
Knowledge Gap
rt Association



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Applications, (acute) heart failure

Heart failure



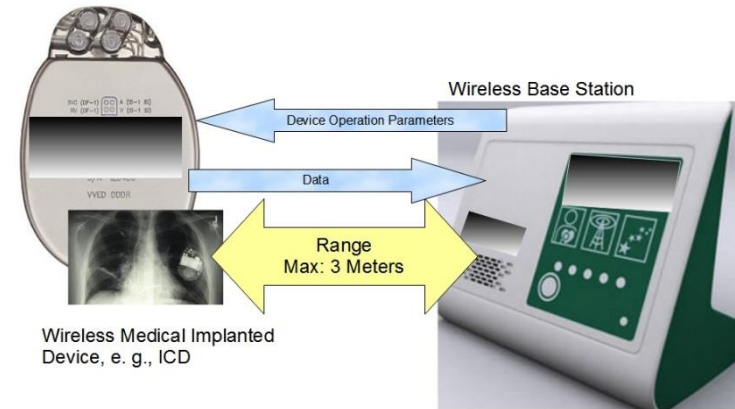
Readmissions (clinical and cost aspects)

- Readmission rates for heart failure are high: 25% of patients discharged is readmitted
- Mortality in (re)hospitalized patients is significantly higher
- Quality of life is significantly lower in patients who are frequently readmitted
- Heart failure costs 30 billion US dollars in the United States annually
- 80% of these costs is due to hospitalizations

Heart fail



Wireless Communication Between Implanted Medical Device and Base Station



Trials

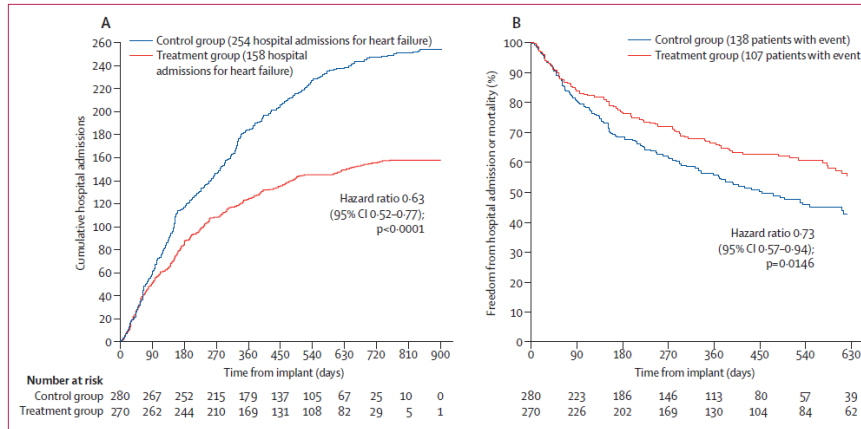


Figure 3: Cumulative heart-failure-related hospitalisations during entire period of randomised single-blind follow-up (A), and freedom from first heart-failure-related hospitalisation or mortality during the entire period of randomised follow-up (B)

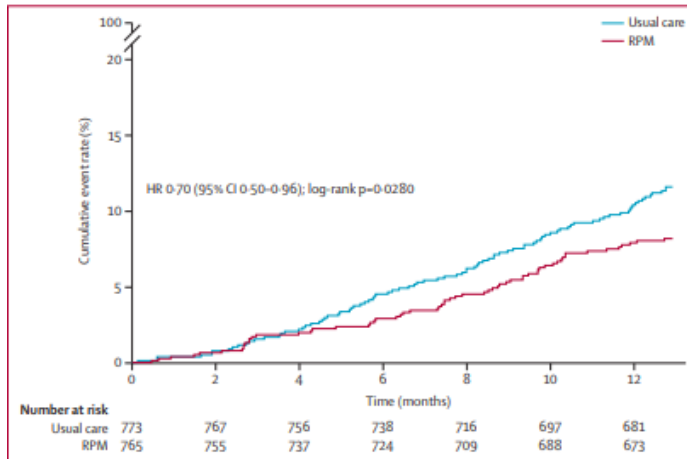
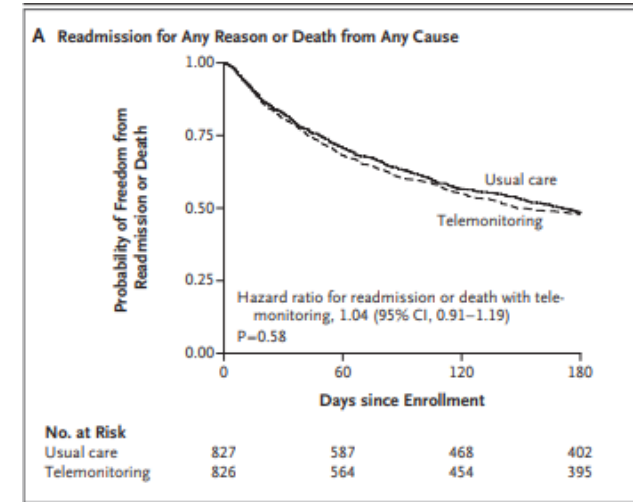


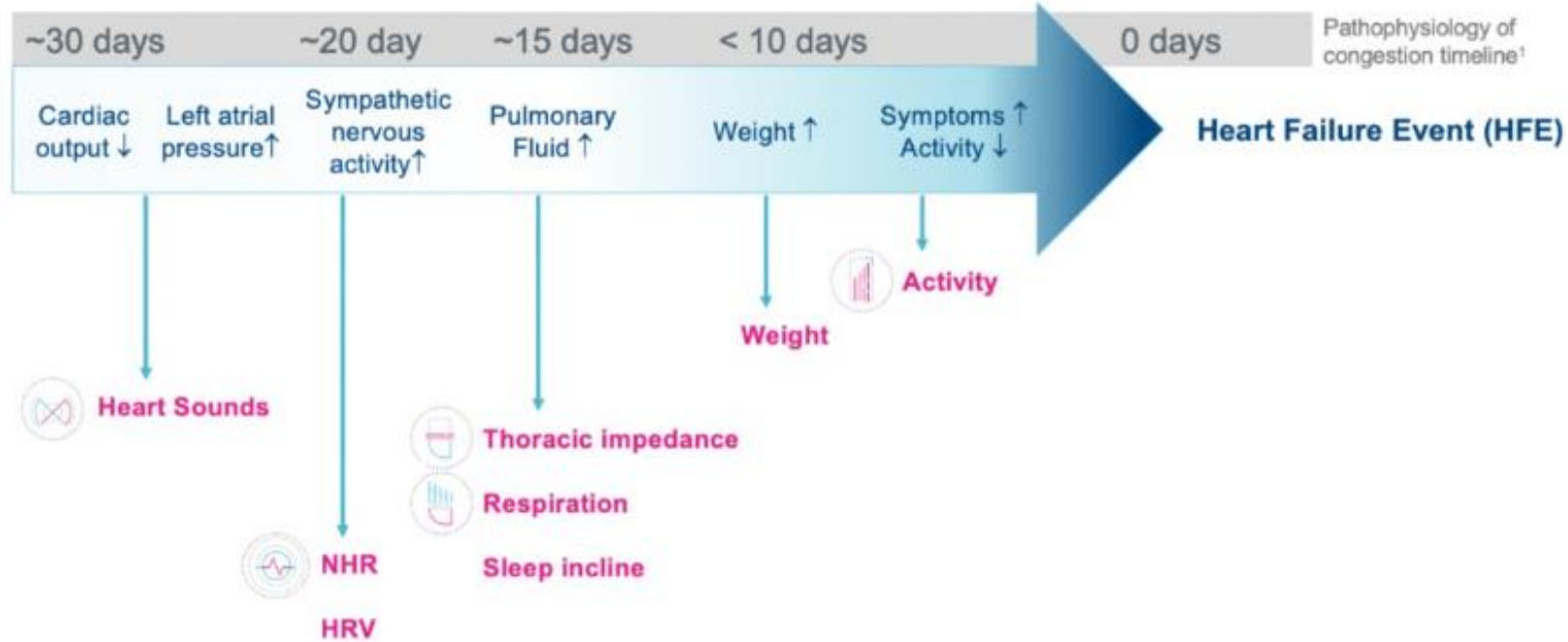
Figure 2: Kaplan-Meier cumulative event curve for all-cause death
HR=hazard ratio. RPM=remote patient management.

	Telemonitoring group (n=333)	Control group (n=331)	p value
Worsened	63 (18.9%)	90 (27.2%)	0.013*
Death	10 (3.0%)	27 (8.2%)	0.004*
Overnight admission to hospital for worsening heart failure†	23 (6.9%)	27 (8.2%)	..
Worsened NYHA functional class and global self-assessment	0 (0.0%)	1 (0.3%)	..
Worsened NYHA functional class only	23 (6.9%)	31 (9.4%)	..
Worsened global self-assessment only	7 (2.1%)	4 (1.2%)	..
Improved‡	111 (33.3%)	105 (31.7%)	..
Unchanged	159 (47.8%)	136 (41.1%)	..

Data are n (%). Patients are included only once, in the topmost subcategory. *Also statistically significant difference in a post-hoc multivariable logistic regression model after adjustment for use of angiotensin-converting enzyme inhibitors or angiotensin-receptor blockers (the only substantial imbalance between groups at randomisation; data not shown). †Adjudicated by an endpoint committee masked to patients' treatment assignment (appendix). ‡Improved NYHA class or moderately to markedly improved self-assessed condition. NYHA=New York Heart Association.

Table 2: Results for composite clinical score

Signs of heart failure decompensation



Note: There is a large individual variability in presentation and time course, even for the same patient. Thus, several patterns may precede a decompensation.

Intrathoracic impedance for early detection of fluid retention

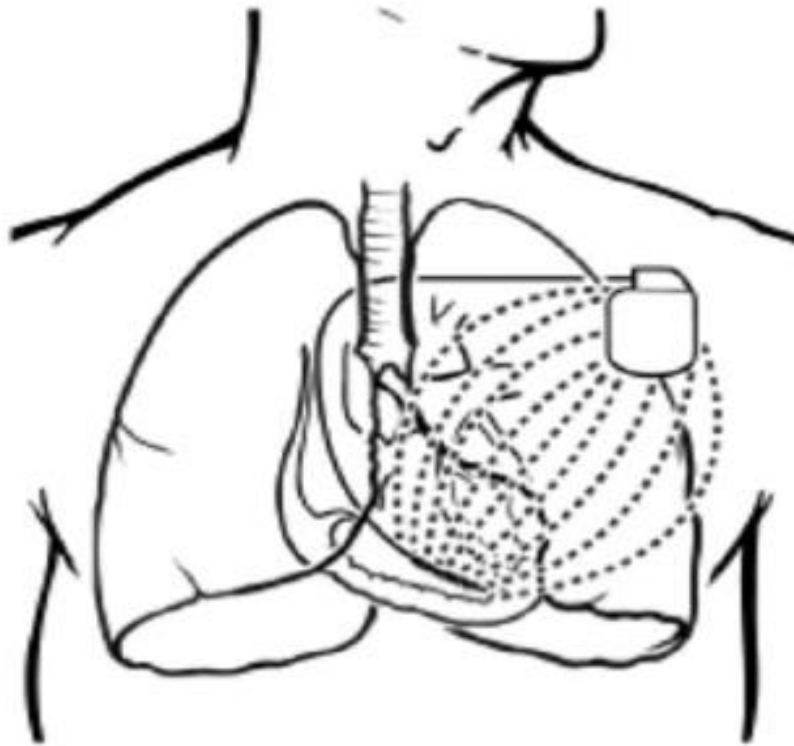
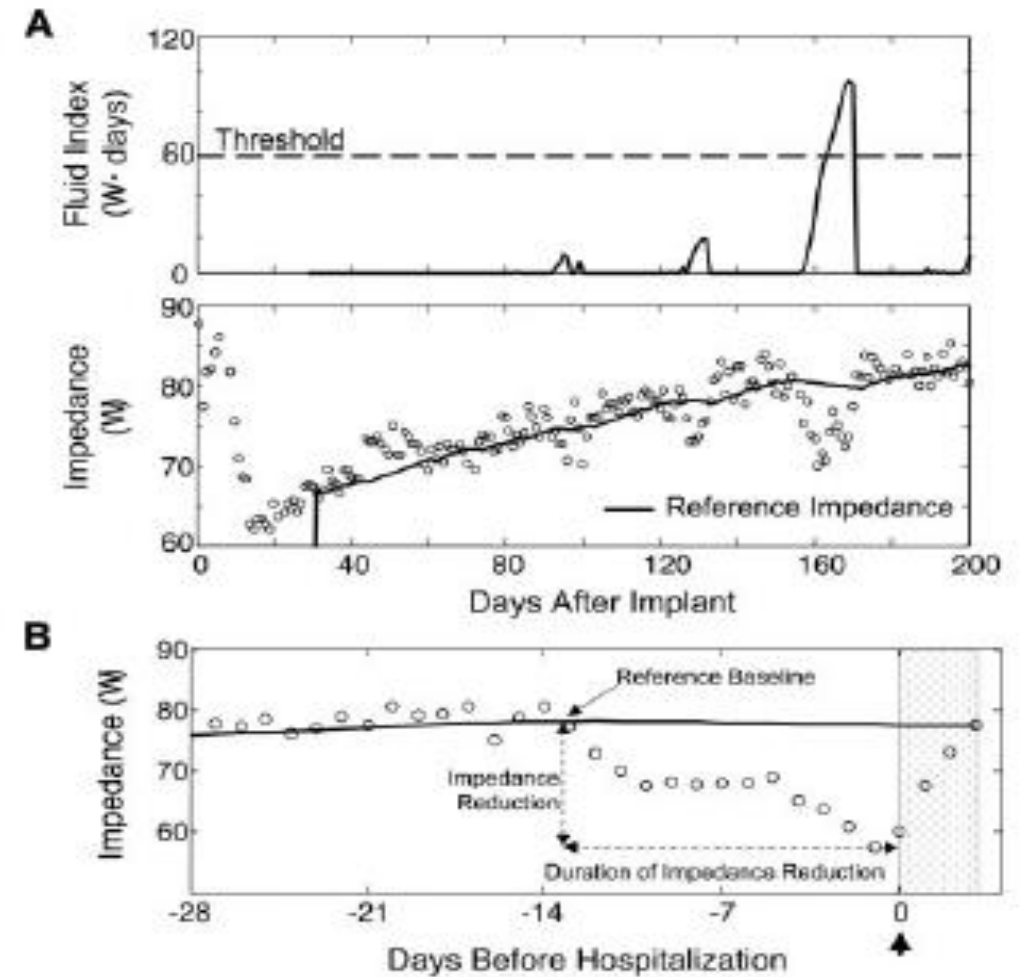
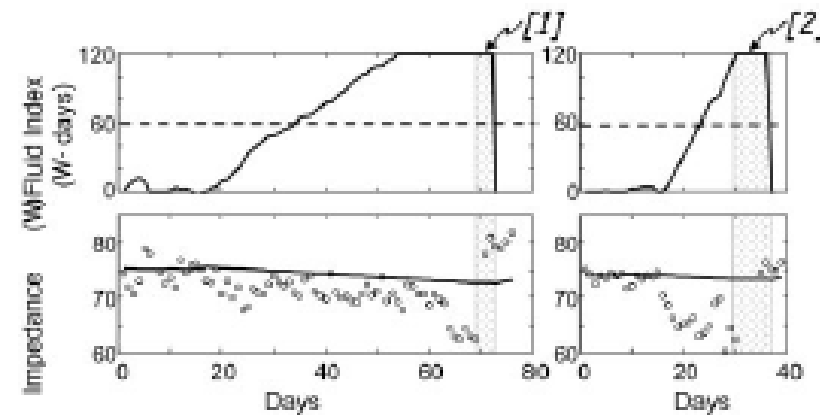
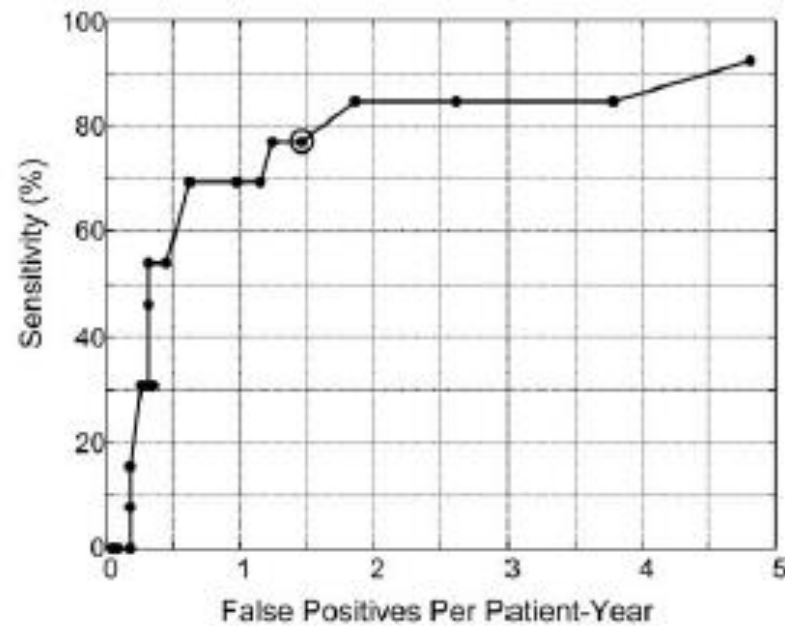


Figure 1. Intrathoracic impedance measurement by implantable system.



Results

- Ten patients, 25 hospitalizations for fluid retention
- Impedance reduction: 15.3 ± 10.6 days in advance
- Symptoms worsening: 3.0 ± 2.5 days in advance



RCT (intrathoracic impedance measurement)

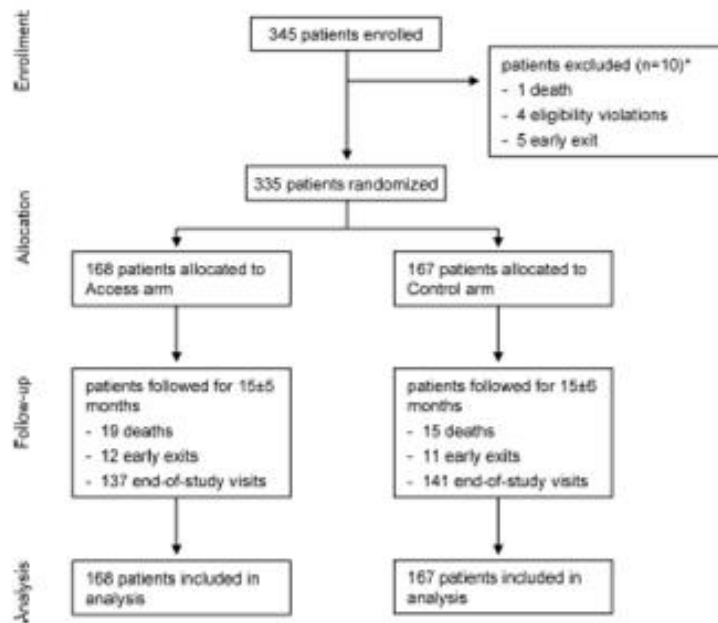


Figure 2. Consolidated Standards of Reporting Trials (CONSORT) diagram of the study. *One major violation (left ventricular ejection fraction, 60%) was identified on a blinded review of eligibility. This patient was randomized but is excluded from the final (analyzed) cohort. The other eligibility violations were discovered before randomization. Two randomization codes were generated erroneously for a death and for a patient lost to follow-up before randomization.

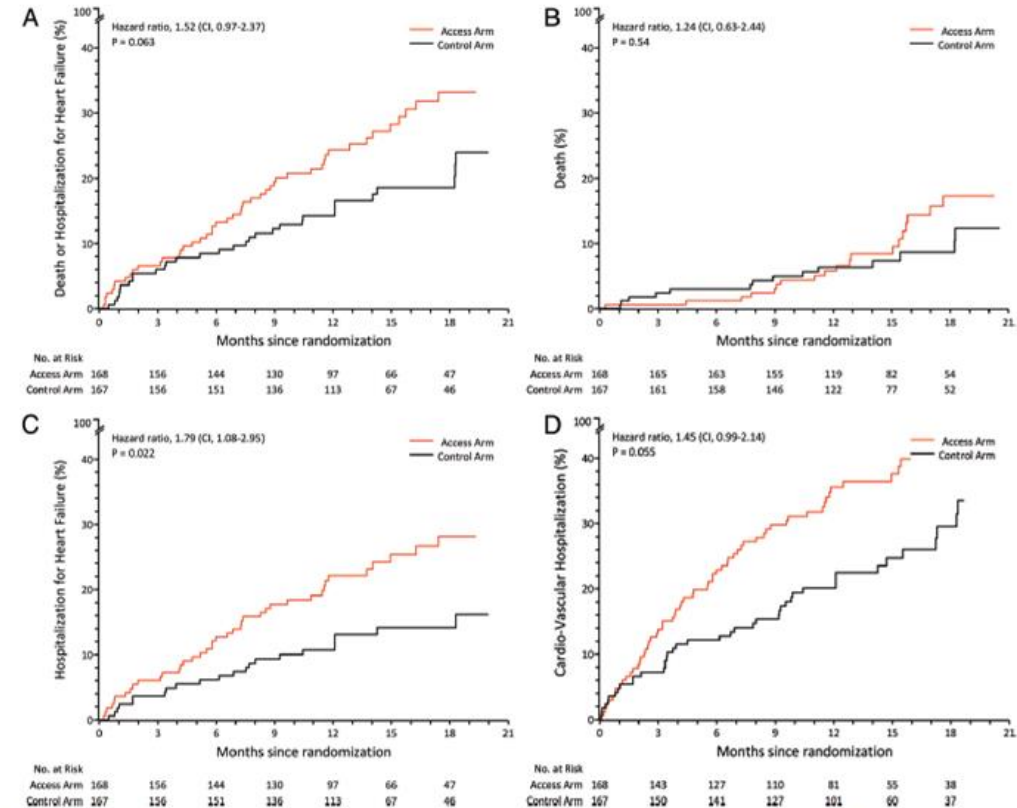


Figure 3. Kaplan-Meier estimates of the cumulative incidence of clinical events according to treatment group. **A**, Incidence of the primary end point (time to first end point, ie, all-cause death, heart transplantation, or [unplanned] heart failure hospitalization). **B**, All-cause death (secondary end point). **C**, First unplanned heart failure hospitalization (secondary end point). **D**, First cardiovascular hospitalization (secondary end point).

Combining sensors



HEART SOUNDS

Reveals signs of elevated filling pressure and weakened ventricular contraction.



THORACIC IMPEDANCE

Measures fluid accumulation and pulmonary edema.



RESPIRATION

Monitors rapid shallow breathing pattern associated with shortness of breath.



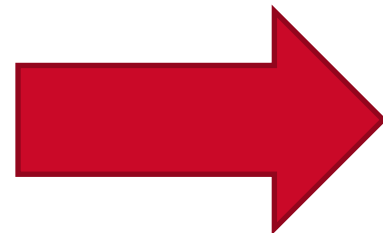
HEART RATE

Indicates cardiac status and arrhythmias.

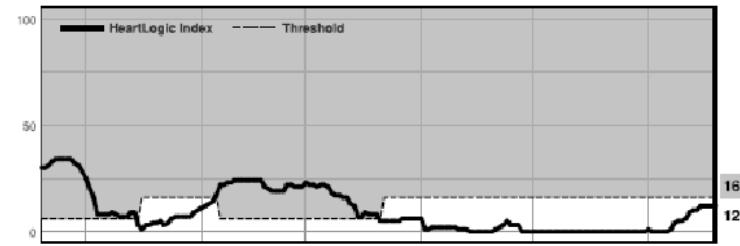


ACTIVITY

Shows activity levels and reflects the patient's overall status and fatigue.

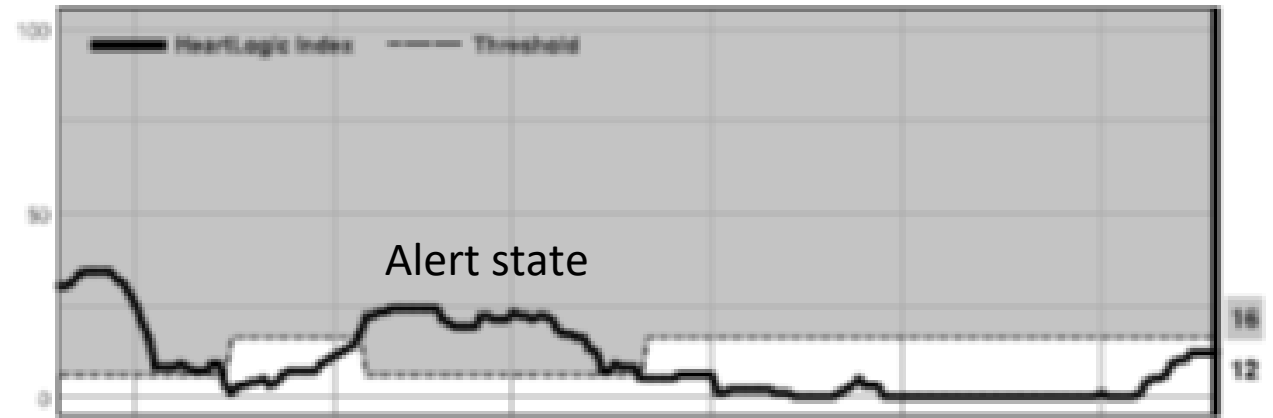


Multisensor algorithm

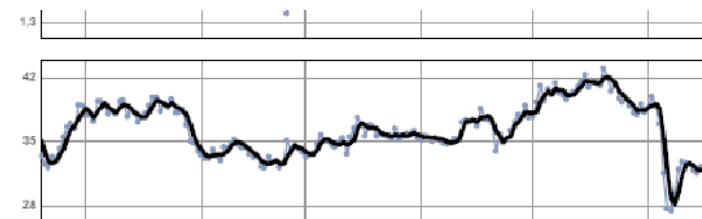
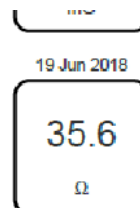


Trend Graphs

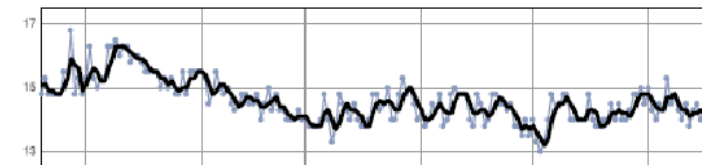
Daily Value 3 Day Average



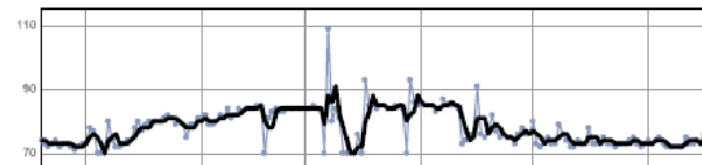
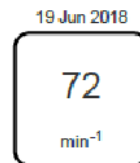
Thoracic Impedance



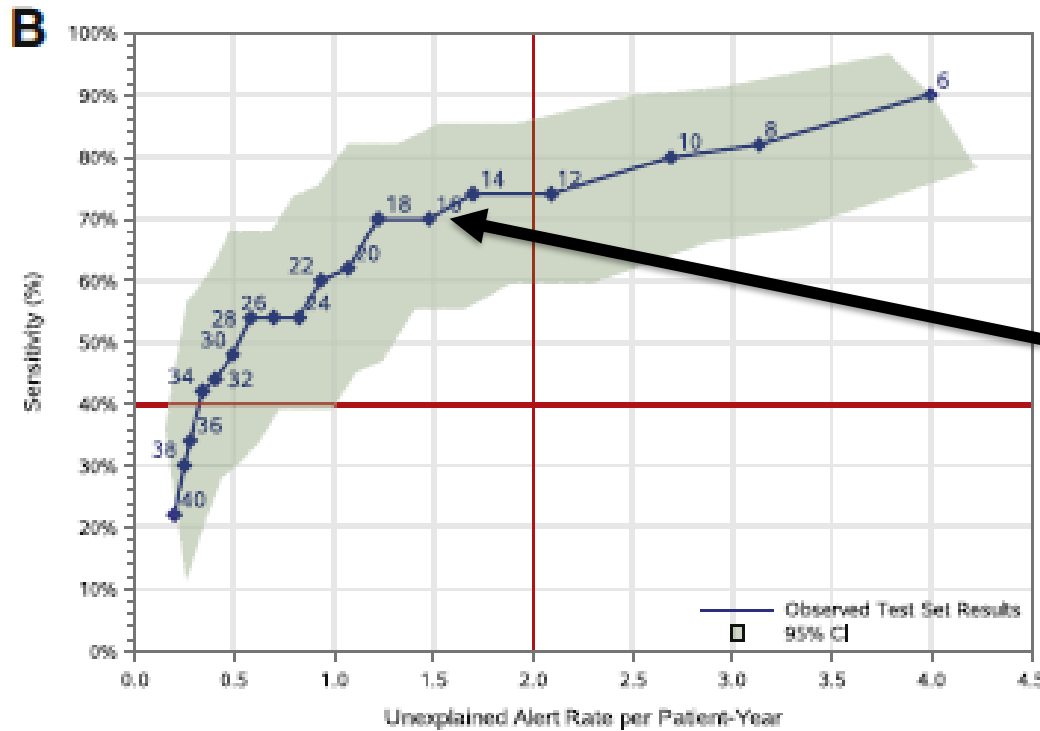
Respiratory Rate



Night Heart Rate



Multisense - Results



Median time alert-to-event (in days): 34 days

Sensitivity: 70%

Unexplained alert rate: 1.47

≤2 weeks to event: 89% alert

Problem: recognizing + no action = no change of outcome



eHealth is the camera
that brings you this picture

What do we do after an alert?



Approaches differ

TABLE 1 Demographics and baseline clinical parameters of the study population

Parameter	
Male gender, n (%)	
Age, years	
Ischemic etiology, n (%)	
QRS duration, ms	
NYHA class	
Class I, n (%)	
Class II, n (%)	
Class III, n (%)	
Class IV, n (%)	
LV ejection fraction, %	
AF History, n (%)	
AF on implantation, n (%)	
Valvular disease, n (%)	
Diabetes, n (%)	
COPD, n (%)	
Chronic kidney disease, n (%)	
Hypertension, n (%)	
β-Blocker use, n (%)	
ACE-inhibitor use, n (%)	
Diuretic use, n (%)	
Antiarrhythmic use, n (%)	
Ivabradine use, n (%)	
CRT device, n (%)	96 (92)
Primary prevention, n (%)	101 (97)

100 HeartLogic alerts

Proportion of HF-related conditions associated with HeartLogic alerts judged clinically meaningful (n=60)



meaningful alerts

information

actionable alerts

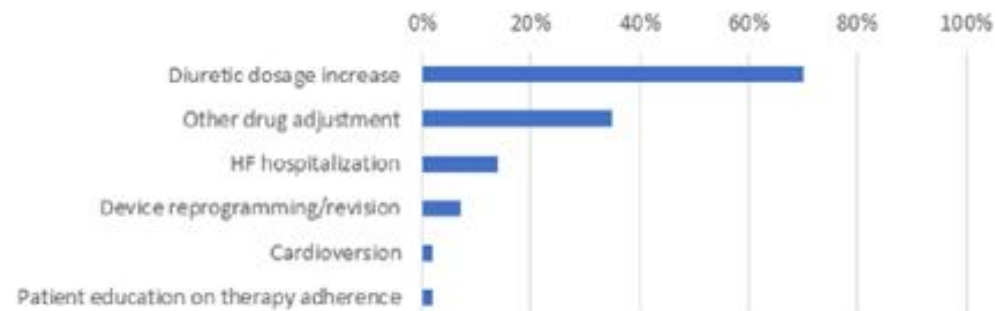
actionable alerts

80% 100%

alerts (n=43)

80% 100%

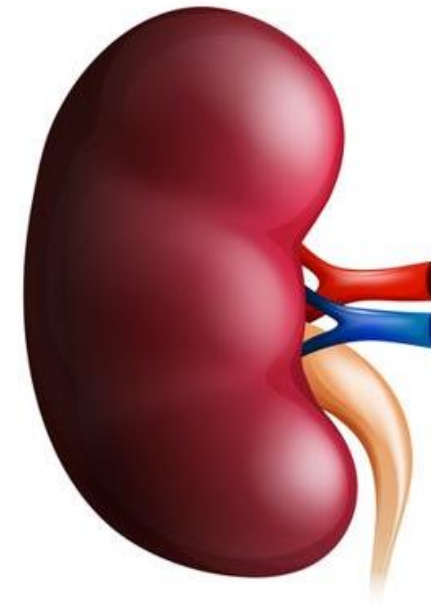
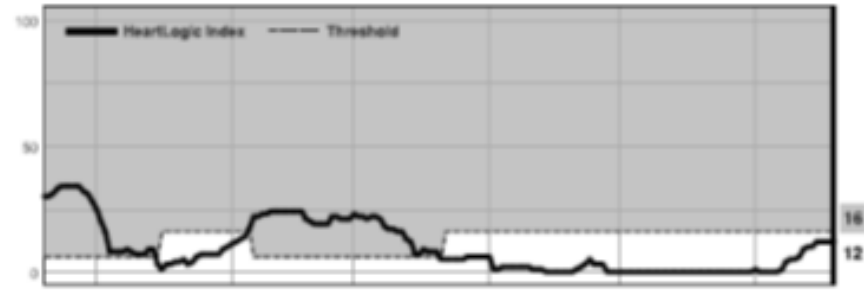
Proportion of triggered actions for actionable HeartLogic alerts (n=43)



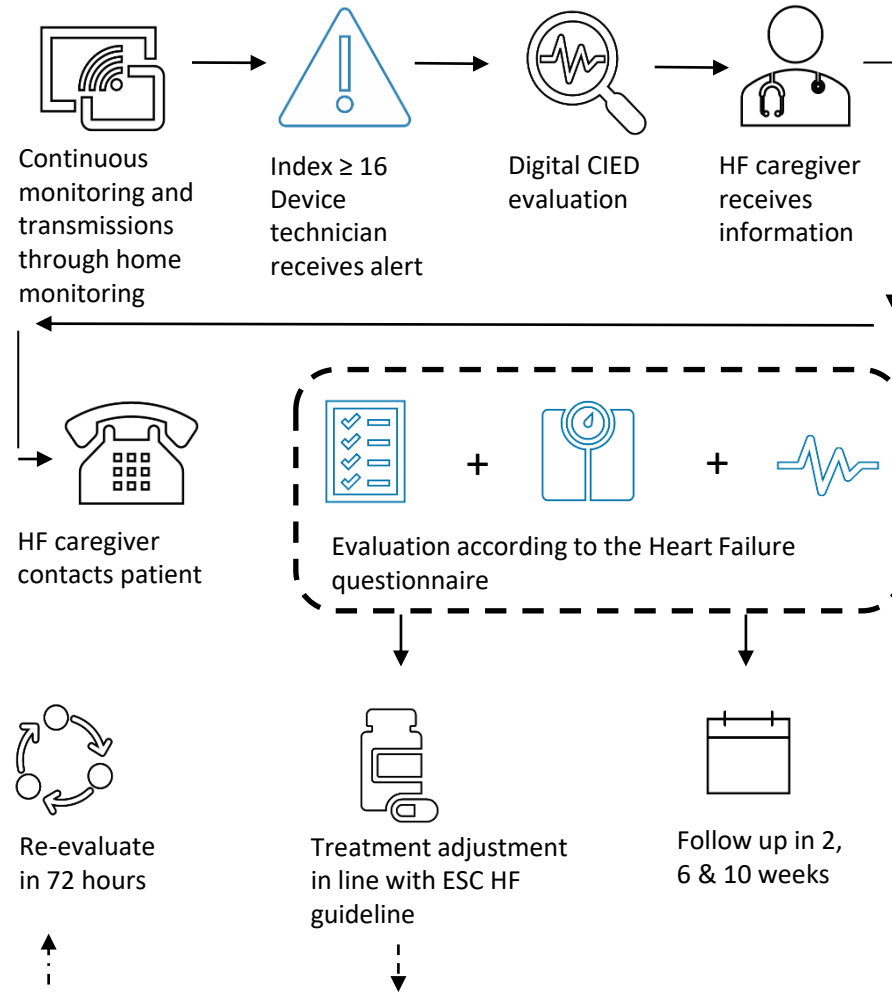
Cardioversion

Patient education on therapy adherence

MANAGE HF II



Heart Failure care path



- **True positive** ☐ Alert + ≥ 2 symptoms and/or signs of congestion
- **False positive** ☐ Alert + ≤ 1 symptoms and/or signs of congestion
- **True negative** ☐ ≤ 1 symptoms and/or signs of congestion
- **False negative** ☐ ≥ 2 symptoms and/or signs of congestion

Results

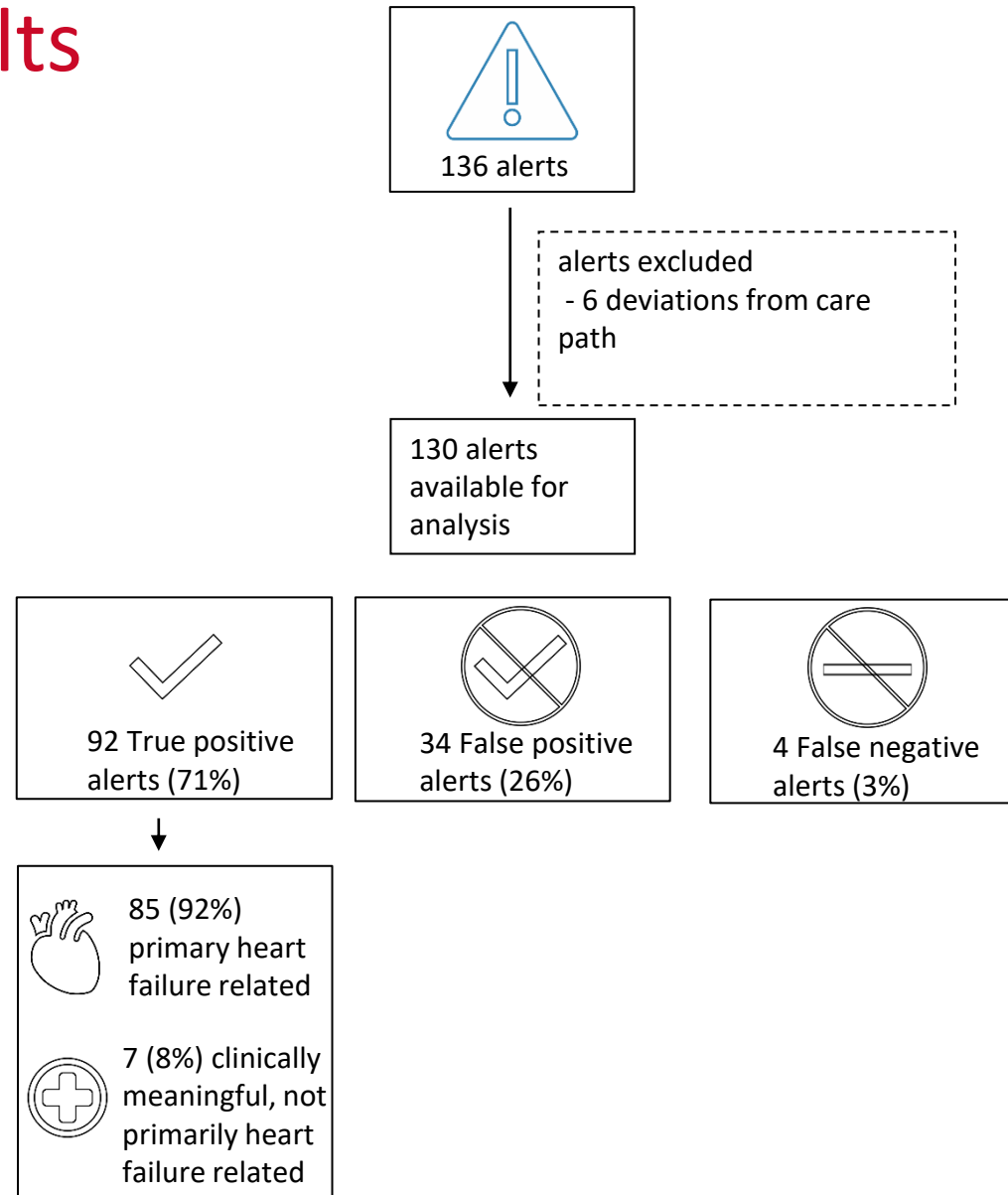


Figure 2 Number of hospitalizations, average duration of hospitalization, and number of patients hospitalized. Analysis of hospitalizations for heart failure before and after activation of HeartLogic™.

average number of hospitalizations per patient year

proportion of hospitalized patients

hospital length of stay per hospitalization

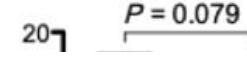
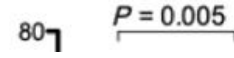
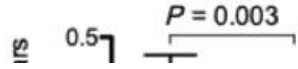
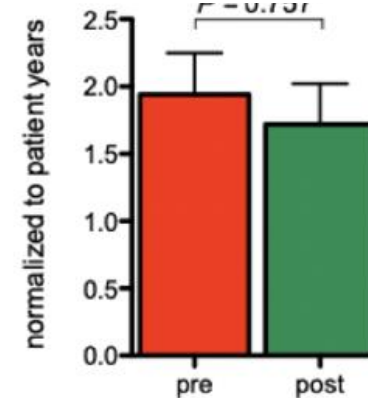
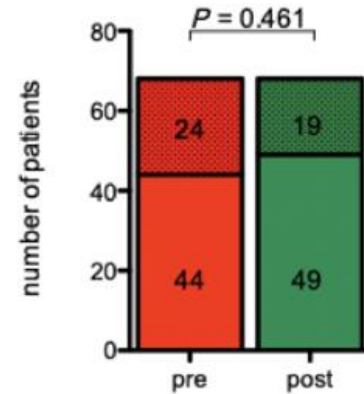
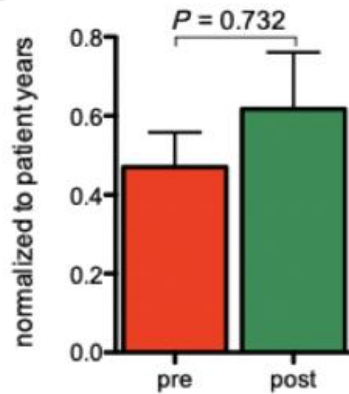


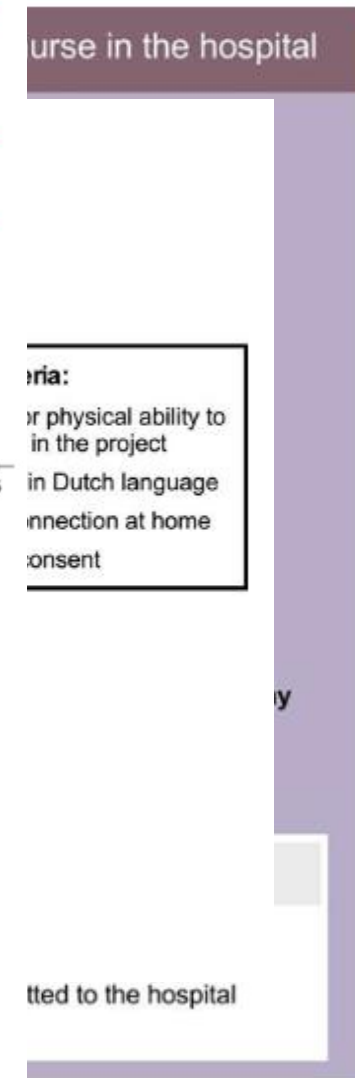
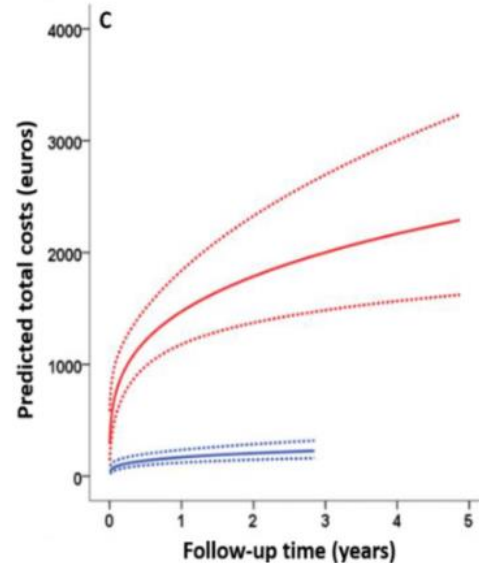
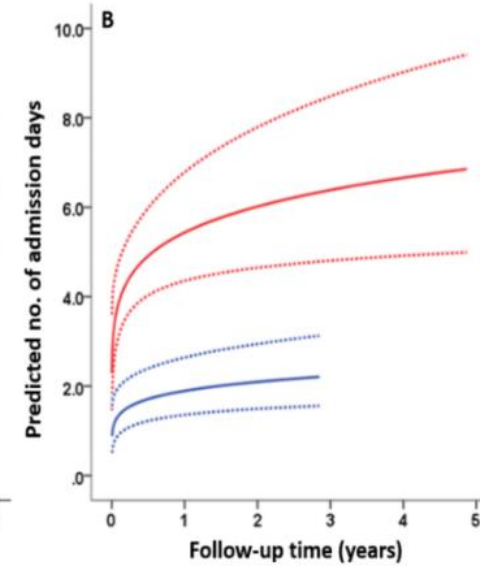
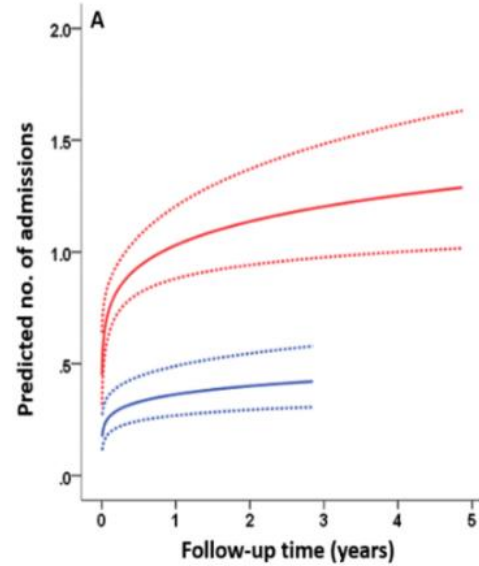
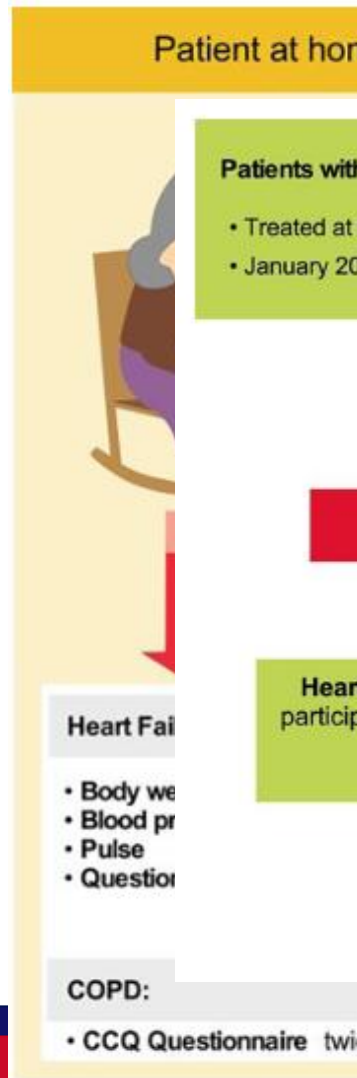
Table 2 HF events in the pre-activation vs. post-activation period (N = 68)

	Pre-activation	Post-activation
Total number of HF admissions	27	7
Total number of 1 day clinic visits	32	42
Total number of ambulatory visits	132	117

HF, heart failure.



Monitoring of symptoms



Monitoring weight, blood pressure and symptoms

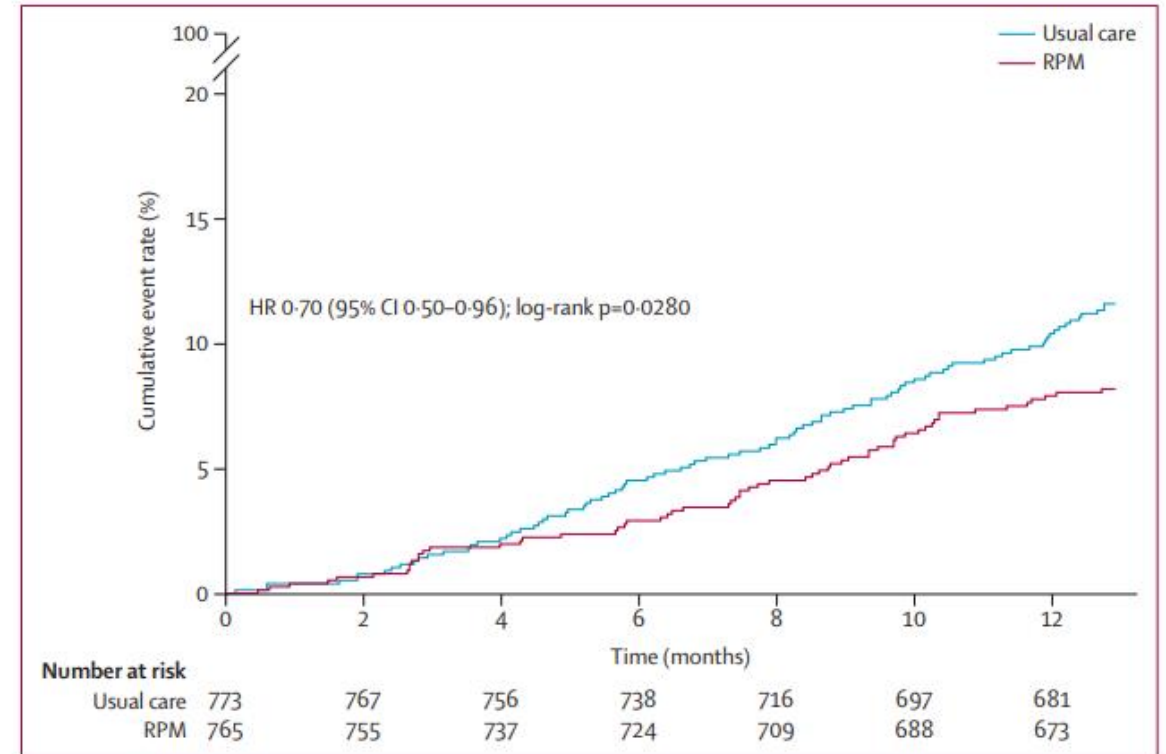
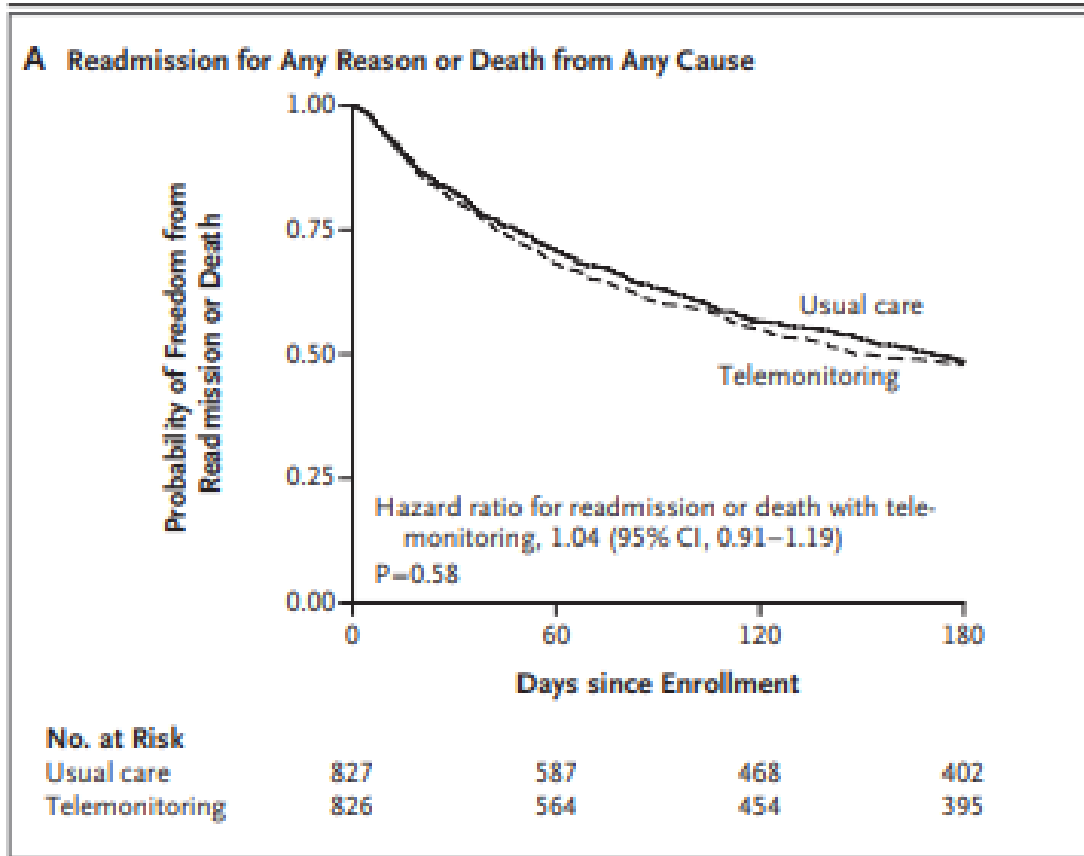


Figure 2: Kaplan-Meier cumulative event curve for all-cause death
HR=hazard ratio. RPM=remote patient management.

Koehler et al.

	Number of interventions	Median (range) per patient
Evaluation of patient-transmitted vital parameters*	1 026 078	1421.0 (6–3962)
Patient case review by TMC physicians and nurses	38 694	36.0 (0–273)
Monthly structured telephone interview	9189	12.0 (1–13)
TMC initiated contact with patient for evaluation of key vital parameters	4324	4.0 (0–37)
TMC initiated contact with patient after discharge, physician appointment, and for validation of medication list	6037	7.0 (1–27)
TMC initiated medication changes	3546	3.0 (0–57)
TMC initiated scheduled 3-month medical report sent to patient's local physician (GP or cardiologist)	2812	4.0 (0–4)
TMC physician and patient telephone consultations	1535	1.0 (0–40)
TMC initiated contact with health-care professionals	863	0.0 (0–21)
Patient home heart failure education including caregivers	765	1.0 (1–1)
TMC initiated emergency department visits	30	NA
TMC initiated unplanned cardiovascular hospital admissions	57	NA
TMC initiated unplanned non-cardiovascular hospital admissions	13	NA

TMC=telemedicine centre. GP=general practitioner. NA=not applicable; only the total number is known, and not the median per patient. *Vital parameters are bodyweight, blood pressure, self-rated health status, and electrocardiogram including peripheral capillary oxygen saturation.

Table 4: Selected interventions of TMC physicians and nurses in the remote patient management group



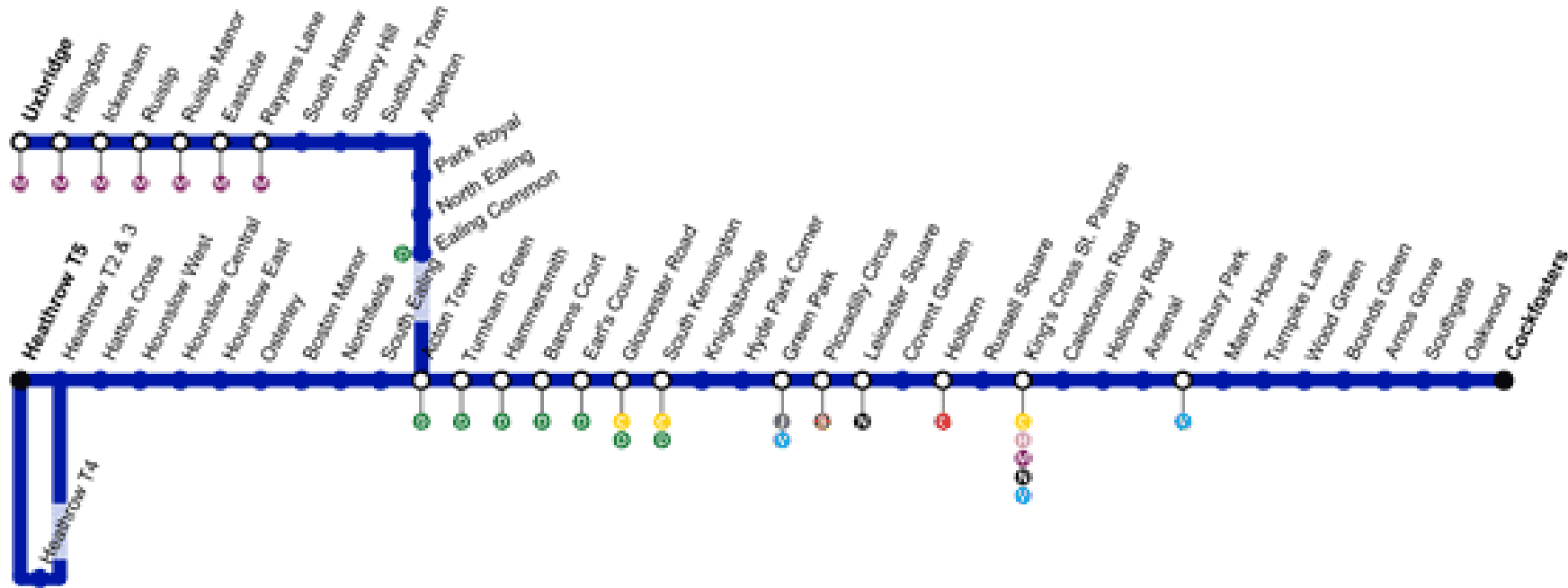
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Applications, cardiothoracic surgery

Metrolijn – CTC zorgpad



I



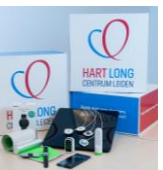
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ALGEMEEN:

1. CTC website
2. CTC film met ‘echte patient’ en op CVIC/Basalt/ICU
3. Patient ervaringen meenemen, Buddy Systeem
4. Populatie dashboard (kwaliteit, registraties, onderzoek)
5. Patient dashboard (patienten zorg, snelle inzage problemen)

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Prehabilitatie programma:

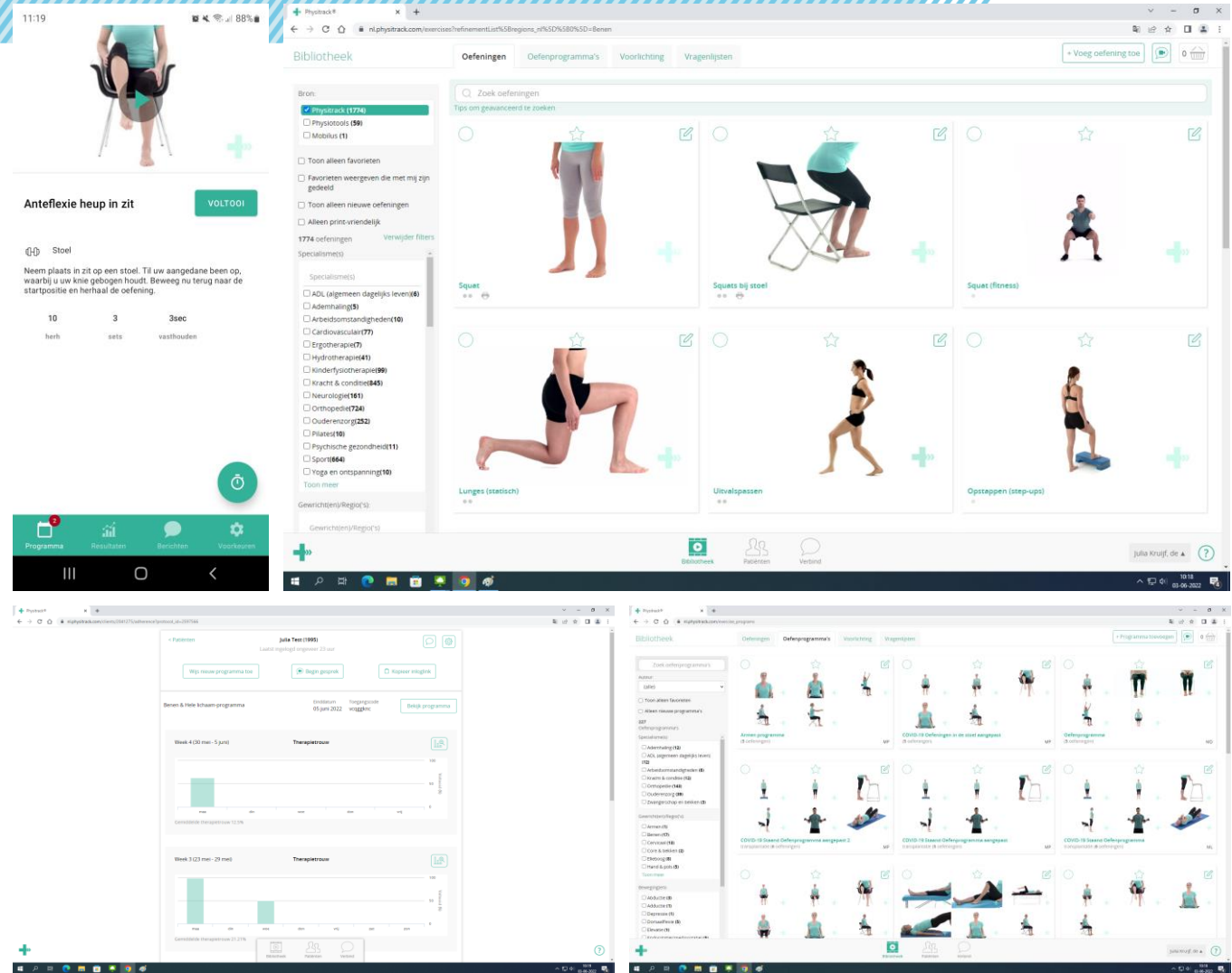
1. Fitter operatie ingaan - Physitrack app, Fysiotherapie, BOX
2. Screenen Psycho-sociaal (Angst, Delier, Frailty, Depressie)
3. Screenen Leefstijl (stop roken, alcohol), CVRM
4. Wensen en Verwachtingen Patient
5. Voedingsadviezen

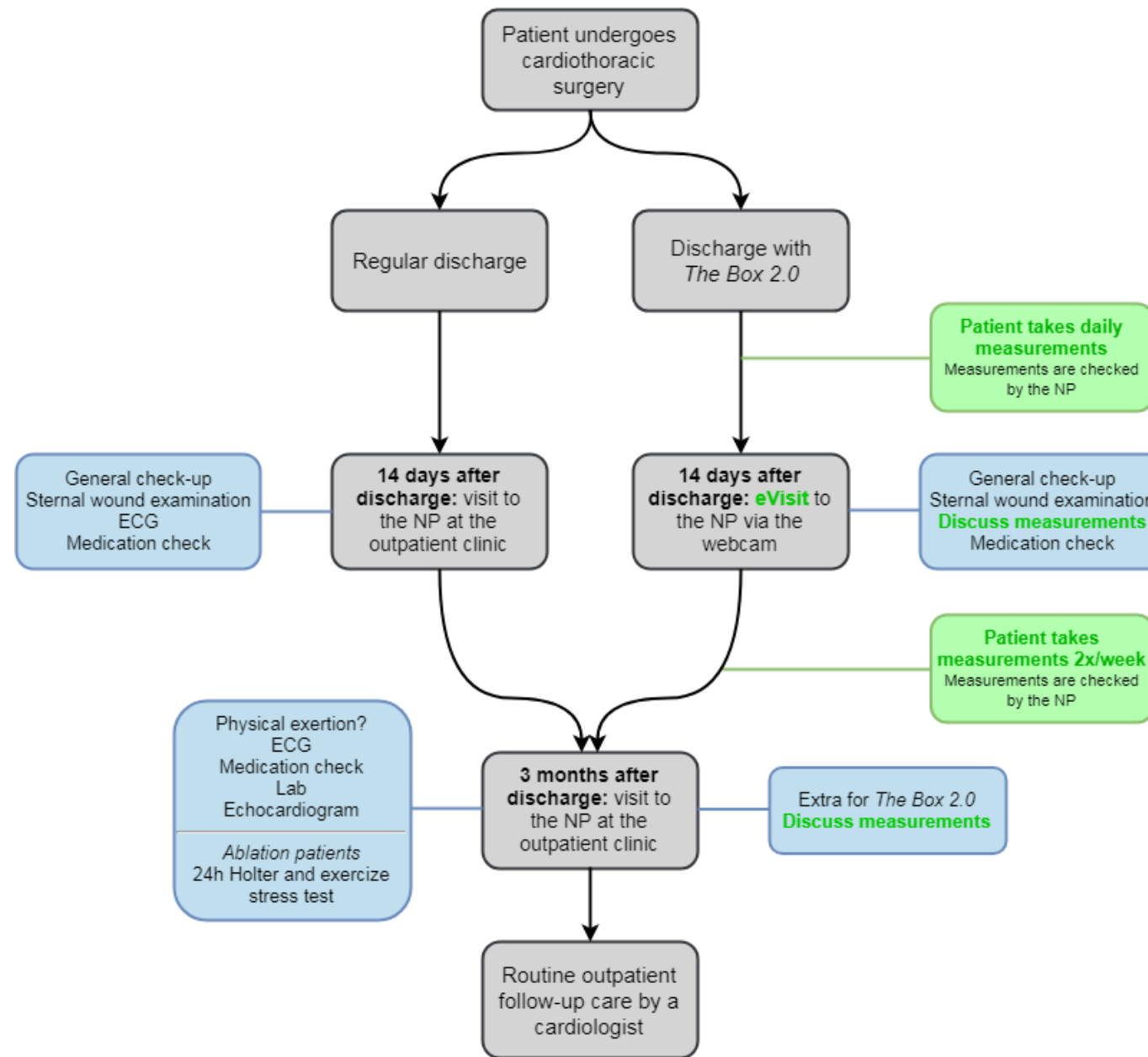
Betere informatie voorziening – Website, Film, Dashboards

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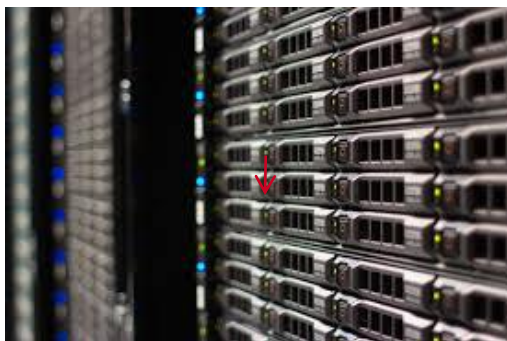
Physitrack App







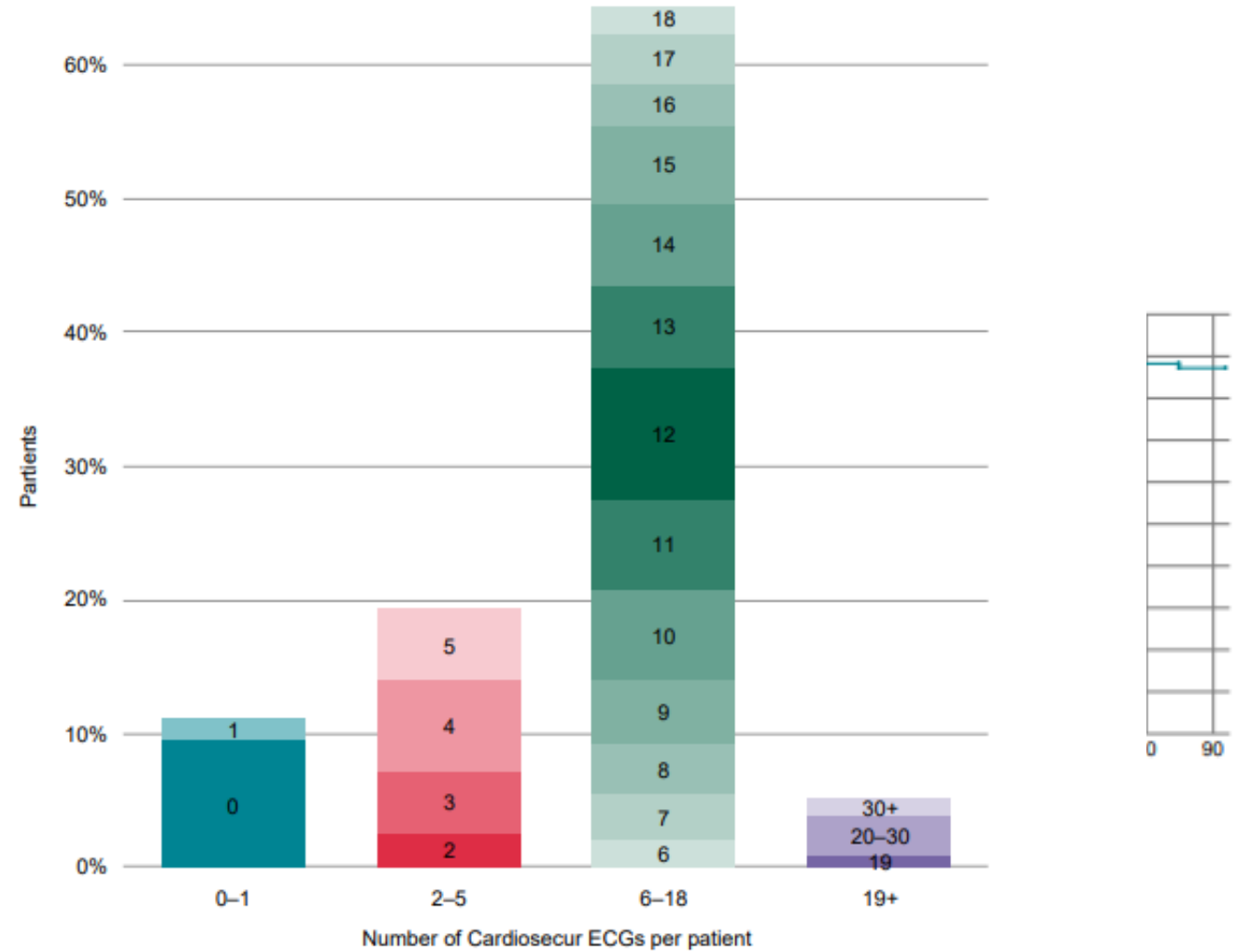
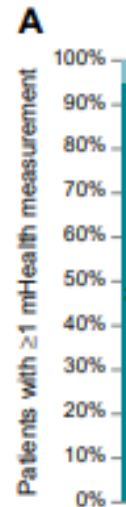
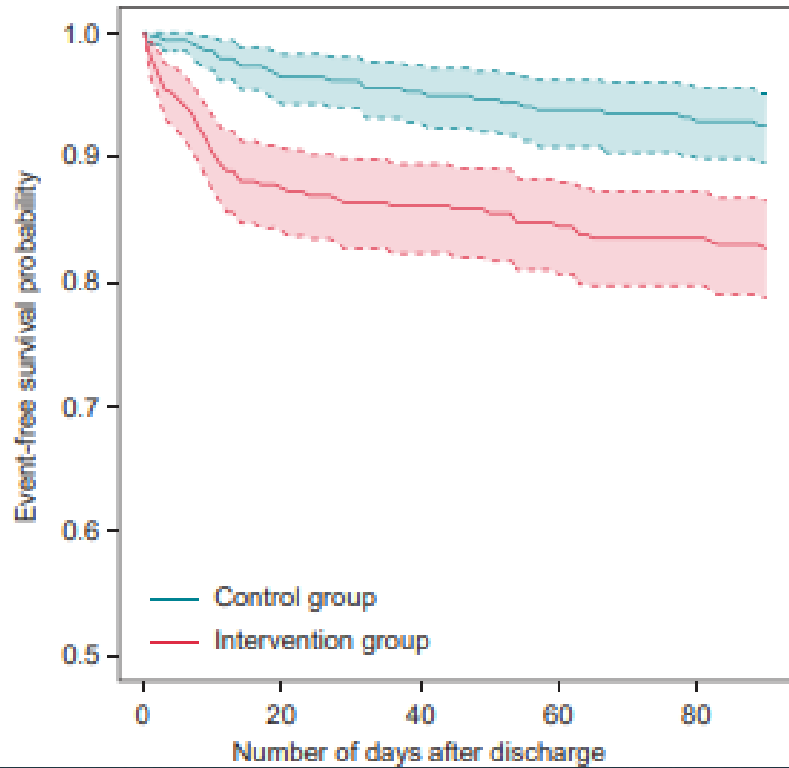
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EPD
VISION 

Connecting Care!

Outcomes





- **Zorgkwaliteit** (patient tailored care, lagere morbiditeit en mortaliteit)
- **Kosten-efficientie** (kortere ligduur, minder opnames)
- **Betrokkenheid Patient en verwijzers** (patient empowerment)
- **Betere planning** en optimaal gebruik opname capaciteit (UFT track)

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Robotics

Robotics



Nurse Robot



Lab vs clinical practice





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Case report

Male, 75 years old

Echo:

- Dilated LV, moderately reduced function after
- Good RV function
- MI gr 4, AoI gr 2, TI gr 2, sPAP 50 mmHg

CAG:

- RCA: significant stenosis mid RCA
- LCA: CTO RDA, sign stenosis MO, stent RDP open

Male, 75 years old

1986: Anteroseptal myocardial infarction

2005: VT's for which ICD secondary prevention

2017: Progressive HF, NYHA 3

- RR 110/60 mmHg, congested

- Hb 7,9 mmol/L, GFR 21 ml/min/1,73 m², pro BNP 6614
ng/L

Co-morbidity:

- Hypertension
- Chronic kidney disease
- Excessive alcohol intake

Fenprocoumon

Bumetanide 2 + 1 mg

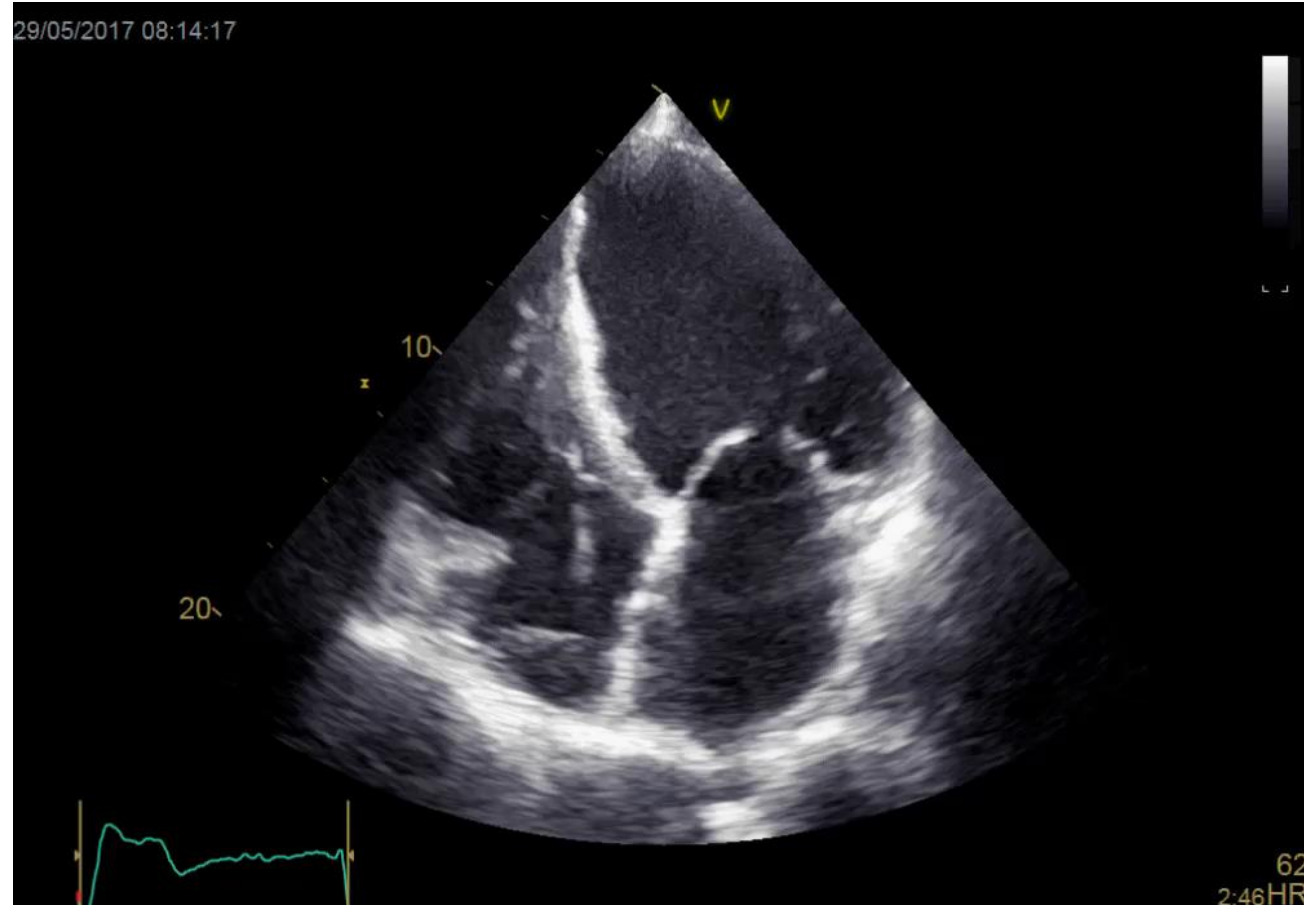
Spirolacton 25 mg

Fosinopril 10 mg

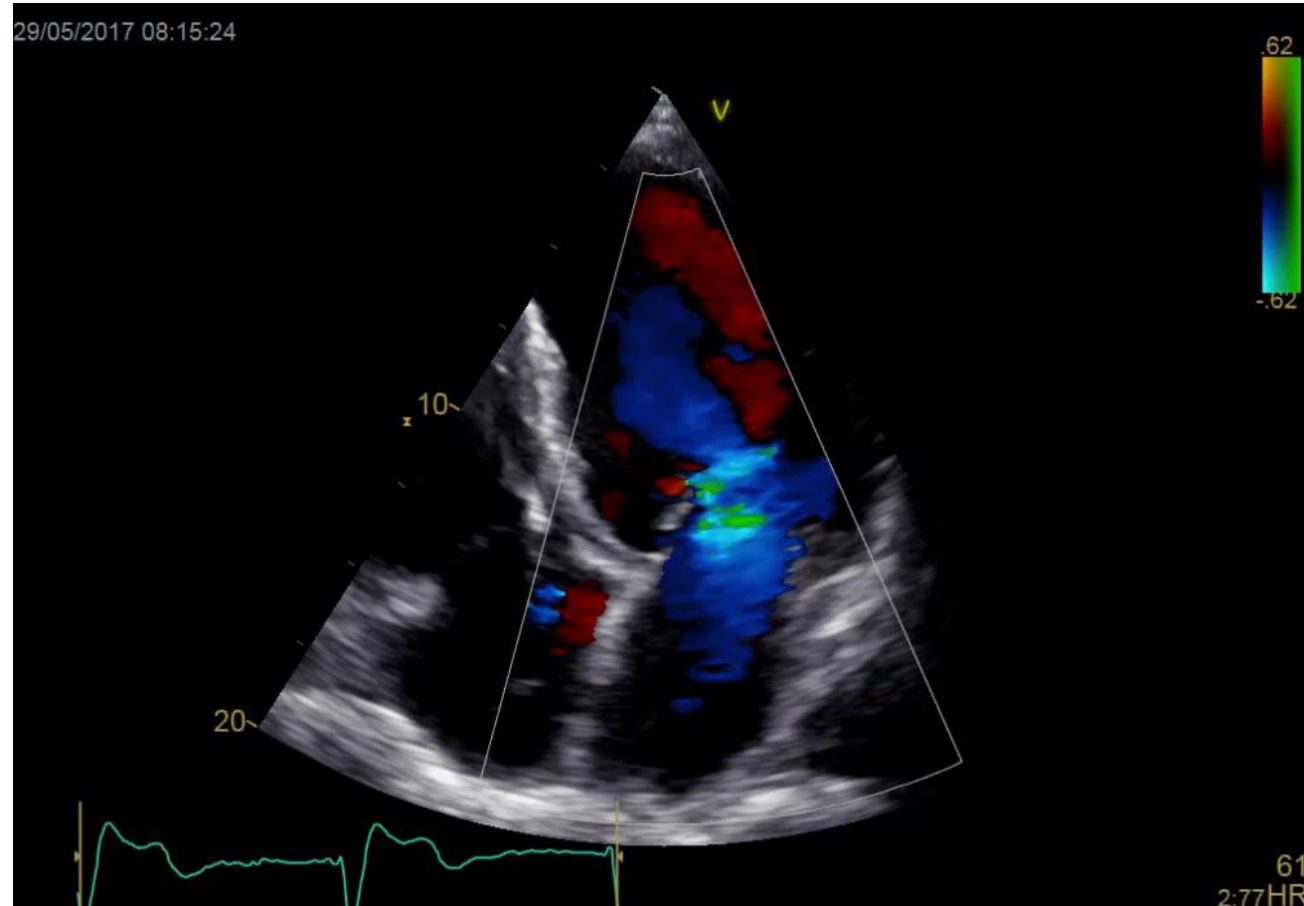
Amiodarone 200 mg

Rosuvastatine 10 mg

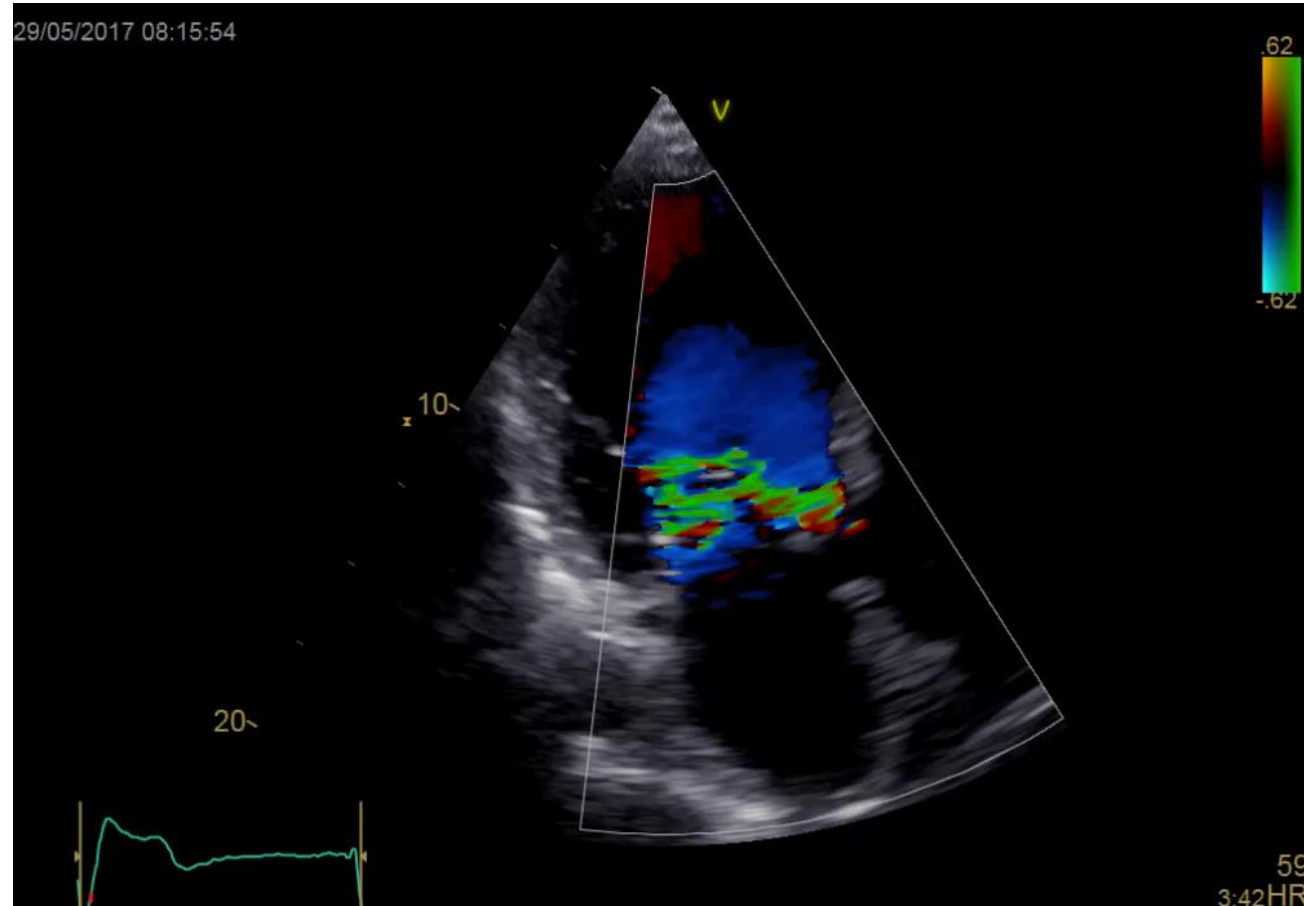
Male, 75 years old



Male, 75 years old



Male, 75 years old



Male, 75 years old



Male, 75 years old

Oct 2017:

CABG + AVR + MVP + LV reconstruction + LV lead

2 weeks ICU

Upgrade to CRT-D

GFR 29 ml/min/1,73 m²

Sent to cardiac rehabilitation

Fenprocoumon

Bumetanide 2 + 1 mg

Metoprolol 25 mg

Amiodarone 200 mg

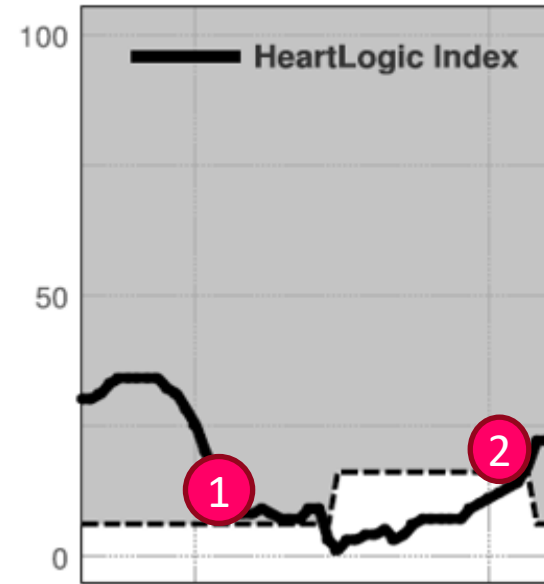
Rosuvastatine 10 mg

Geen ACE/MRA ivm NF

Male, 75 years old

01 Jan 2018

01 Feb 201

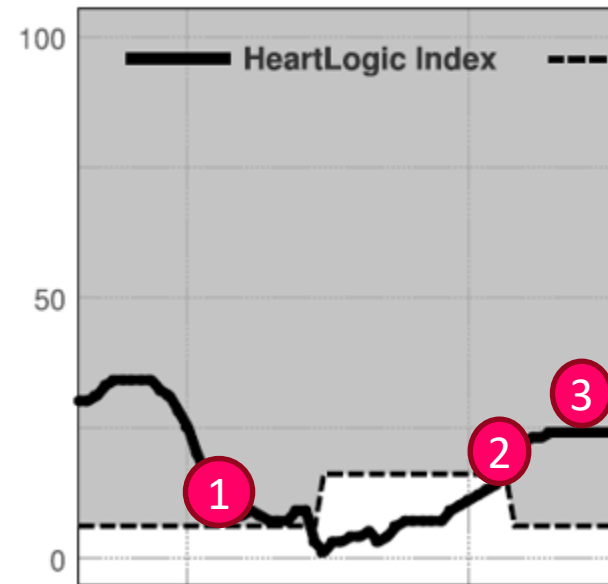


- 1 Inclusion. HeartLogic 8, eGFR 44, BNP 6474 ng/L
- 2 Alert and evisit: HeartLogic 17, asymptomatic

Male, 75 years old

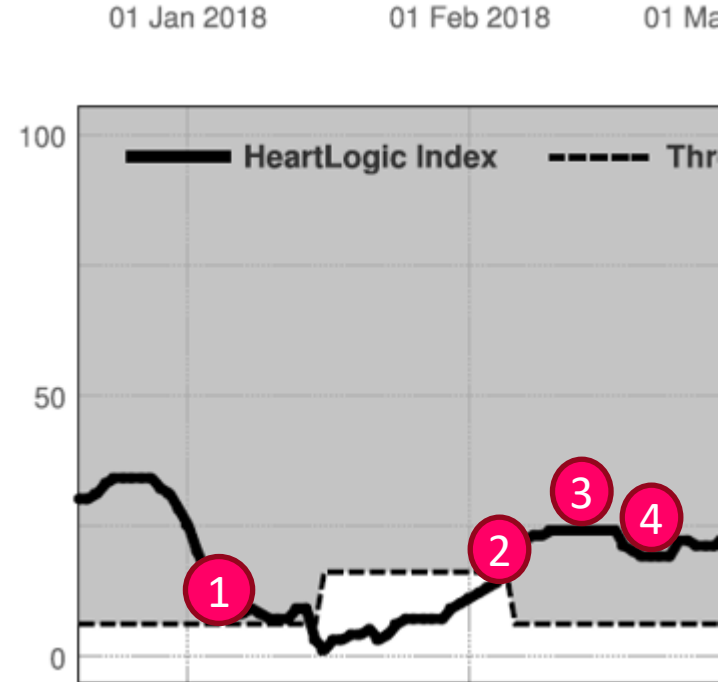
01 Jan 2018

01 Feb 2018



- 1 Inclusion. HeartLogic 8, eGFR 44, BNP 6474 ng/L
- 2 Alert and evisit: HeartLogic 17, asymptomatic
- 3 Evisit: HeartLogic 25, mild symptoms, excessive fluid intake

Male, 75 years old



- 1 Inclusion. HeartLogic 8, eGFR 44, BNP 6474 ng/L
- 2 Alert and evisit: HeartLogic 17, asymptomatic
- 3 Evisit: HeartLogic 25, mild symptoms, excessive fluid intake
- 4 Outpatient clinic visit: HeartLogic 22, congestion, GFR 33, BNP 9650 ng/L

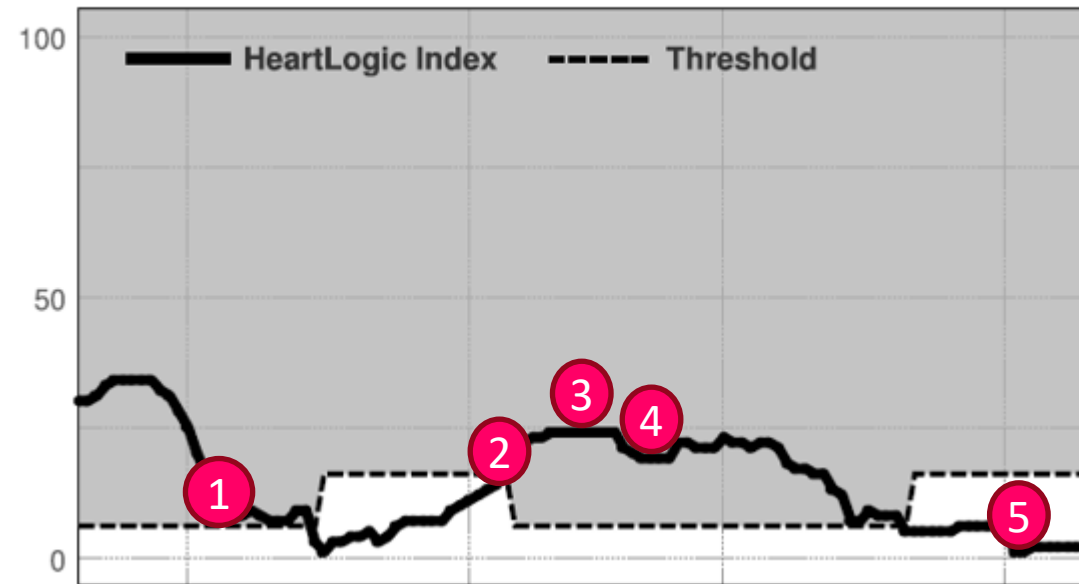
Male, 75 years old

01 Jan 2018

01 Feb 2018

01 Mar 2018

01 Apr 2018



- 1 Inclusion. HeartLogic 8, eGFR 44, BNP 6474 ng/L
- 2 Alert and evisit: HeartLogic 17, asymptomatic
- 3 Evisit: HeartLogic 25, mild symptoms, excessive fluid intake
- 4 Outpatient clinic visit: HeartLogic 22, congestion, GFR 33, BNP 9650 ng/L
- 5 Outpatient clinic visit: HeartLogic 0, reduction symptoms, eGFR 42, BNP 4173 ng/L



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Back up slides