

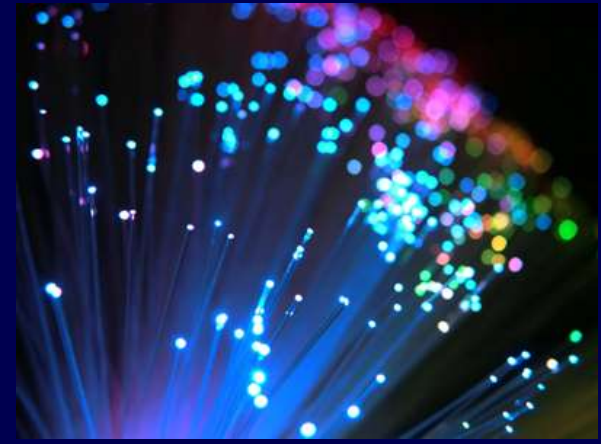
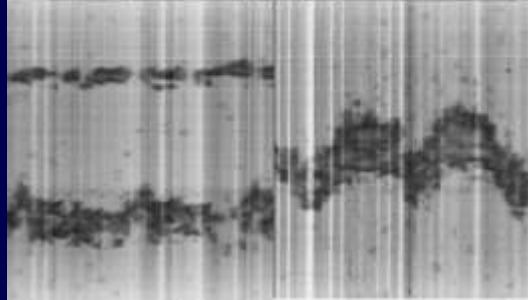
# Troubleshooting pacemakers remotely

**Dr Paul Foley**  
**Consultant Cardiologist**  
**Wiltshire Cardiac Centre and Oxford Heart Centre**



**Declaration of interests: none (invited speaker – no payment received)**

# Technology changes



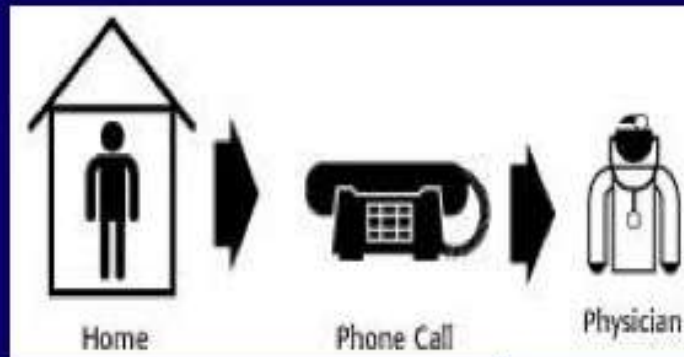
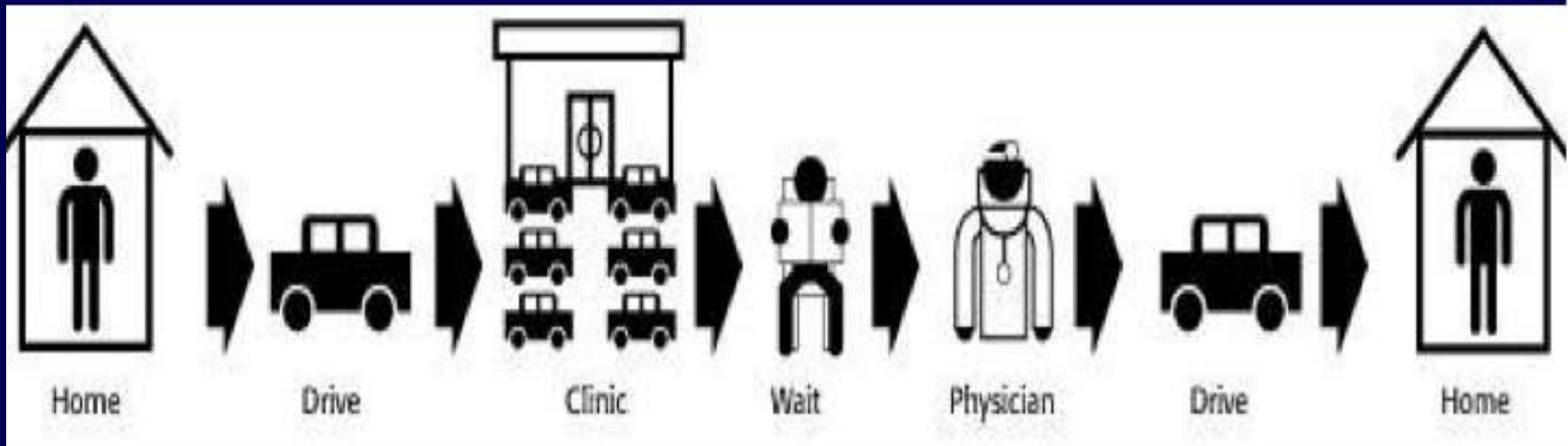
# *The First ECG remote transmission*

*(Einthoven, 1905, March 22)*

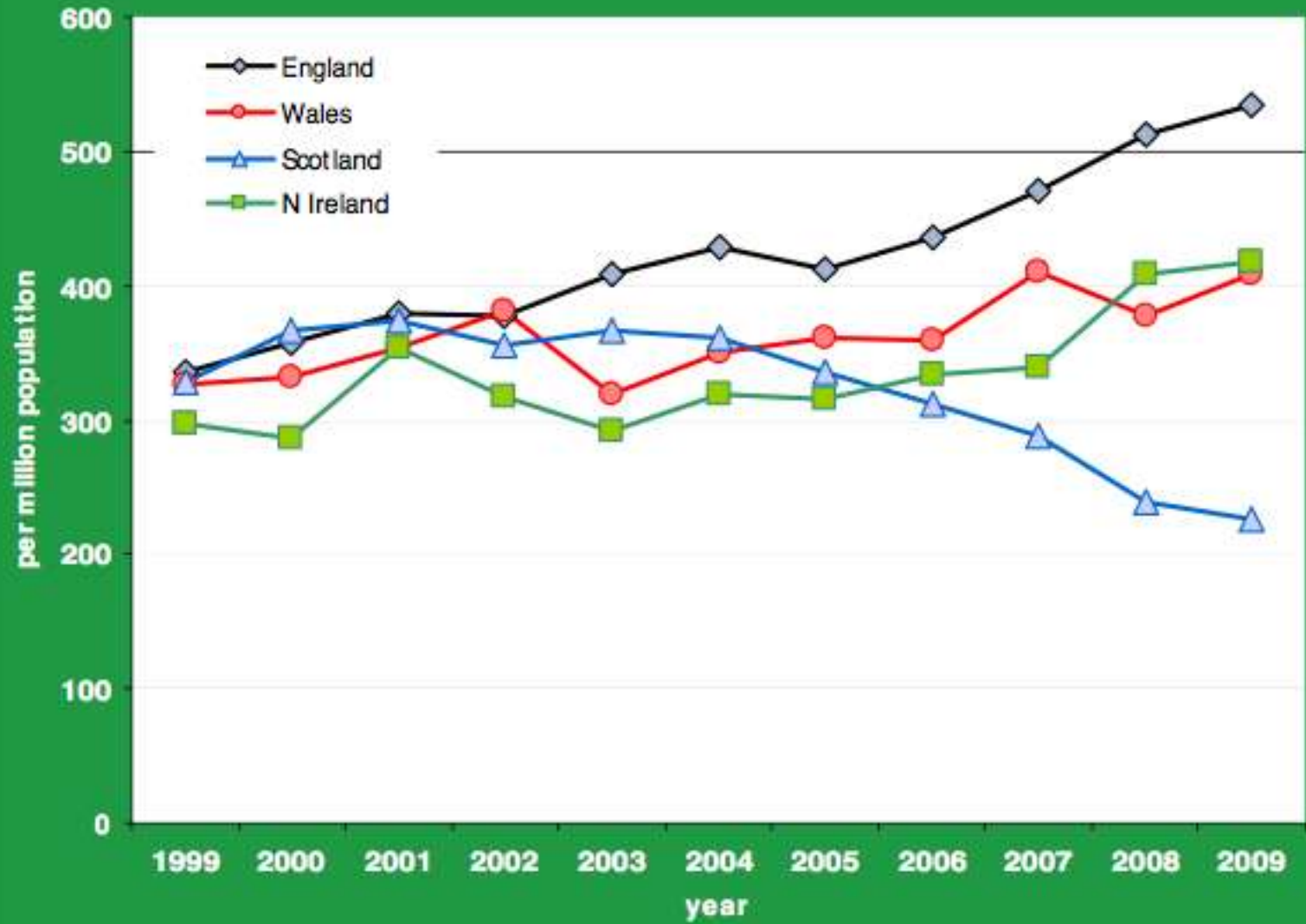


**Transtelephonic transmission of ECG  
from the hospital to the outpatient clinic  
(2 Km far away)**

# Current practice vs. remote monitoring



# Pacing implants per million



# Conventional follow up clinic – what changes are made

	In-hospital (n = 1526)	Hospital discharge to first 2 months (n = 1320)	Between 2 and 6 months (n = 1186)	Between 6 and 12 months (n = 983)	After 12 months (n = 601)
Settings changed					
Overall	54.0	54.2	54.1	45.2	23.5
Mode change	6.4	3.1	3.4	1.9	1.8
Sensor turned ON	10.3	10.2	5.5	6.2	1.6
Sensor turned OFF	4.1	0.4	0.8	1.0	0.5
Lower rate	18.6	9.3	7.0	4.8	2.2
Maximum tracking rate	17.4	4.7	4.6	2.9	1.8
Maximum sensor rate	12.4	5.8	5.1	3.9	2.9
Atrio-ventricular delay	19.2	8.4	7.9	4.3	4.5
Pulse duration					
Atrial	5.7	2.8	2.5	3.2	1.4
Right ventricle	5.8	3.4	5.6	4.4	2.6
Pulse amplitude					
Atrial	9.1	21.1	22.7	13.2	4.7
Right ventricle	11.9	25.4	31.6	20.3	7.9
Sensing					
Atrial	15.7	11.0	7.2	7.6	3.3
Right ventricle	10.7	5.6	5.3	3.0	1.8
Mode switch	0.3	0.3	0.3	0.3	0.3
Arrhythmia therapy	1.0	0.4	0.4	0.6	0.2

All values are percentages except stated otherwise.

## Conventional follow up clinic – travel distances + family involvement

Characteristic	Description
Out-of-region patients	176 (5%)
Travel time (min) <sup>a</sup>	20 (15–40)
1–20	1704 (51%)
22–30	700 (21%)
Above 30	957 (28%)
Distance (km) <sup>a</sup>	15 (6–25)
0–9	1135 (34%)
10–20	1224 (36%)
Above 20	1003 (30%)
Travel modality	
Accompanied by family member	2059 (61%)
Unaccompanied using personal car	937 (28%)
Unaccompanied using public transportation	177 (5%)
Ambulance	189 (6%)

Data are reported as counts and (%), unless specified. <sup>a</sup>median (25<sup>th</sup>–75<sup>th</sup> percentiles).

21.7% of pacemaker patients required re-programming or medication change

## Change follow up

- Reduce workload
- Detect device malfunction
- Improve QOL of patient and staff
- Manage longevity
- Reduce costs

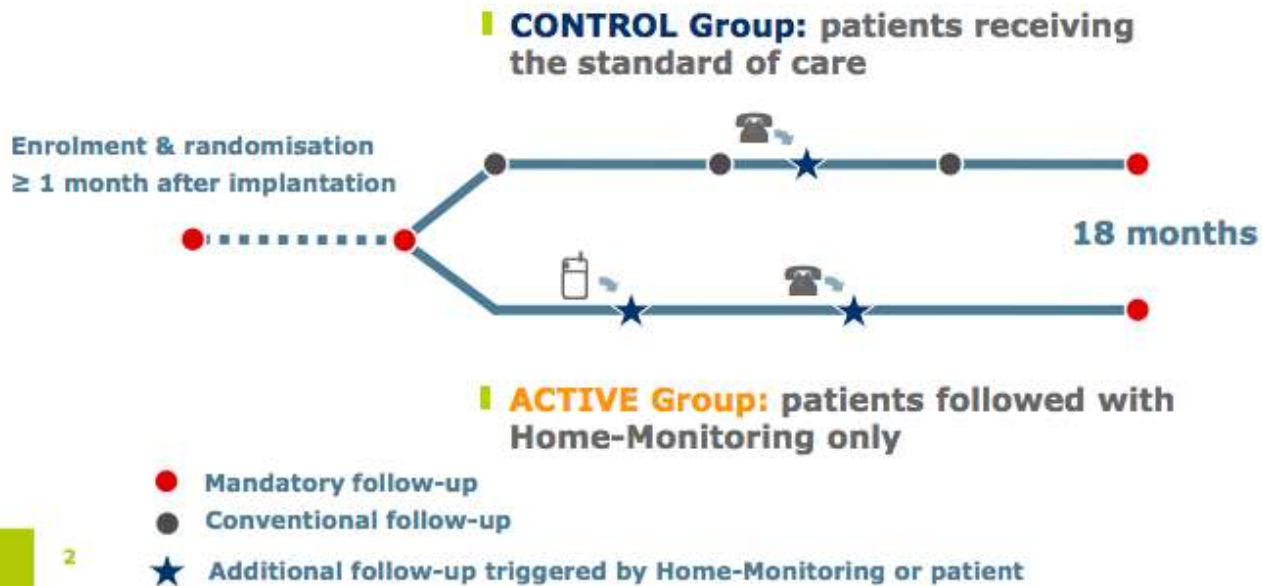
## • Treat problems

- AF
- Heart failure
- Potentially decrease hospitalisation, morbidity and mortality



## Study Objective and Design

The study investigates whether Home-Monitoring FU of PM patients is as efficient as conventional "in office" FU  
Prospective, multicenter, randomized trial

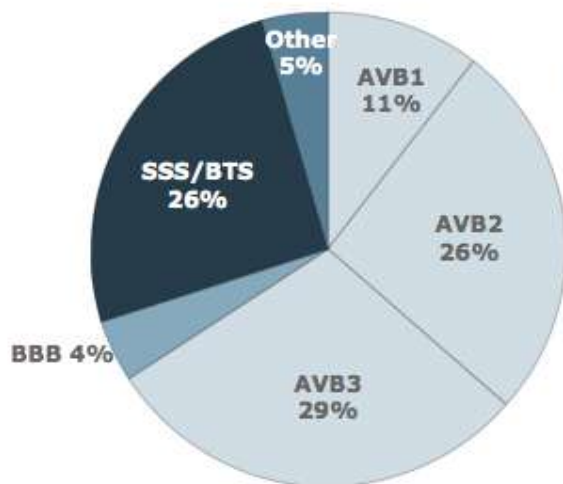


# Indications for pacemaker implantation in COMPAS



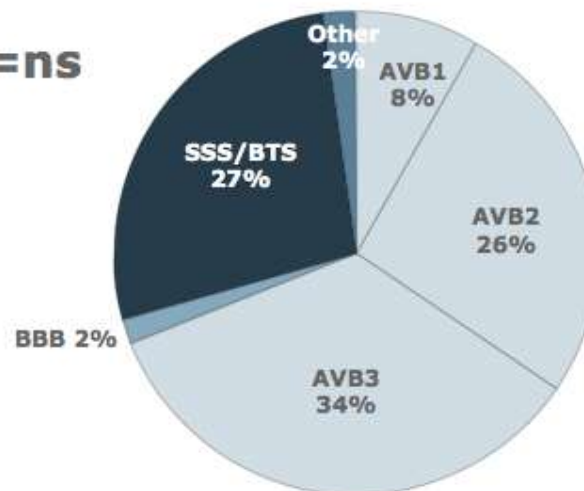
## Primary ECG indications

### ACTIVE Group



p=ns

### CONTROL group



9

\*BBB=Bundle Branch Block



## Secondary Endpoint : Cardiovascular SAE Hospitalisations related to:

	ACTIVE (n=248)		CONTROL (n=246)	
	Events	Patients	Events	Patients
Ventricular arrhythmia	1	1	1	1
Atrial arrhythmia	4	4	10	10
Stroke	2	2	8	7*
Heart failure	18	13 **	6	6
Acute Coronary Event	6	5	6	6
Valvular heart disease	2	2	1	1
Pericardial disease	2	2	0	0
Other	2	2	1	1
<b>TOTAL</b>	<b>37</b>	<b>29 (11.7%)</b>	<b>33</b>	<b>32 (13.0%)</b>

\* Including 4 deaths

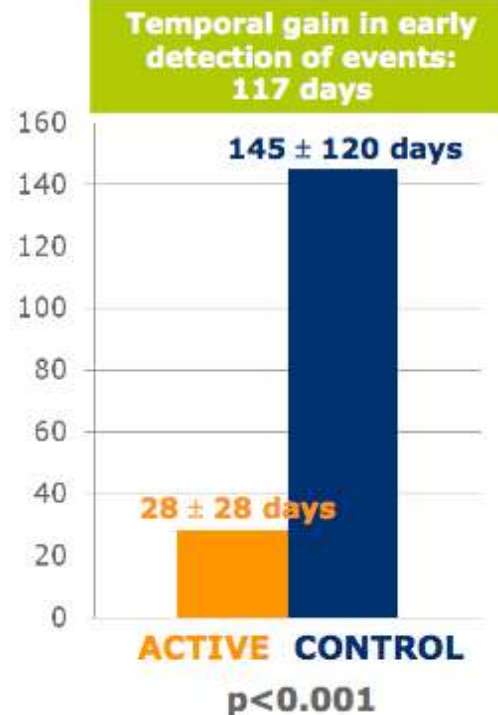
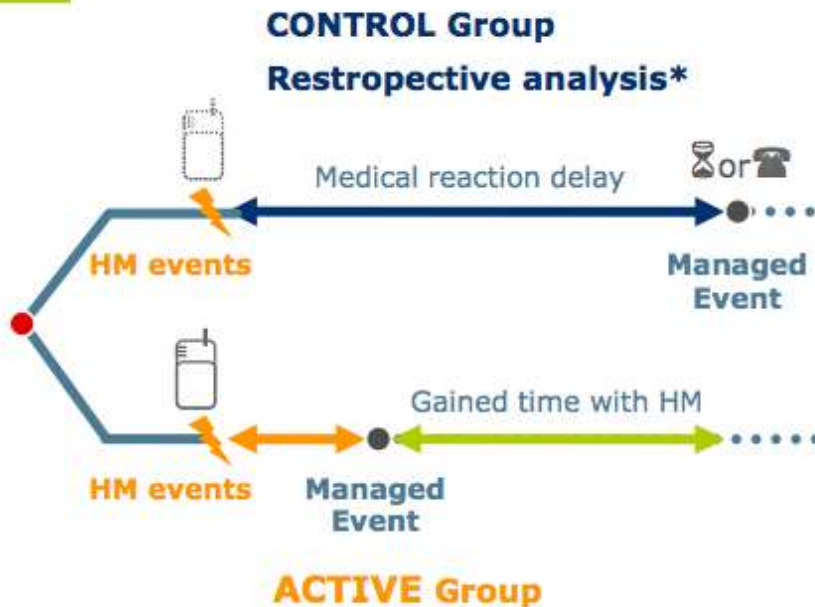
\*\* Including 3 deaths

**p=ns**

# COMPAS – time to detection of event



## Medical Reaction Delay



22 \* To allow a retrospective analysis, the control group patients were equipped with Blinded Remote Monitoring.

# COMPAS – effect of home monitoring on QoL



## Quality of Life – SF36

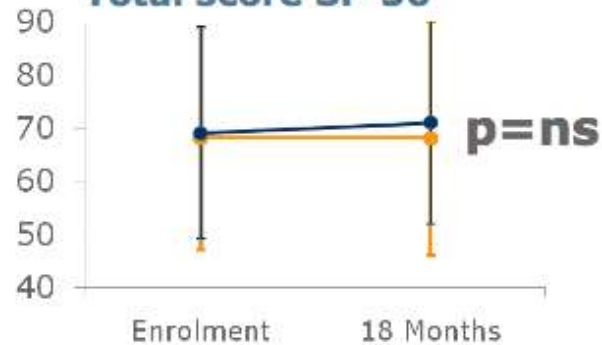
### Physical health



### Mental health



### Total score SF-36

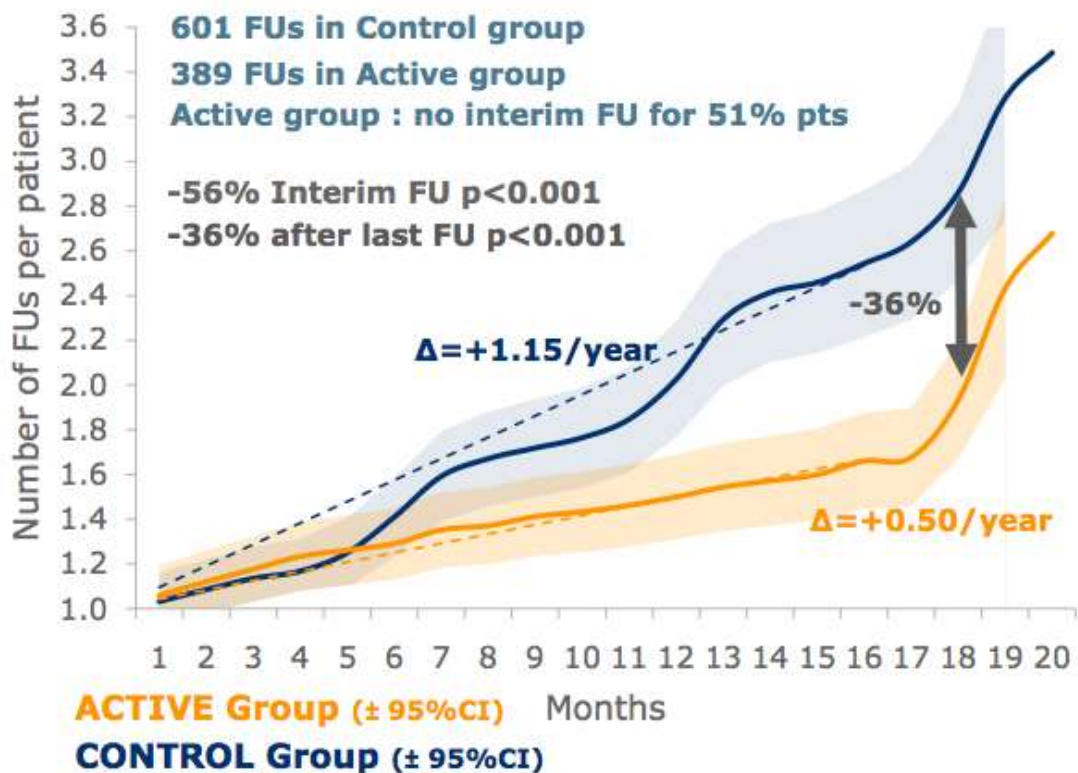


**ACTIVE Group**  
**CONTROL Group**

# COMPAS: remote monitoring reduced follow ups



## Total Follow-Ups over time



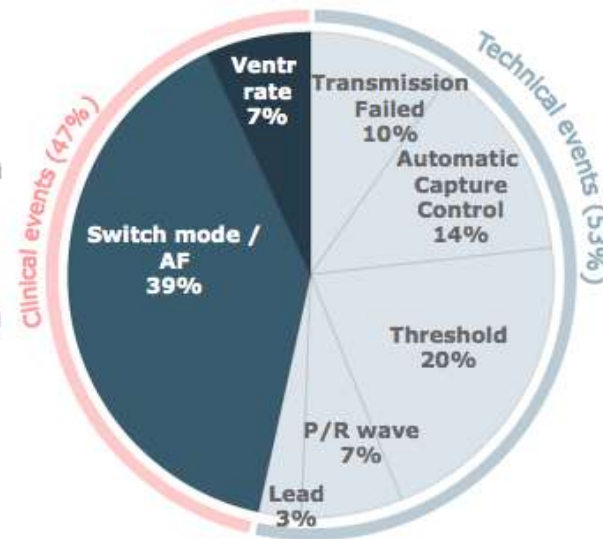
# COMPAS – reason for triggered follow up in HM arm



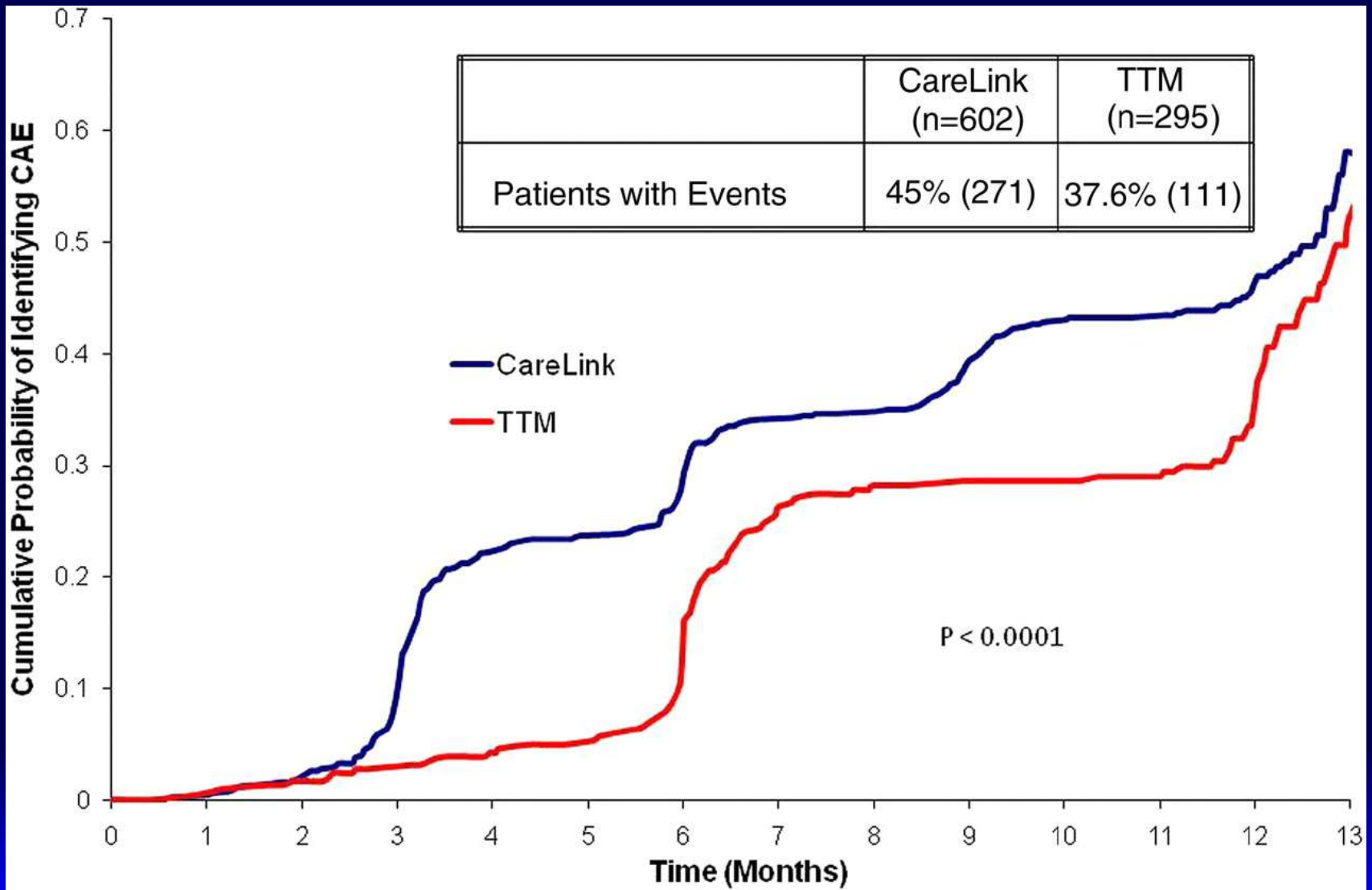
## 73 FUs triggered by Home-Monitoring



- 34 Clinical events (47%)**  
82% leading to clinical intervention
- 39 Technical events (53%)**  
67% leading to clinical intervention



# Home monitoring identifies problems earlier



## Treating AF and reducing stroke

---

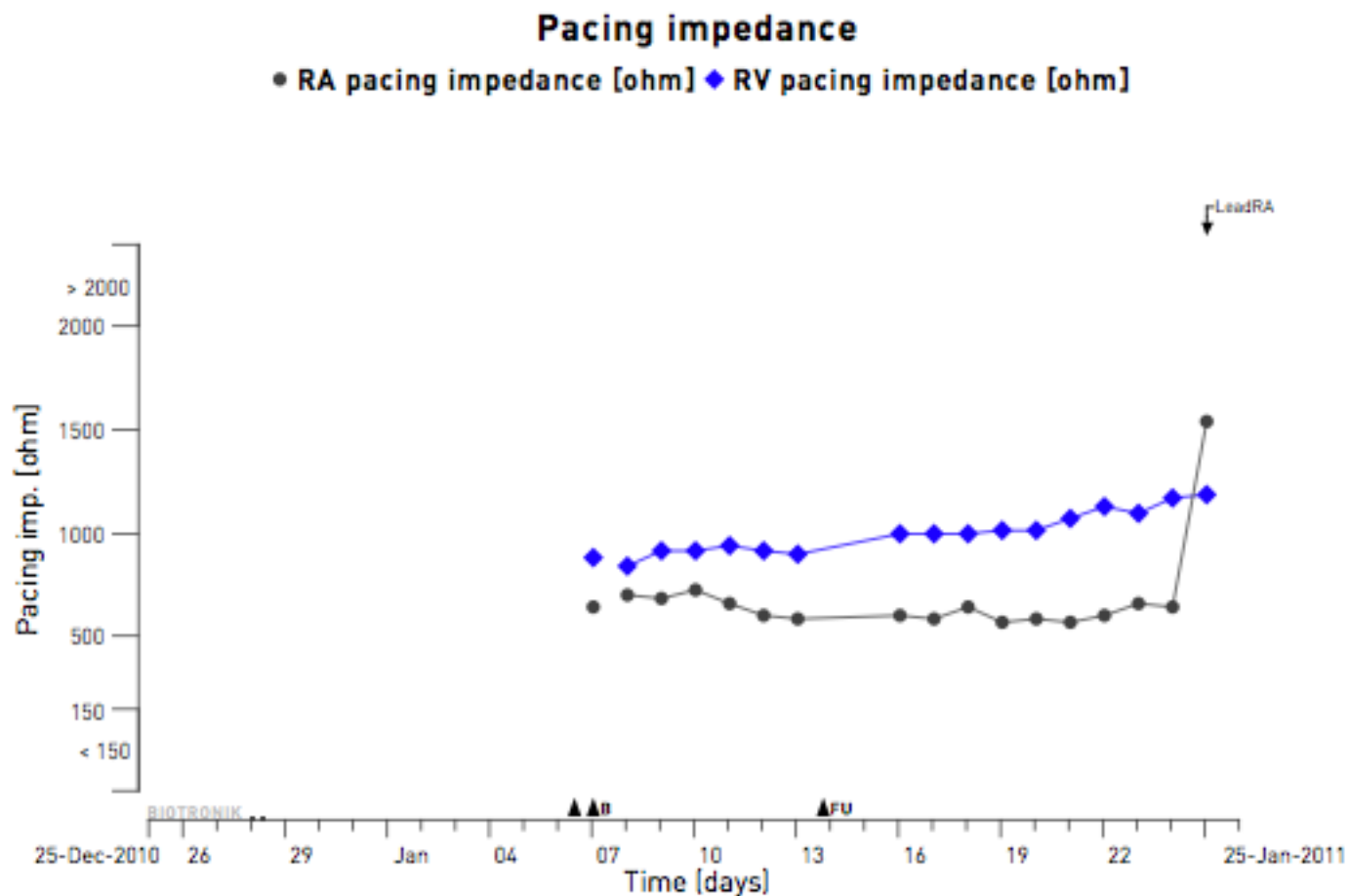
Annual risk	Current monitoring
Stroke	4.5% <sup>a</sup>
Probability of death if stroke	19% <sup>b</sup>
Non-stroke mortality	2% <sup>c</sup>
Post-stroke mortality	10% <sup>d</sup>

<sup>a</sup> Gage *et al* [27]  
<sup>b</sup> 30-day fatality rate after a first stroke [28]  
<sup>c</sup> Based on expected number of deaths without stroke conversion  
<sup>d</sup> Death rate between 1-2 years after the patient's first stroke

**COMPAS study 25% risk of atrial fibrillation over 18 month follow up.**



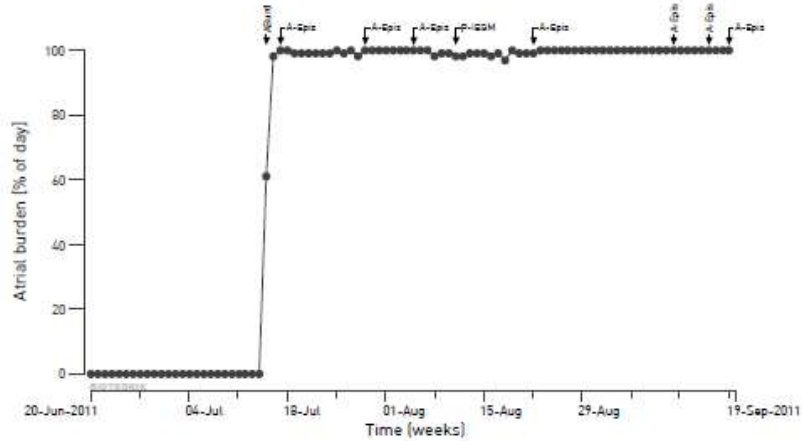
# Identifying complications – atrial lead displacement



# Identifying arrhythmias

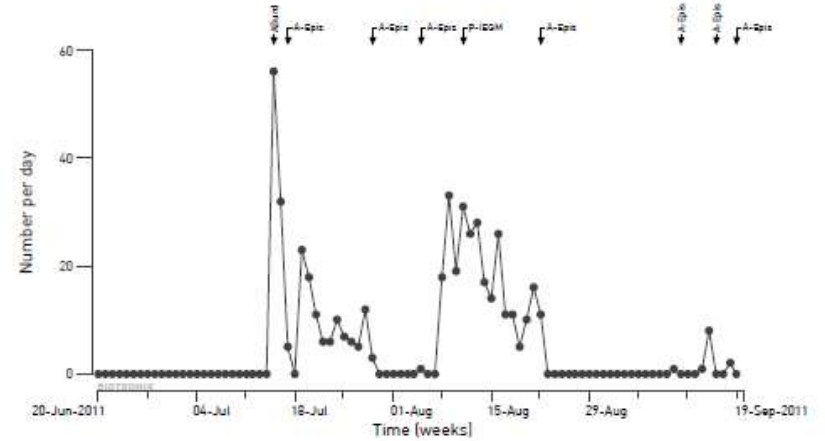
## Atrial burden

• Atrial burden [% of day]



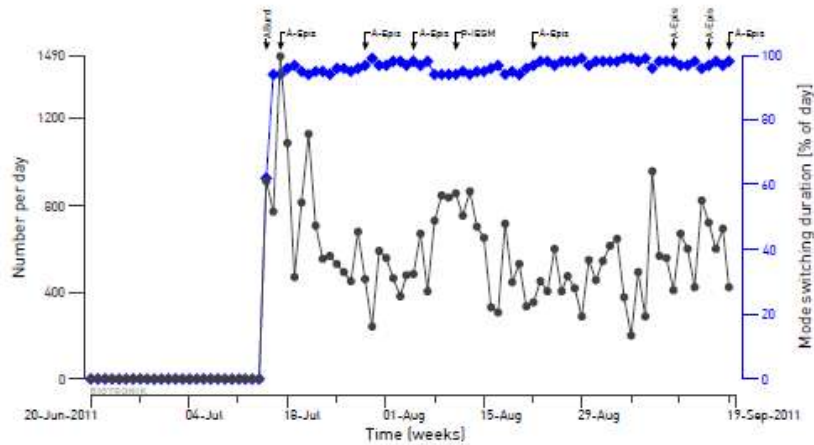
## Atrial episodes

• Atrial arrhythmia episodes per day



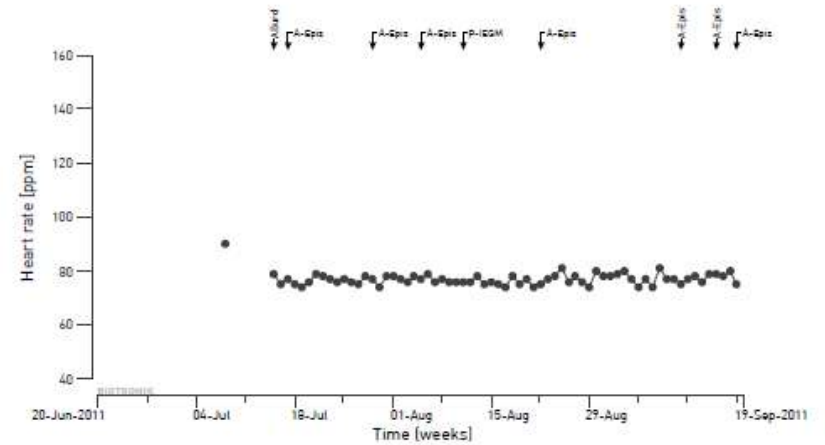
## Mode switching

• Number of mode switching per day ♦ Duration of mode switching [% of day]

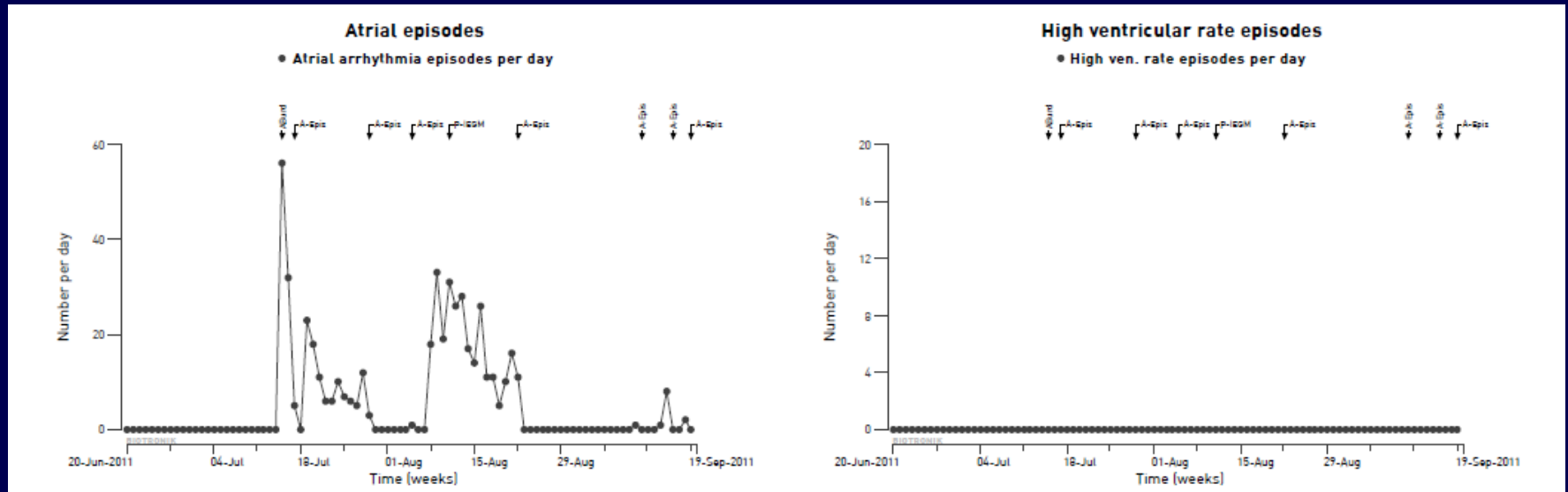


## Mean ventricular rate during mode switching

• Mean ventricular rate during mode switching [ppm]



# Identifying arrhythmias



## Filtering is vital

---

- **3,004,763 transmissions**
  - **Duration of monitoring/patient from 1 to 49 months (10,057 years)**
  - **86% events disease-related**
  - **47.6% patients had no events**

# Conclusions

---



- ***“Remote monitoring of CIEDs is indicated when the patient’s medical condition is stable and no anticipated device programming is required.”***
- ***“...it is recommended that any patient with a CIED be assessed in person at least once a year.”***

Remote monitoring can identify problems early.

Remote monitoring alone is not yet approved, but nursing home patients may benefit.