

eHealth 4.0

GÖG Colloquium
Wien, 11. April 2018

Gesundheit Österreich
GmbH 

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Digital Health Information Systems

Center for Health and Bioresources

AIT Austrian Institute of Technology GmbH



Industrie 4.0

Die industrielle Produktion soll mit moderner Informations- und Kommunikationstechnik verzahnt werden, um maßgeschneiderte Produkte zu produzieren.

eHealth 4.0

Die Gesundheitsversorgung soll mit moderner Informations- und Kommunikationstechnik verzahnt werden, um personalisierte Medizin (precision medicine) zu unterstützen.

eHealth 2.0 ?

eHealth 3.0 ?

What are the 4 **P** terms in Participatory Medicine

- **P**articipatory
 - Give patients a chance to take an active part in their health care
- **P**ersonalized
 - Therapy adjusted to the particular needs of individual patients
- **P**redictive
 - Predict situations with significant risk of negative health impact
- **P**reventive
 - Intervene timely to avoid negative impacts

Agenda

- Hintergrund / AIT
- Die Evolution von „ICT 4 Healthcare“ im Kontext
 - Eigene Erfahrungen
 - Telemonitoring bei chronischen Erkrankungen
 - eHealth 1.0 – 4.0
- Zusammenfassung und Ausblick

AIT Austrian Institute of Technology

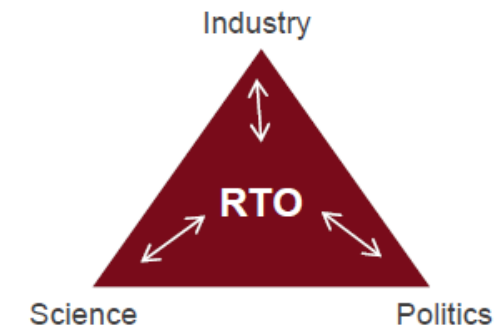
The largest applied research institute in **Austria**



Finance structure



Research and Technology Organisation



Owner structure

50.46%

Republic of Austria

49.54%

Federation of Austrian Industries

1300

Employees

Health & Bioresources	Digital Safety & Security	Vision, Automation & Control
Low-Emission Transport	Technology Experience	Innovation Systems & Policy
Energy	Mobility Systems	

Digital Health Information Systems

Three office locations in Austria

- ~ 45 staff members at 3 locations



Graz

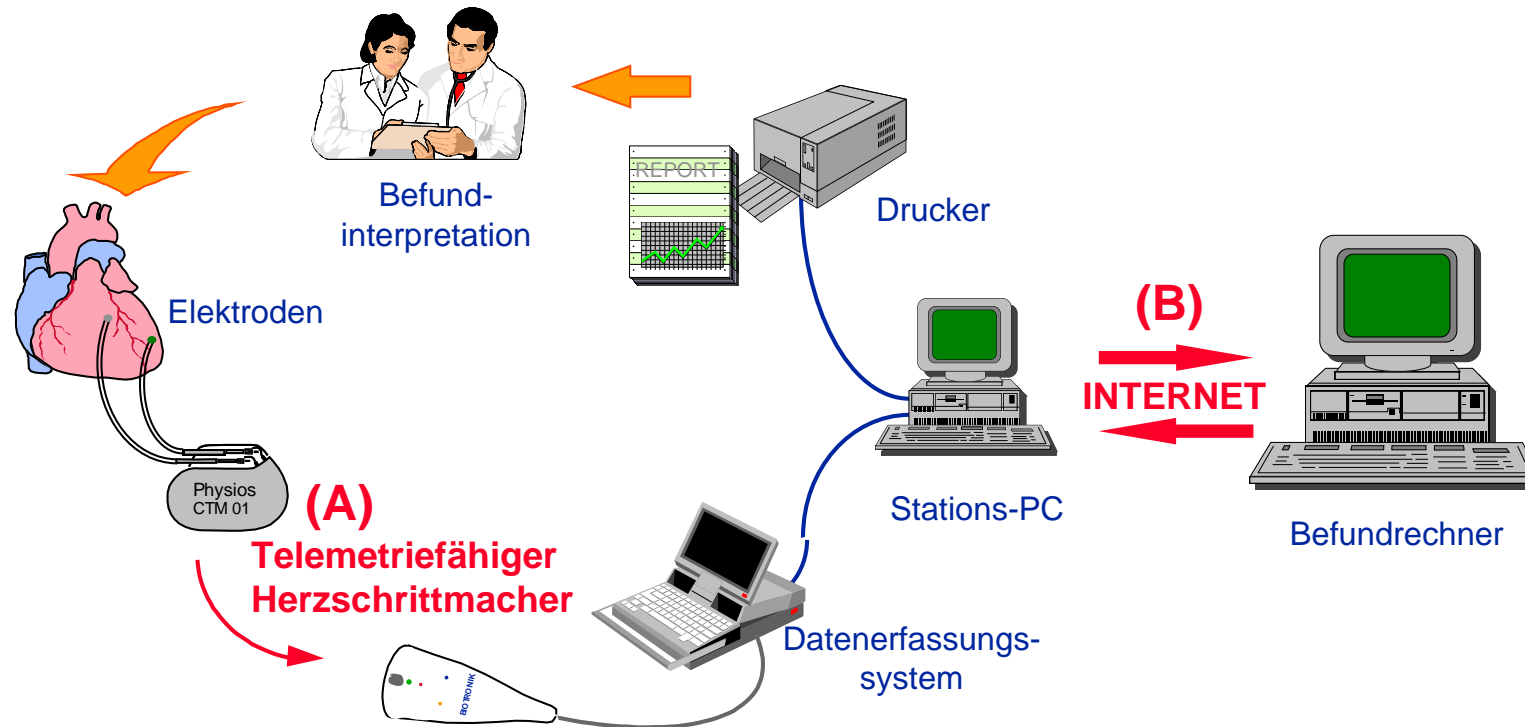


Hall in Tirol
(Innsbruck)



Vienna

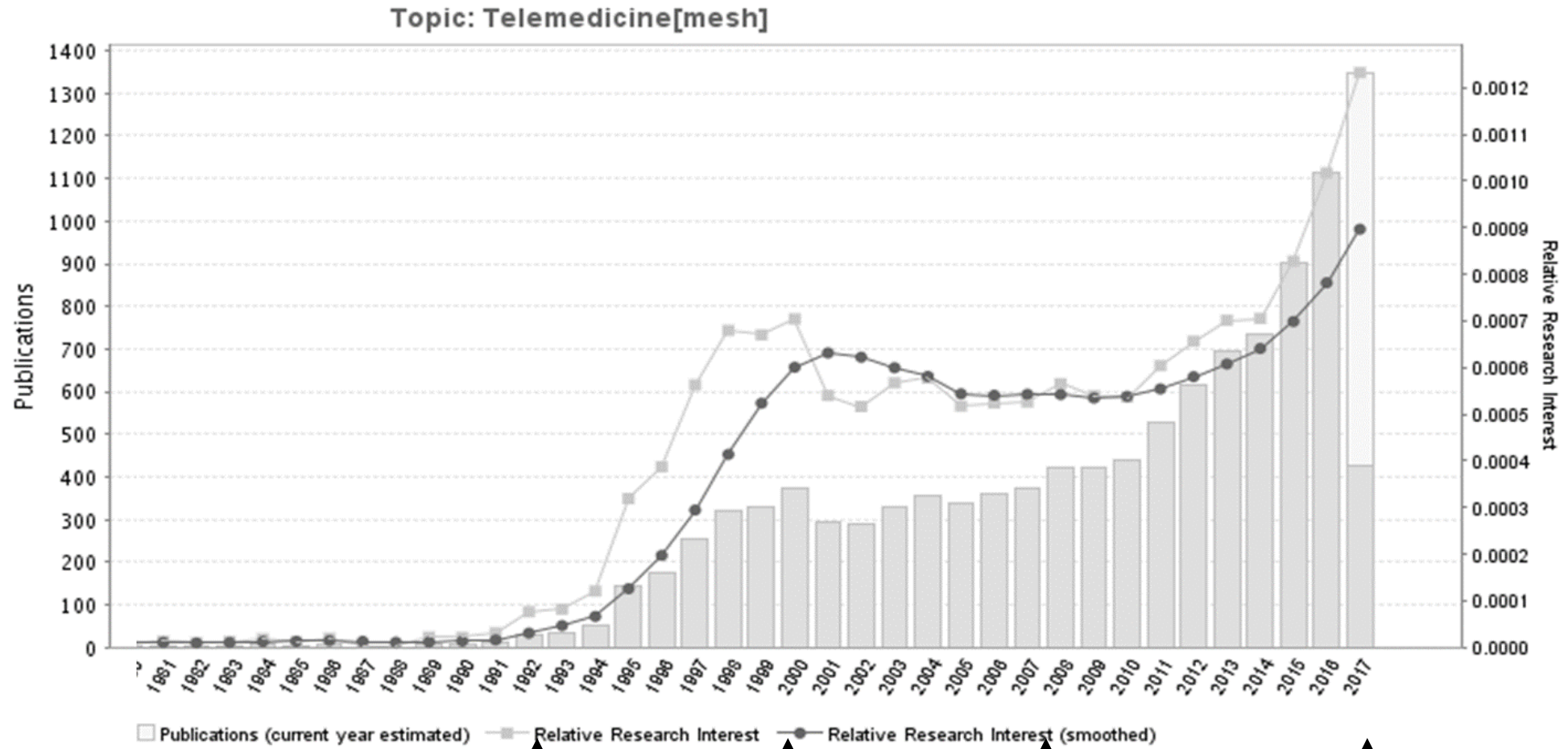
eHealth 1.0 mein erster Kontakt mit Tele...



Hutten H, Kastner P, Schreier G. **Kardiales Telemonitoring durch Kopplung von Nahbereichs-Telemetrie und Internet-Übertragung.** Biomedizinische Technik 1997;42:67-69

eHealth 1.0

Pubmed Literature Survey



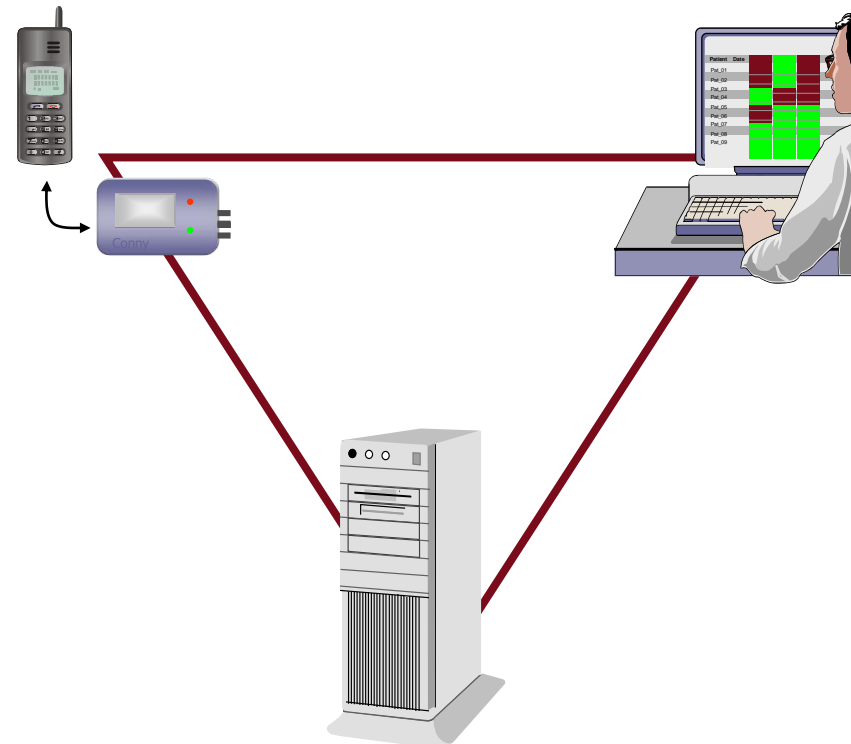
**Internet
(eHealth)
1.0**

**Mobile Comm.
(mHealth)
2.0**

**Apps, Wireless
(pHealth)
3.0**

**IoT
(dHealth)
4.0**

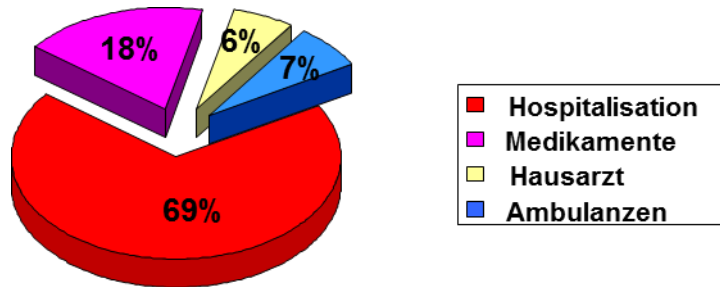
Telehealth 2001 - Technology



Schreier G, Kastner P, Marko W. Entwicklung eines indikationsübergreifenden Health-Monitoring-Systems. In: Proceedings der 1. Jahrestagung der Österreichischen Wissenschaftliche Gesellschaft für Telemedizin; 2001 Oct 5-6; Innsbruck. 2001. p. 44-46

Heart Failure (Herzschwäche)

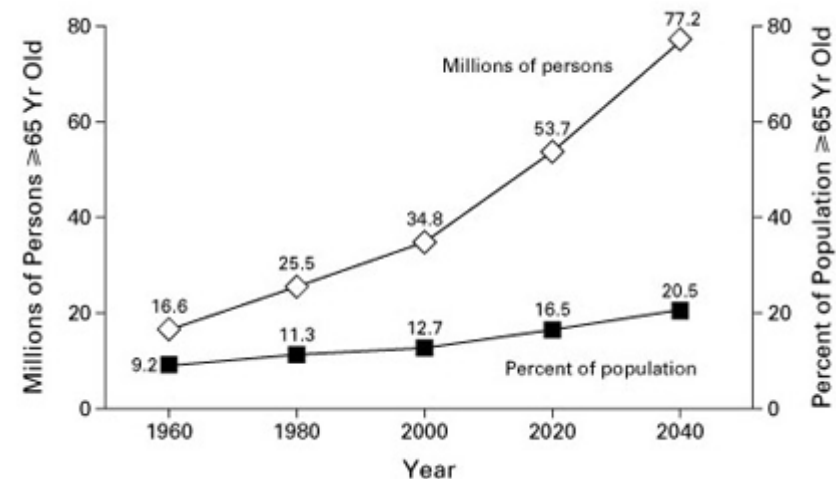
- Numbers from Austria (2016)
 - ~27.000 hospitalisations
 - ~2.500 Deaths
 - **Length of stay 8,4 days**
 - Estimated Hospitalisation costs: € 300 Mio



Kostenverteilung

http://www.statistik.at/web_de/statistiken/menschen_und_gesellschaft/gesundheit/stati/onaere_aufenthalte/spitalsentlassungen_nach_ausgewaehlten_diagnosen/index.html

- Increasing prevalence

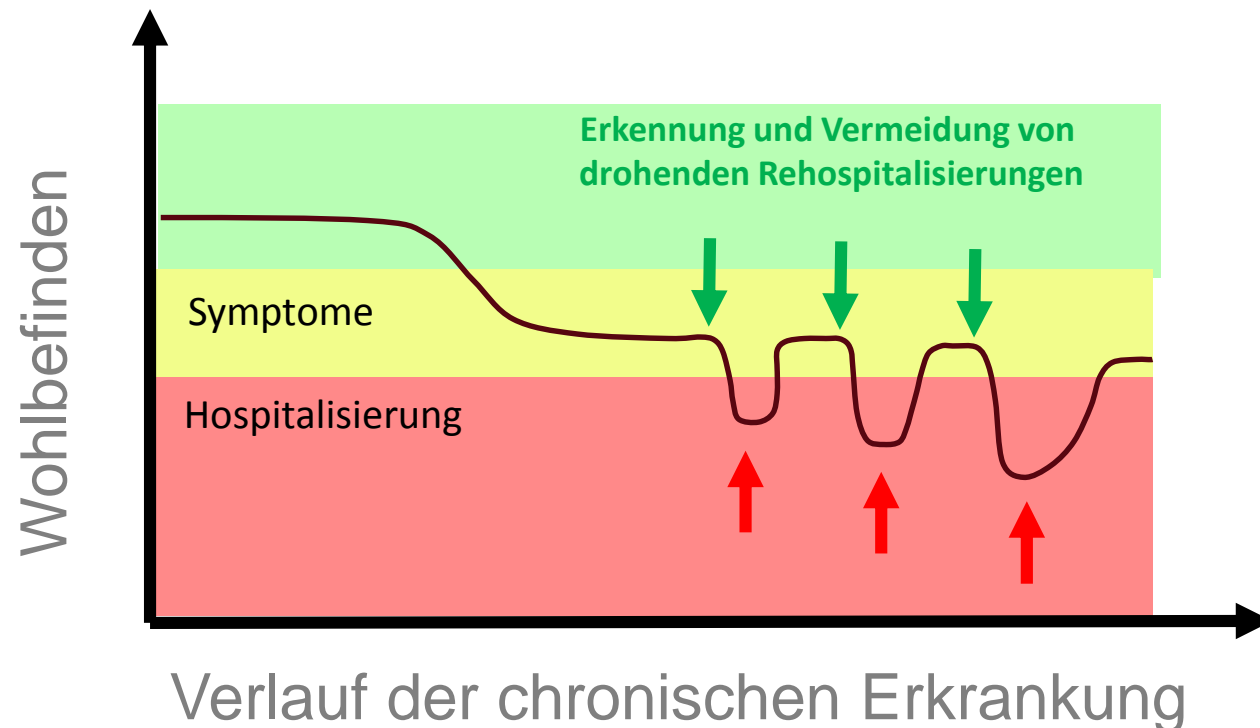


U.S. Census Bureau. NEJM 2003, 347:1442

Herzschwäche Krankheitsverlauf

Motivation für Telemonitoring: Vermeidung von Hospitalisierungen

- **Kosten**
- **Lebensqualität der Patienten (“Quality of Life”)**



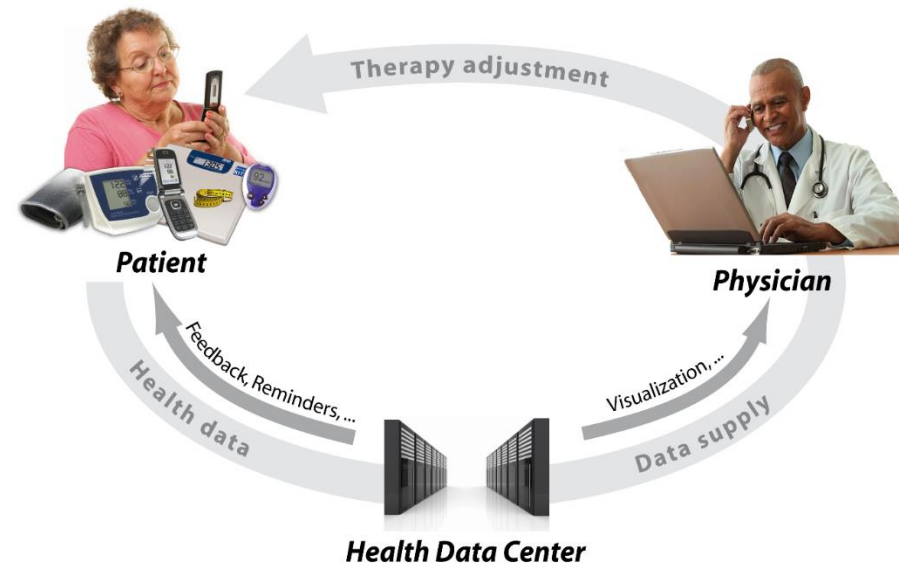
Treatment strategies in heart failure

- Just in case
 - Optimization in hospital
 - Changes remain unknown
 - Re-hospitalisation
- Just in time
 - Telemonitoring
 - Detection of critical changes
 - Early intervention
 - Avoiding escalation



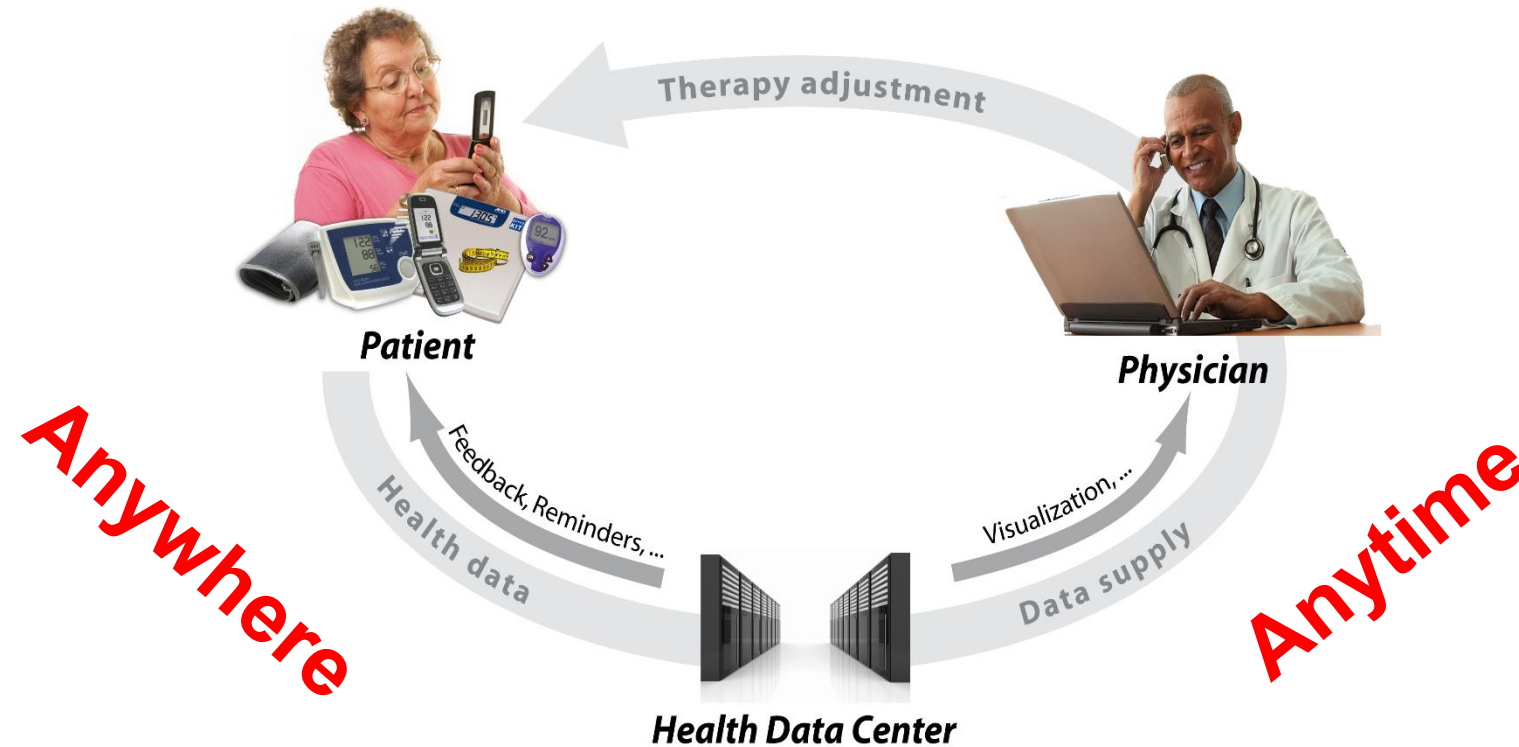
Chronic diseases: 4 barriers

1. Distance
 - Mobile communications
2. Time
 - Store and forward
 - alerts and reminders
3. Access
 - For patients - KIT
 - For physicians – via EHR
4. Knowledge
 - Guidelines
 - Decision support
 - Prediction & prevention



eHealth 2.0

mHealth - Closed Loop Healthcare



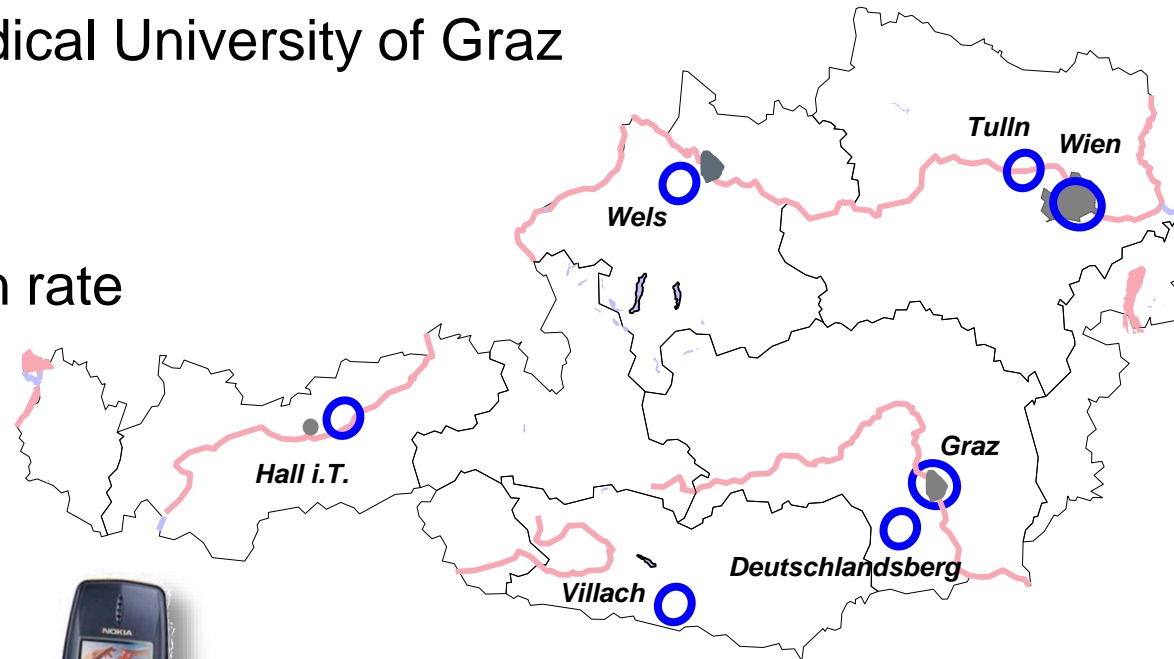
Scherr D, Zweiker R, Kollmann A, Kastner P, Schreier G, Fruhwald FM.
Mobile phone-based surveillance of cardiac patients at home.
J Telemed Telecare 2006;12(5):255--261

Example of a successful telemedial intervention



MOBITEL - randomised multicentre clinical trial

- Clinical Partner: Medical University of Graz
- Safety
- Efficacy
 - Re-hospitalisation rate
 - Quality of life



Manual
data entry



MOBITEL trial – <http://www.jmir.org/2009/3/e34/>

	Telemonitoring	Control	<i>p-Value</i>
Number of Patients, per protocol (m/f)	54(40/14)	54(39/15)	
Age (Median IQR)	65 (62 – 72)	67 (61 – 72)	n.s.
# comined Endpoint (re-hosp. / death)	8 (8/0)	18 (17/1)	
Risk / Eventrate [%]	15%	33%	
Relative Risk Reduction [%]	56% (7 – 79)		< 0.05
Duration of re-hospitalisations [days]	6,5 (5,5 – 8,25)	10 (7 – 13)	< 0.05
Total number of hospitalisation days	52	180	
NYHA – Class (Median before / after)	III / II	III / III	< 0,001

Mobile phone based telemonitoring can be used to reduce **the number and duration of hospitalisations** and to improve **prognosis (NYHA)** in heartfailure patients.

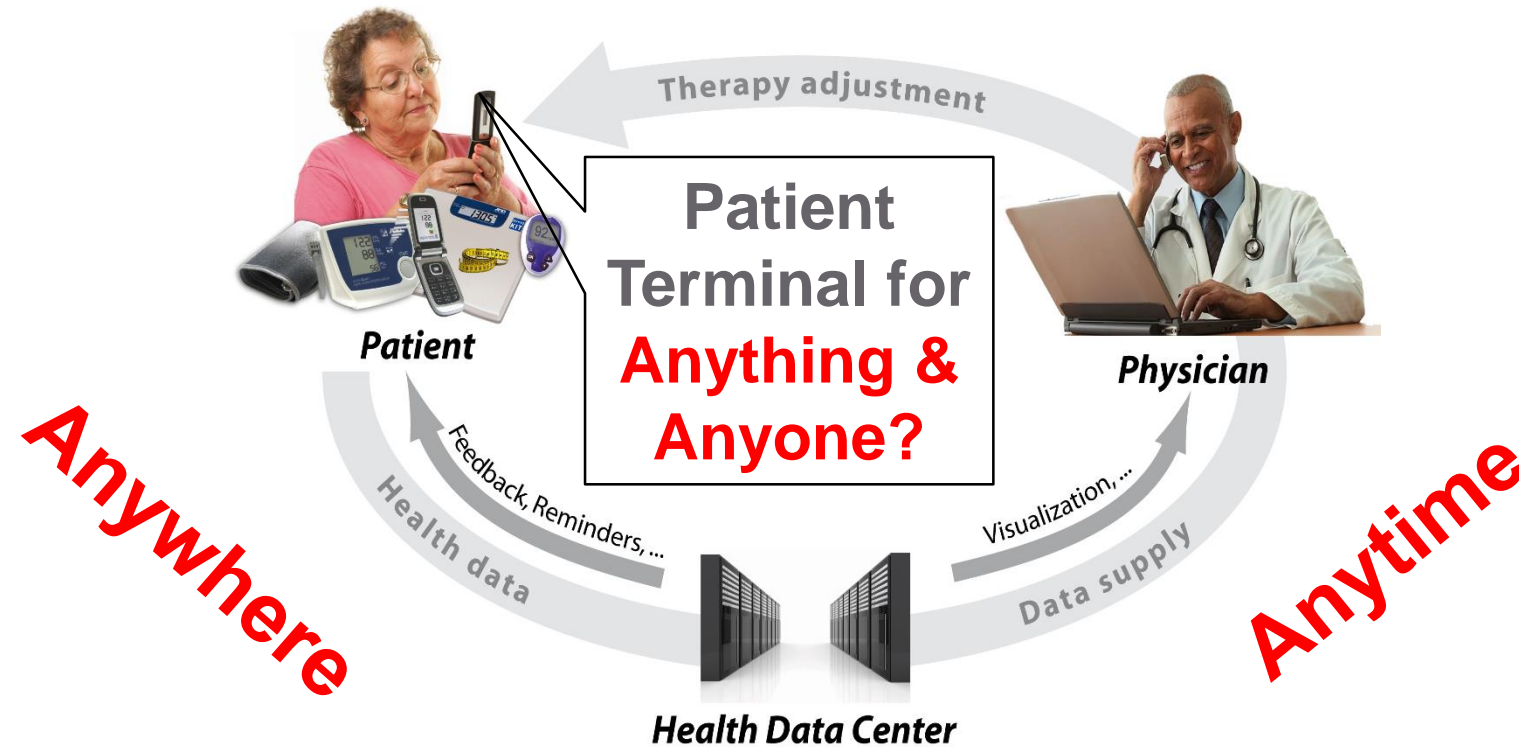
Scherr, et al, J Med Internet Res 2009, 11:e34

MOBITEL: Data acquisition via keypad of phone

- 12 (18%) of patients were not willing or able to do this.



4 “any” properties for Closed Loop Healthcare



Umfrage

- Wer von Ihnen benutzt “contactless payment“?



mHealth History ...

- 1967 – tricorder*
- 2007 – “triband” smartphone



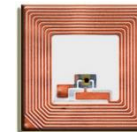
Star Trek, episode #28
“The City on the Edge of Forever”
first broadcast on April 6, 1967.



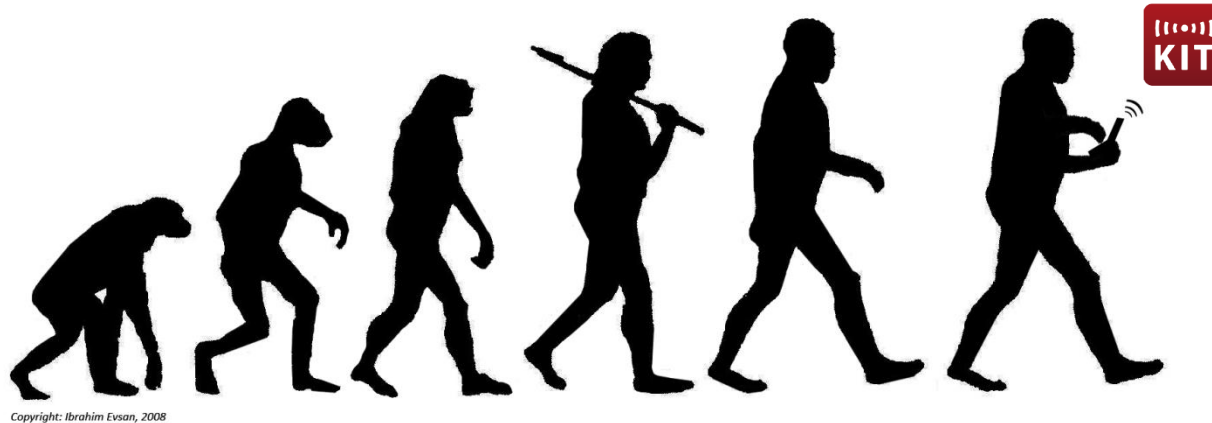
**The universal mHealth
toolbox**

eHealth 3.0 - pHealth based on Near Field Communication (NFC)

- Short range (5 cm), low-power, wireless communication technology
- “Bring-in-Touch” – paradigm
 - Touch contactless smartcard to
 - start software application automatically
 - read data for identification and authentication
 - exchange data with NFC enabled devices
 - read out static data from RFID tag
- all without prior pairing



Years of trial & error



Morak, J, Kumpusch H, Hayn D, Modre-Osprian R, Schreier G.

Design and evaluation of a telemonitoring concept based on NFC-enabled mobile phones and sensor devices.

IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE 16 (1):17-23, 2012

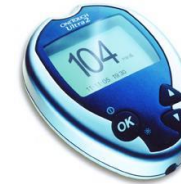
Internet of Things based Telehealth



Spirometer



Smart Blisters



Blutzucker-
Messgerät



ECG Event
Recorder

Anything

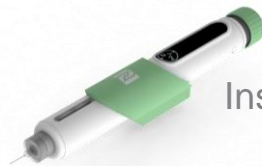
Blutdruck-
Messgerät



Pedometer



ID-Karte



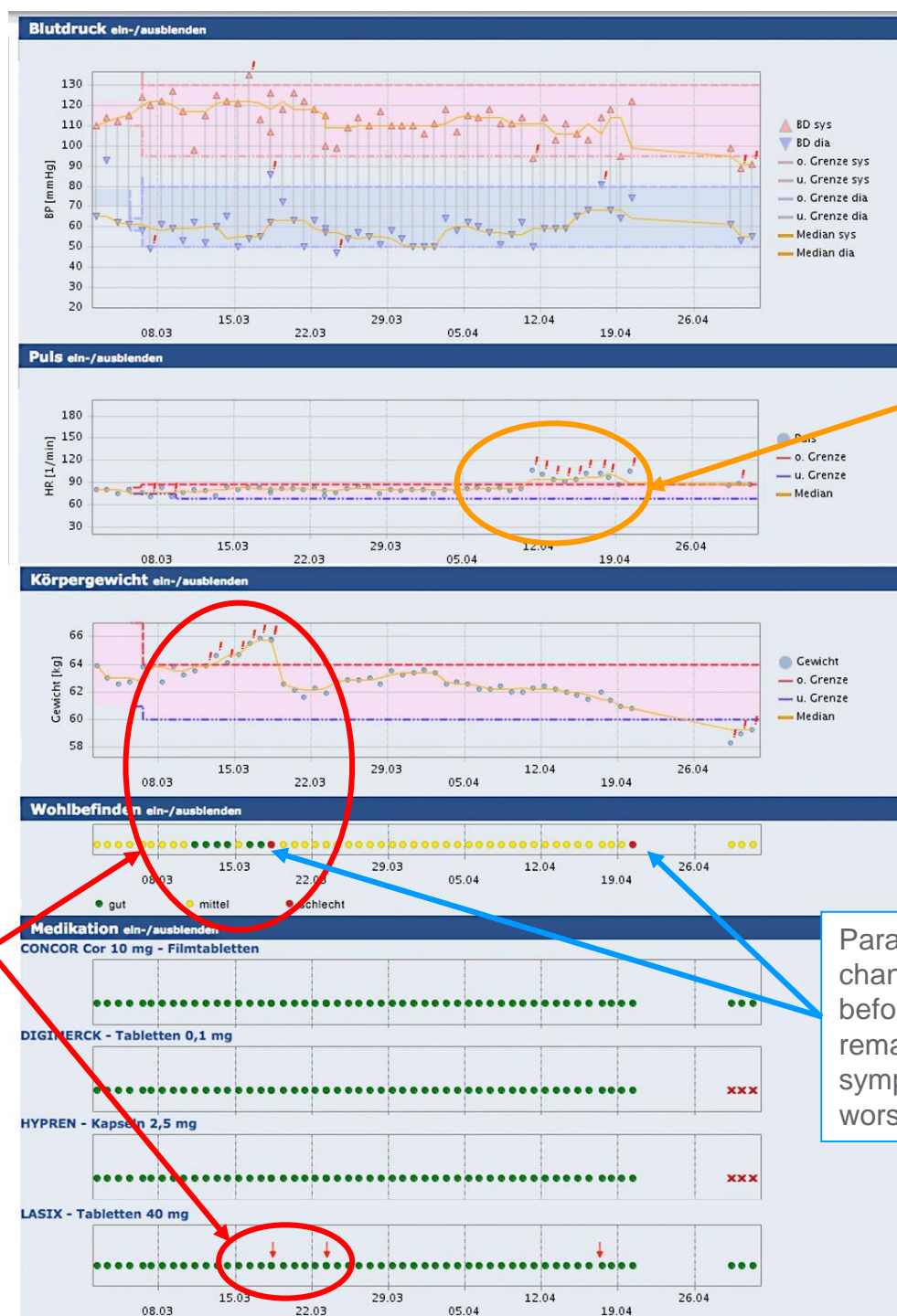
Insulin Pen



Körperwaage

Example

82 years, Male, DCM



continuously increased heart rate as a possible sign for AF → patient was admitted to the hospital

Kastner P, Morak J, Modre R, Kollmann A, Ebner C, Fruhwald FM, Schreier G.
Innovative telemonitoring system for cardiology: from science to routine operation.
Appl Clin Inf 2010; 1: 165–176

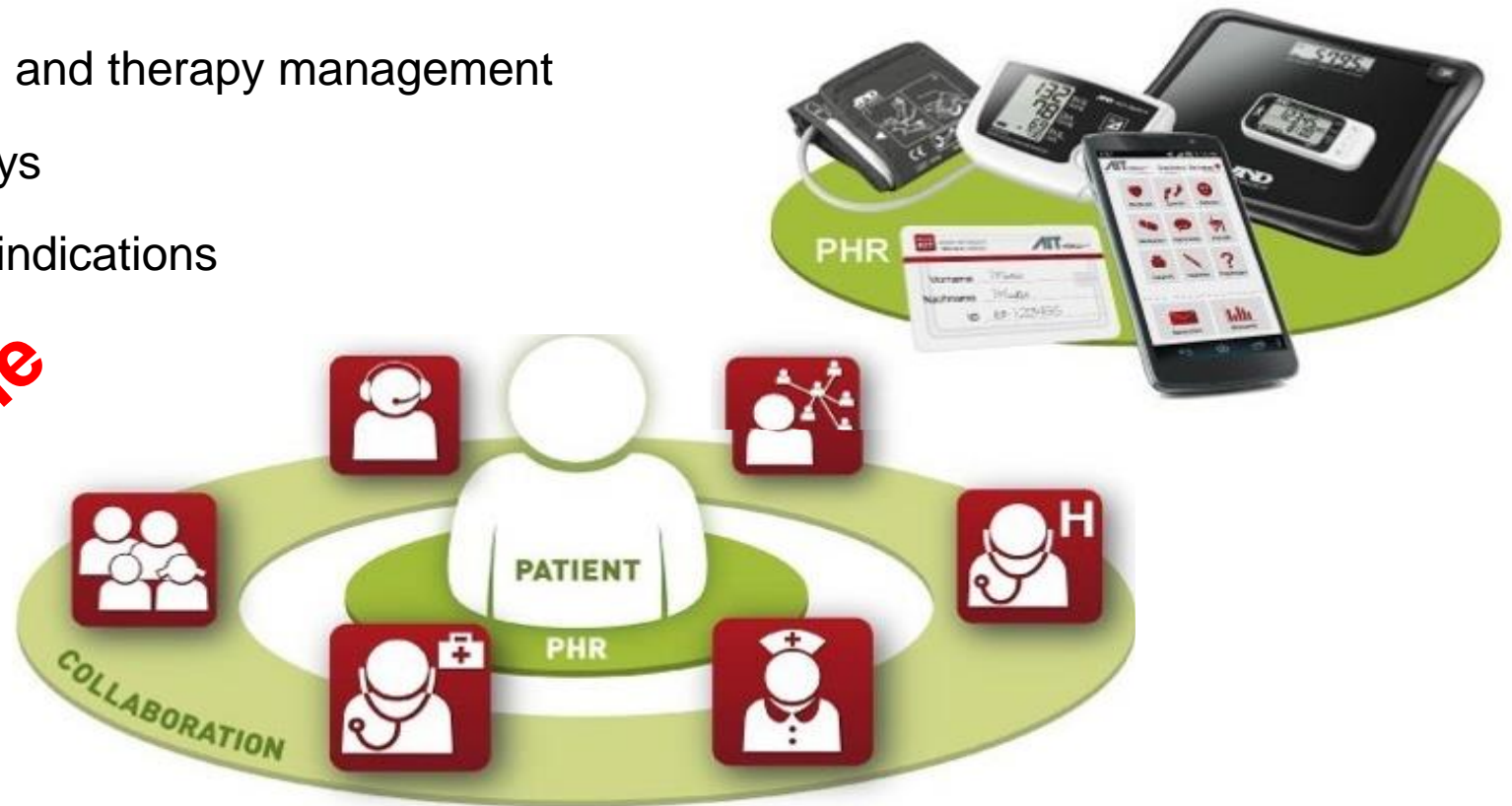
Successful telemedical intervention

Parameters show change days before the patients remarks any symptomatic worsening

AIT Mission: **Active patient involvement**

- 15+ years of expertise in telehealth and therapy management
 - over 1 million telemonitoring days
 - in a variety of different medical indications
 - Heart failure
 - Diabetes
 - Hypertension
 - ...
- with a partner network of clinicians and other stakeholders
- <https://kit.ait.ac.at>

Anyone



Telemedizinische Betreuung von Herzinsuffizienz, Diabetes mellitus und Bluthochdruck

HerzMobil Tirol

 **Keep in Touch
with your Heart**



 **DiabCare
Tirol**
TELEMONITORING-SET
DIABETES





CardioMemory
Telemonitoringsystem für
Bluthochdruck Patienten



Willkommen beim
Gesundheitsdialog Diabetes
Ein Service für Versicherte der VAEB

Mehr Informationen Anmelden



**VERSICHERUNGSANSTALT
FÜR EISENBAHNEN & BERGBAU**



Erfahrung aus über 1.000.000 Telemonitoring-Tagen in verschiedenen Anwendungsfeldern

Telegesundheitsdienste in Österreich

HerzMobil Tirol

Kooperation von Tirol Kliniken, AIT, TGKK, UMIT, Tiroler Ärztekammer und Land Tirol;
Herzinsuffizienz-Telemonitoring-Betreuung durch Ärzte aus Klinik und niedergelassenen Bereich sowie mobile HI-Schwestern und HI-Pflegepersonen;
seit Juli 2017 Einsatz in der Regelversorgung

Gesundheitsdialog Diabetes VAEB

Kooperation von VAEB und AIT;
Diabetes-Telemonitoring-Betreuung durch Gesundheitszentren der VAEB und durch niedergelassene Ärzte;
Österreichweite Versorgung von VAEB-versicherte PatientInnen

DiabCare Tirol

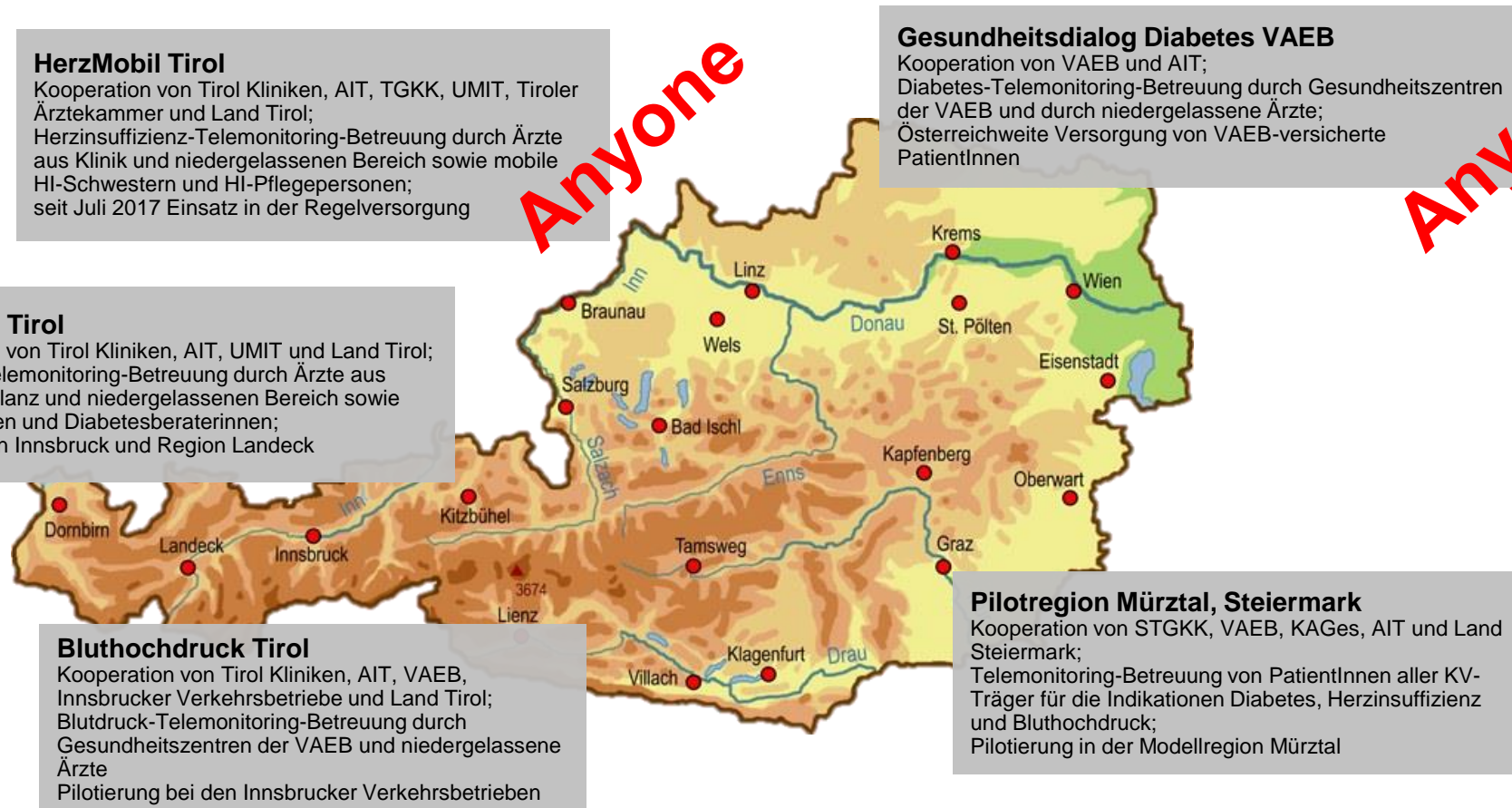
Kooperation von Tirol Kliniken, AIT, UMIT und Land Tirol;
Diabetes-Telemonitoring-Betreuung durch Ärzte aus Klinik-Ambulanz und niedergelassenen Bereich sowie Diätologinnen und Diabetesberaterinnen;
Pilotierung in Innsbruck und Region Landeck

Bluthochdruck Tirol

Kooperation von Tirol Kliniken, AIT, VAEB, Innsbrucker Verkehrsbetriebe und Land Tirol;
Blutdruck-Telemonitoring-Betreuung durch Gesundheitszentren der VAEB und niedergelassene Ärzte
Pilotierung bei den Innsbrucker Verkehrsbetrieben

Pilotregion Mürztal, Steiermark

Kooperation von STGKK, VAEB, KAGes, AIT und Land Steiermark;
Telemonitoring-Betreuung von PatientInnen aller KV-Träger für die Indikationen Diabetes, Herzinsuffizienz und Bluthochdruck;
Pilotierung in der Modellregion Mürztal



4 Steps from idea to innovation

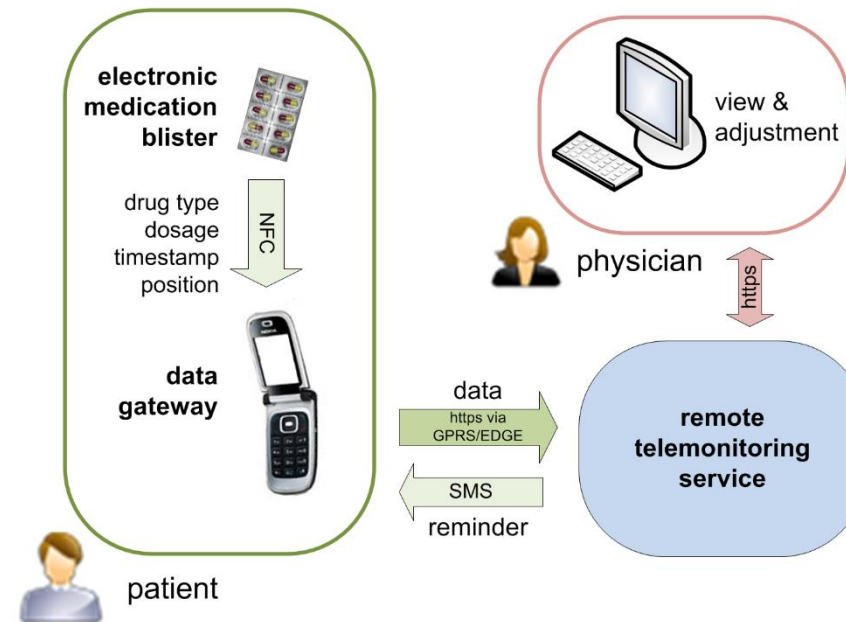
Step	Aspect	Central Question	Regulatory issues
1	Technology	Is it feasible in the lab?	<ul style="list-style-type: none"> • None (QM)
2	Medicine	Is it safe and does it have a health benefit for patients? Safety and Efficacy	<ul style="list-style-type: none"> • Ethics • Medical device Directive • Guidelines
3	Organisational, Healthcare Process	Is it compatible with the (current) practices and pathways in the healthcare system Interoperability	<ul style="list-style-type: none"> • Data protection • Health telematics (ELGA Gesetz) • Standards
4	Health Economics	Is it cost-effective? Business model?	<ul style="list-style-type: none"> • Health Technology Assessment • § 15 a - Vereinbarung • Re-imburement

Medication Monitoring

60 patients utilizing e-blisters



Feedback based on „real time“ compliance measurement



Brath H, Morak J, Kästenbauer T, Modre-Osprian R, Strohner-Kästenbauer H, Schwarz M, Kort W, Schreier G.

Mobile health (mHealth) based medication adherence measurement – a pilot trial using electronic blisters in diabetes patients.

British Journal of Clinical Pharmacology, 2013, 76 (Suppl. S1):47-55.

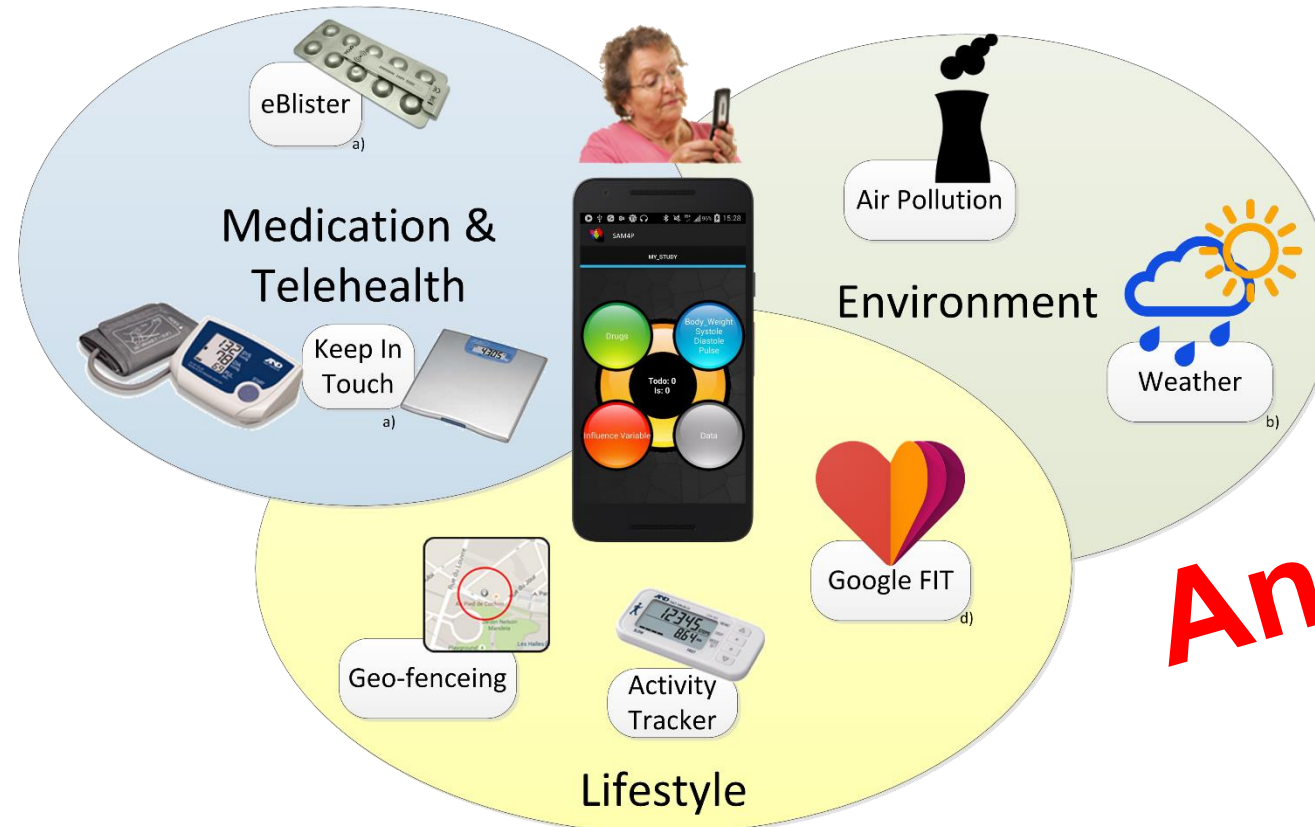
Medication monitoring systems - state of the art

Anything



Stegemann S, Baeyens JP, Cerreta F, Chanie E, Lofgren A, Maio M, Schreier G, Thesing-Bleck E.
Adherence measurement systems and technology for medications in older patient populations.
European Geriatric Medicine 2012, 3:254–260

Advanced Adherence Monitoring and Management



Anything

H. Ebner, D. Hayn, M. Kropf, R. Modre-Osprian, and G. Schreier, "Internet of Things Based Medication Adherence Assessment," *Stud Health Technol Inform*, vol. 221, p. 118, 2016.

Umfrage

- Wer von Ihnen benutzt einen Schrittzähler?
 - App
 - Fitnessstracker

The Internet of Things (IoT)

smart objects with 4 technological attributes

- Identification
 - Location
 - Sensing
 - Connectivity
-
- enables communication between people and things, and things and things



eHeath4.0

Internet of Things (IoT)

- Smart objects to enable communication between
 - The physical world and the Internet
 - “cyber physical systems”
-
- Enabling technologies
 - RFID
 - NFC
 - Bluetooth
 - 4G, 5G
 - ...

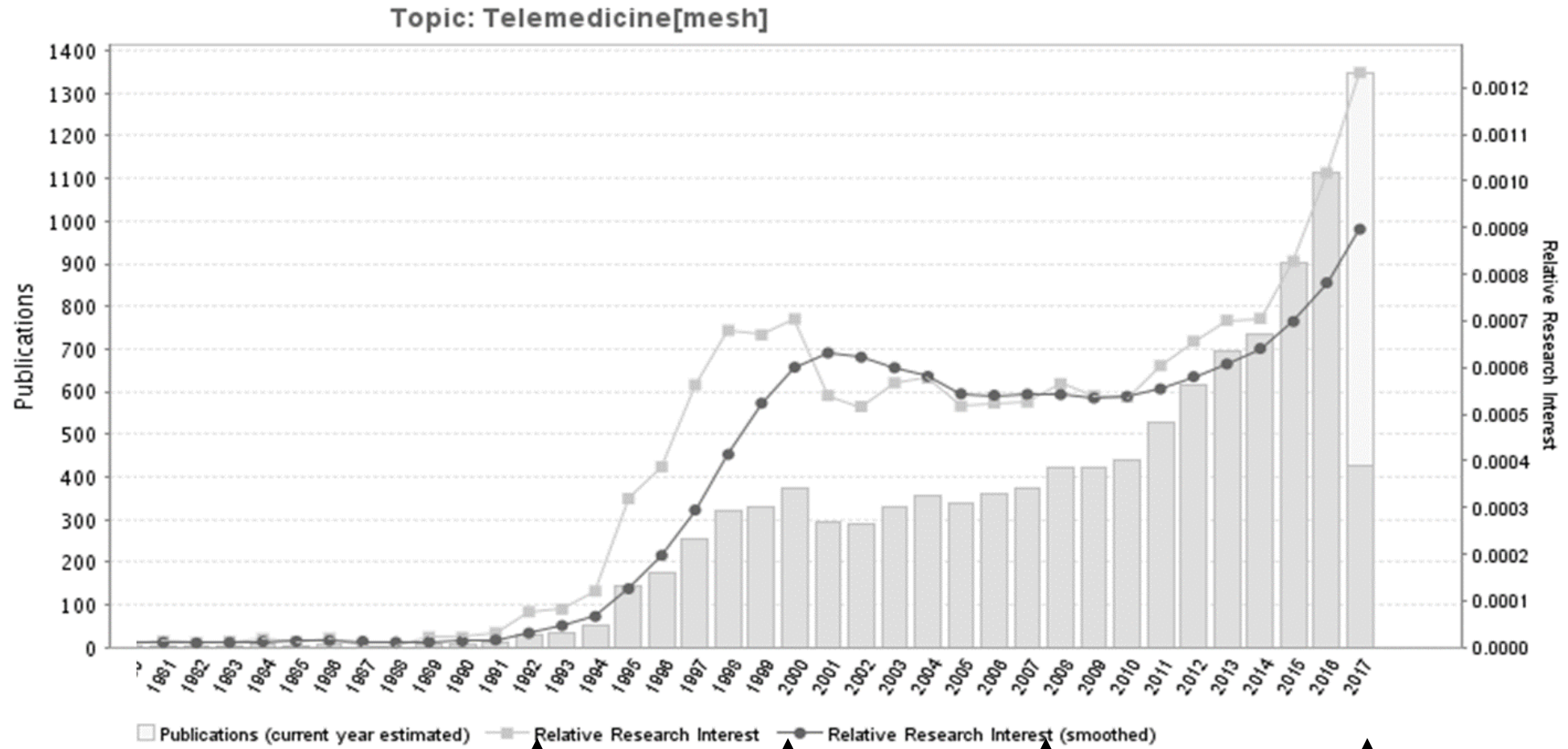
ANYWHERE

ANYTHING

ANYTIME

ANYONE

4 Waves of enabling ICTs



What's next?

Anywhere
+ Anytime
+ Anyone
+ Anything

BIG
DATA

Text mining
Machine learning
Predictive modeling
Visual analytics

data **d**riven healthcare - > **d**Health

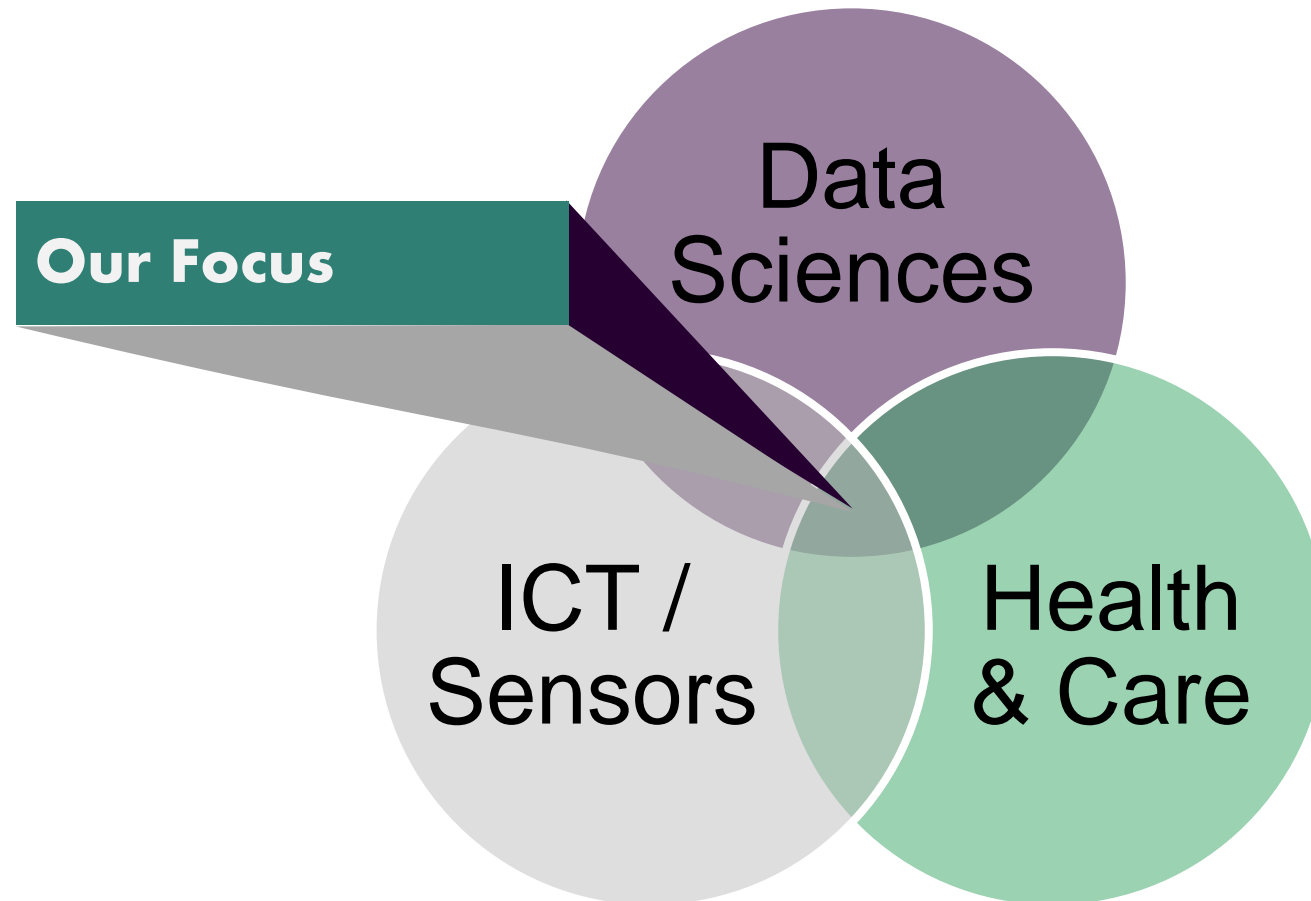
Zwei sich ergänzende Ansätze

- Regelbasierte Klassifikation / Triage
 - Patient braucht Aufmerksamkeit ja/nein
→ Als Medizinprodukt zugelassen
- Machine learning based approach
 - Vorhersage, welcher Patient hohes Risiko hat
 - mit der Datenübertragung aufzuhören (Adhärenz)
 - für ungeplanten Krankenhausaufenthalt
 - Im Labor-Stadium



Predictive Healthcare Information Systems

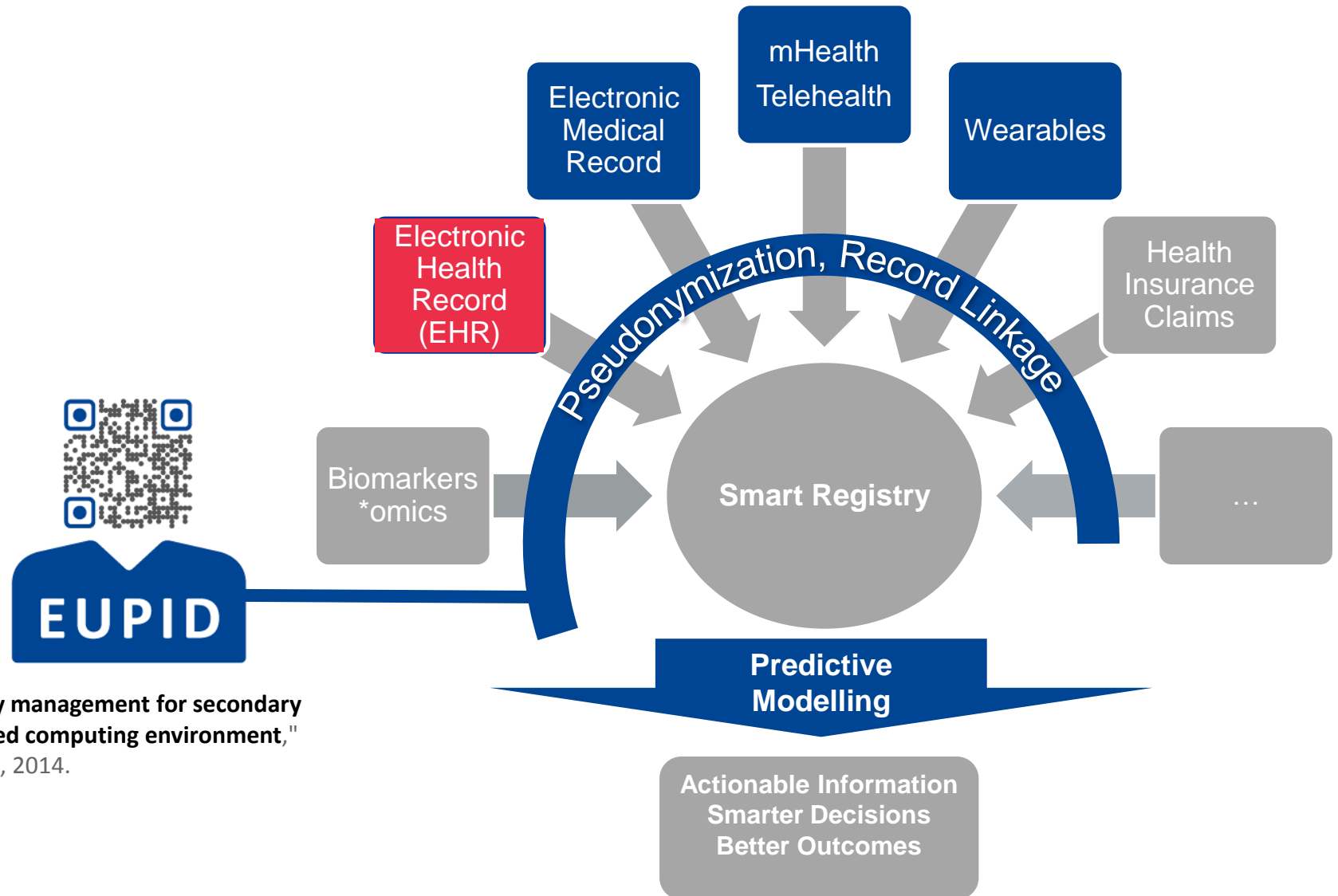
We address
the intersection of
data sciences,
ICT / mHealth and
health & care



Xie Y, Schreier G, Chang DC, Neubauer S, Liu Y, Redmond SJ, Lovell NH.
"Predicting Days in Hospital Using Health Insurance Claims,,,"
IEEE J Biomed Health Inform, vol. 19, pp. 1224-33, Jul 2015.

Approach

**privacy preserved
record linkage of
4 data sources**



M. Nitzlnader and G. Schreier, "Patient identity management for secondary use of biomedical research data in a distributed computing environment," *Stud Health Technol Inform*, vol. 198, pp. 211-8, 2014.

Datenschutz versus Patientenschutz ... ein Widerspruch?

2018-04-11

<http://www.orf.at/#/stories/2433704/>

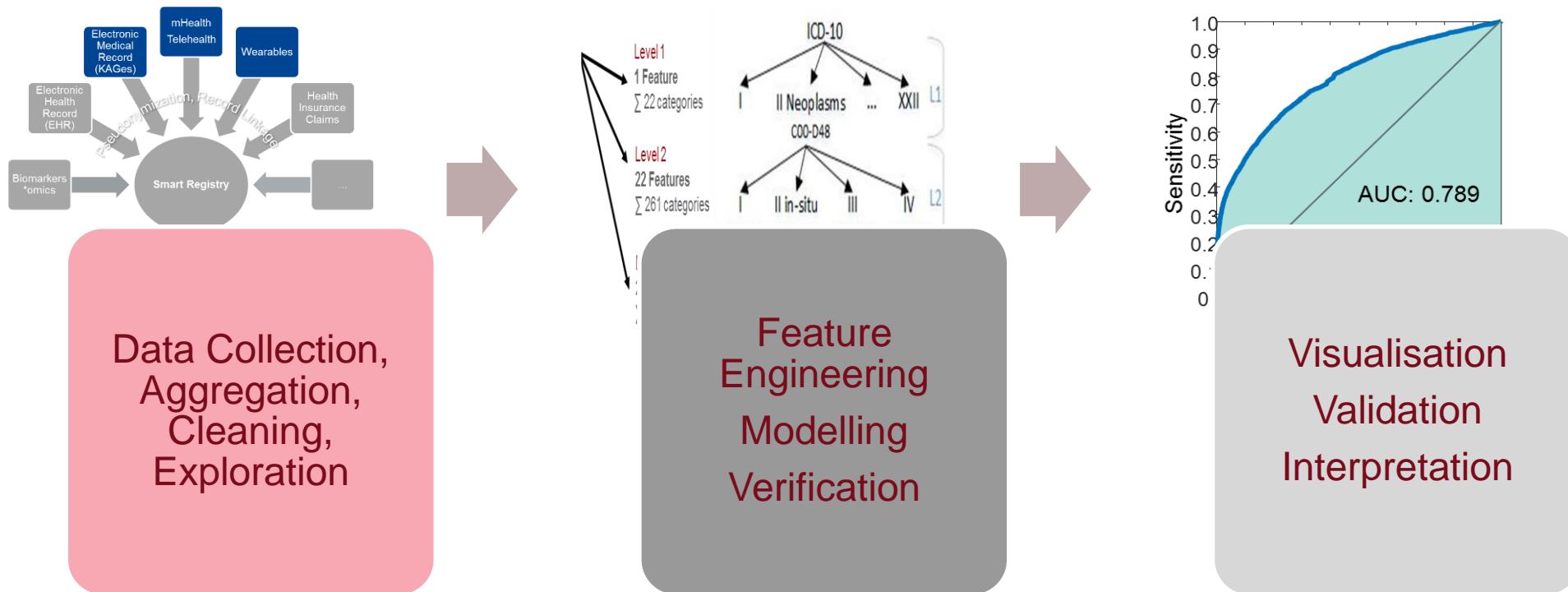
„Regierung will persönliche Daten der Österreicher für die Forschung freigeben, darunter auch Informationen des elektronischen Gesundheitsakts (ELGA) „

Predictive Analytics ...

Vorhersagen über die Zukunft

- „Prognosen sind schwierig, besonders wenn sie die Zukunft betreffen“
Niels Bohr (1885 – 1962)

PATH – Predictive Analytics Toolset for Health



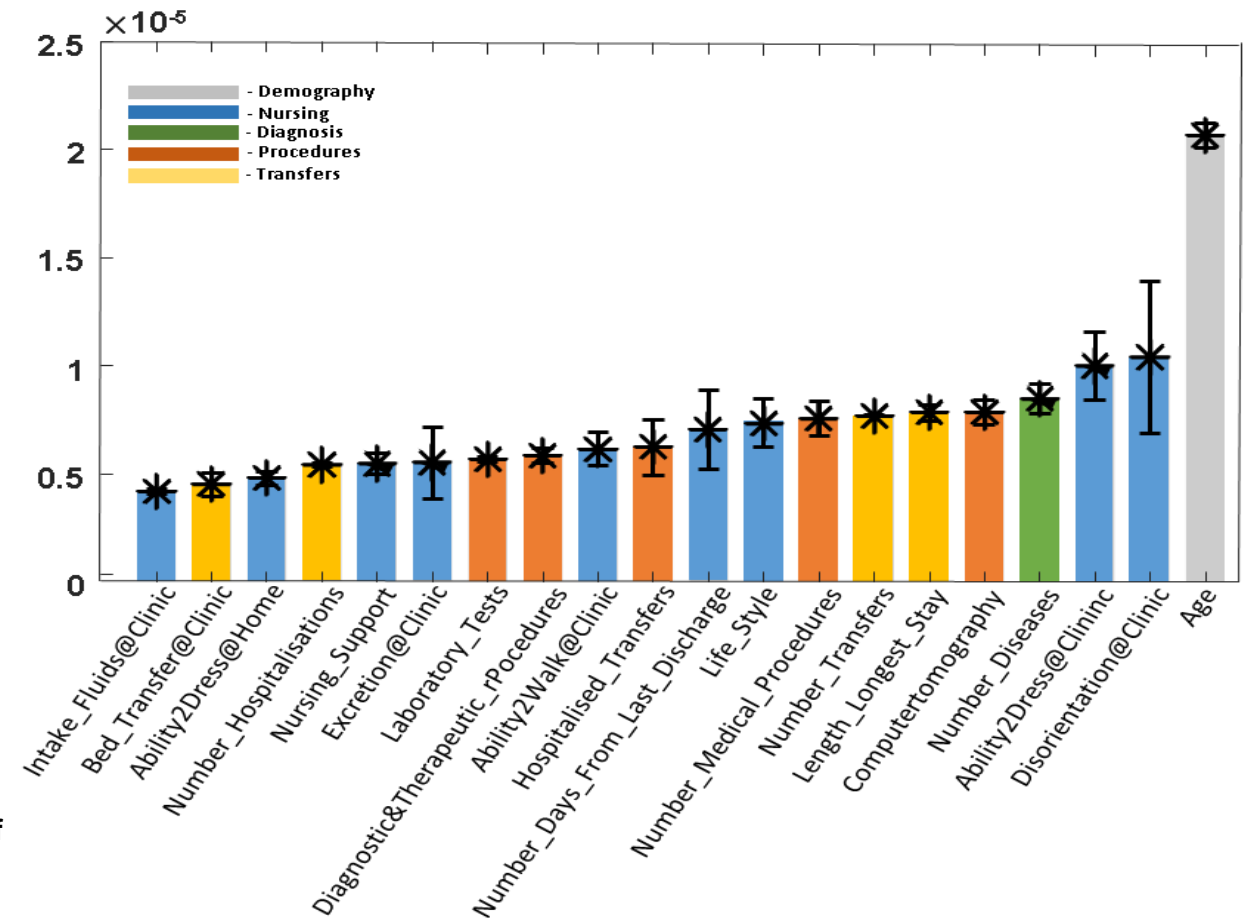
Predicting delirium from Electronic Medical Records (EMR) (1)

- Partner - Cbmed GmbH
 - KAGes (Steiermärkische Krankenanstalten GesmbH)
 - Medical University of Graz
- Data sources
 - KAGes EMR (OpenMedocs) data on current and previous admissions
 - Demographics, nursing assessment, lab data, diagnoses, procedures, transfers, ...
- Approach
 - Collect and merge data sources
 - Feature engineering
 - Build ensemble models



Predicting delirium from EMR (2) - Results

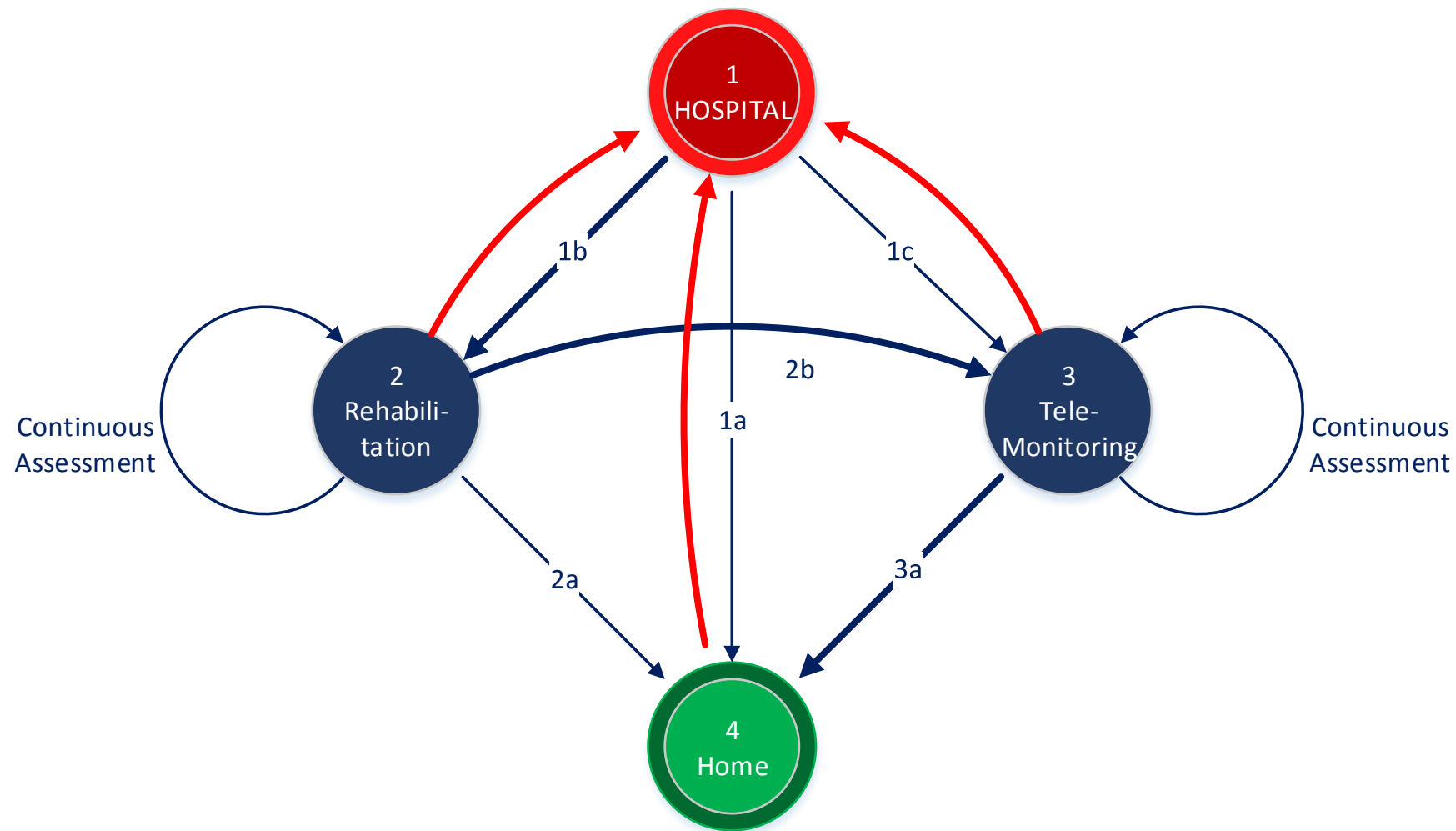
- With decision tree models, the prediction of future delirium seems to be possible with very good performance
 - AUC ~ 90%
- Nursing assessment features are a very important source of information
 - second only to Age



Kramer D, Veeranki S, Hayn D, Quehenberger F, Leodolter W, Jagsch C, Schreier G.
Development and Validation of a Multivariable Prediction Model for the Occurrence of Delirium in Hospitalized Gerontopsychiatry and Internal Medicine Patients.
 Stud Health Technol Inform. 2017;236:32-39. PubMed PMID: 28508776.

Vision

Patient Pathway Optimisation



eHealth 4.0 Governance Framework

Ethical

Best-practice for
obtaining ethical
approval for the
D4Health type of
research

Interventional
versus
observational
Trials

Legal

Data protection

- GDPR
- Privacy preserving
record linkage
(PPRL)

Regulatory

- Medical device
Regulation
- Clinical decision
support
- Adaptive systems

Social

Patient
involvement

- Willingness for data
donation
- Direct control / Self
management
- Role of patient-
organised
communities

Economical

Business models

- Industry driven
- Investigator driven
- Patient driven

Cost
effectiveness

- Health technology
assessment (HTA)

Evaluation

Methodological
approach

Key performance
indicators

4 Stages of Evolution of the (Austrian) electronic Healthcare System

1.0 eHealth Electronic Health Record



2.0 mHealth Direct link to patients



3.0 pHealth Patient-driven/centred



4.0 dHealth Data-driven



Outlook

- eHealth 5.0 ...
 - Artificial Intelligence, Blockchain, ...
- „Die Gesundheit ist nicht alles, aber ohne Gesundheit ist alles nichts“
Arthur Schopenhauer
- „Die Daten sind nicht alles, aber ohne Daten ist alles nichts“

More on eHealth 4.0 ...

- 12th annual scientific conference
- www.eHealth2018.at
- May 8 – 9, 2018, Vienna, Schloss Schönbrunn Conference Centre
- Special Topic: “Biomedical meets eHealth – from sensors to decisions”

