# Healthcare 4.0 - benefits and limits of big data and smart technology for the health care sector

XXXIX Heidelberg Physics Graduate Days

Heidelberg, October 12th, 2017

# Agenda

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# From finance to healthcare 4.0?

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# healthcare@d-fine applies our expertise in problem analysis & data science – fundamental prerequisites of digital transformation

» Who is d-fine? Our **background:**

› > 700 consultants with quantitative and technological background

› > 15 years of experience in the financial and industrial sector

› leading consulting in risk & finance from planning to implementation

» Our **approach from A to Z** with deep knowledge in:

› analysing and solving business and/or technological problems

› data science, i.e. extracting insights from data to act optimal

› understanding (top) management and regulatory requirements

» The **healthcare sector demands** our expertise: what is new?

› a new market and new functional knowledge: cooperation needed!

› need of digitalisation to sustain long term quality of medical care

› a platform is necessary for a technology-integrated consulting

> With our background and approach from A to Z as well as the ability to connect people from business, functional, and technological departments, we go along with healthcare professionals into a digital future.

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# From finance to healthcare: the first Idea

| 1 | Credit Risk Management |
|---|---|

» Risk of a client default

» Potential loss in case of default („PD" and „LGD")

» Processes to manage and control credit risks

» Quantitative methods to digitalise (parts of) processes: Ratings, credit portfolio models, limit systems etc.

» Data base: Financial Ratios, position and run data, market data and a lot more

| 2 | Clinic Management |
|---|---|

» Risk of longliers LL (first: risk of sepsis)

» Potentially: case costs > case income (LL case)

» Management of patient paths / length of stay

» ?!?

Is this the right question of clinicians?
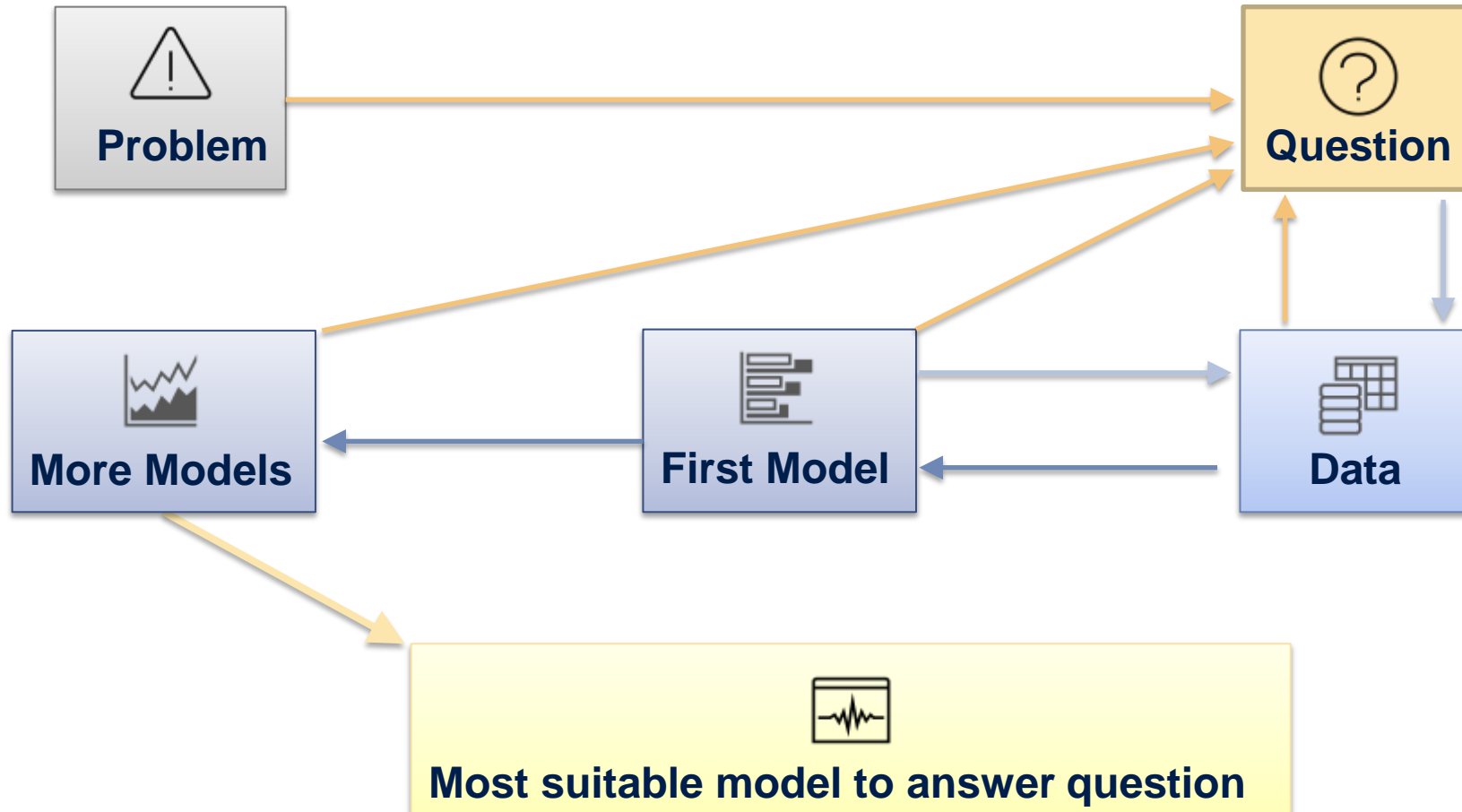
» Data base: §21-data as a start

We ask questions, analyse problems, and find solutions from A to Z – processes, data & models, and tech.

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# Example: online shopping
# First understand the problem, then start data analysis and modelling…

| | Questions | Answers |
|---|---|---|
| Find the rough **Problem** | 1. What is the target?<br>2. How to measure performance?<br>3. Why is it missed → Cause and effect relation? | 1. Increase online market share to x %<br>2. Own and competitors'online sales<br>3. Purchase clicks, prices, recommendations… |
| Find and **analyse Data** Types | 1. What kind of data? Complete?<br><br>2. What to do with big data? | 1. Collect: Website clicks, purchase clicks, reviews, cookies… other services: social media<br>2. connect + reduce & sort + understand & find structure: price x purchase clicks = online sales |
| **Answers** to detailed problem **in data?** | 1. What is the detailed question? Target measure?<br><br>2. Can questions be substantiated? | 1. „What influences price and purchase click?" Optimize price or margin on which horizon?<br>2. Features: Segment, market place, …SEM* + youtube, clicked recommendation / reviews |
| **Best model** to question? | 1. Which models do fit target question & features?<br><br>2. Which model does optimize target measure? | 1. Machine Learning: Rather find patterns („similar cases") or rules („if then else")? Combinations?<br>2. Maximum Gini on test and validation set? |
| **Adjust** target, **problem**, model or data? | 1. Is the result realistic? If not, reason?<br>2. Do I have to adjust the (sub) problem or model?<br>3. Do I need more (correct!) data? | 1. Age>70 → buy pampers? Shipping costs!<br>2. Which product combi by which client and why?<br>3. Shipping address: Recipient = f, age=30-40 Payback: Daughter uses grandpa's 2nd card |

Search engine marketing, SEA=Search Engine Advertising, SEO=Search Engine Optimisation

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# Problem solving in practice is often a non-linear process

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# How digital does the German healthcare system work? Problems… .

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# A patient in the German healthcare system

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# Dieter* Kaschinsky's health record …

| | |
|---|---|
| **name**<br>Dieter Kaschinsky | **place of residence**<br>Dresden |

| | | |
|---|---|---|
| **age**<br>53 | **height**<br>1,87 m | **weight**<br>103 kg |
| **marital status**<br>unmarried | **citizenship**<br>German | **profession**<br>Scaffolder |

*Any resemblance to person living or dead is purely coincidental

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# Dieter had an accident while renovating his private doorway

**when?**
12th August 2017

**what?**
Accident with jackhammer

**where?**
Dresden

**hospital**
Die Dresdenklinik*

**diagnoses**
Fracture of calcaneus

**treatment**
Operative (hospitalisation)

*Any resemblance to a clinic is purely coincidental.

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# The supply chain: an overview
# Who pays for the screws in dieter's calcaneus?



AOK Saxony /Thuringia

AOK

Treatment costs

Contribution payments

Settlement

Medical care

Dieter

Hospital
Die Dresdenklinik

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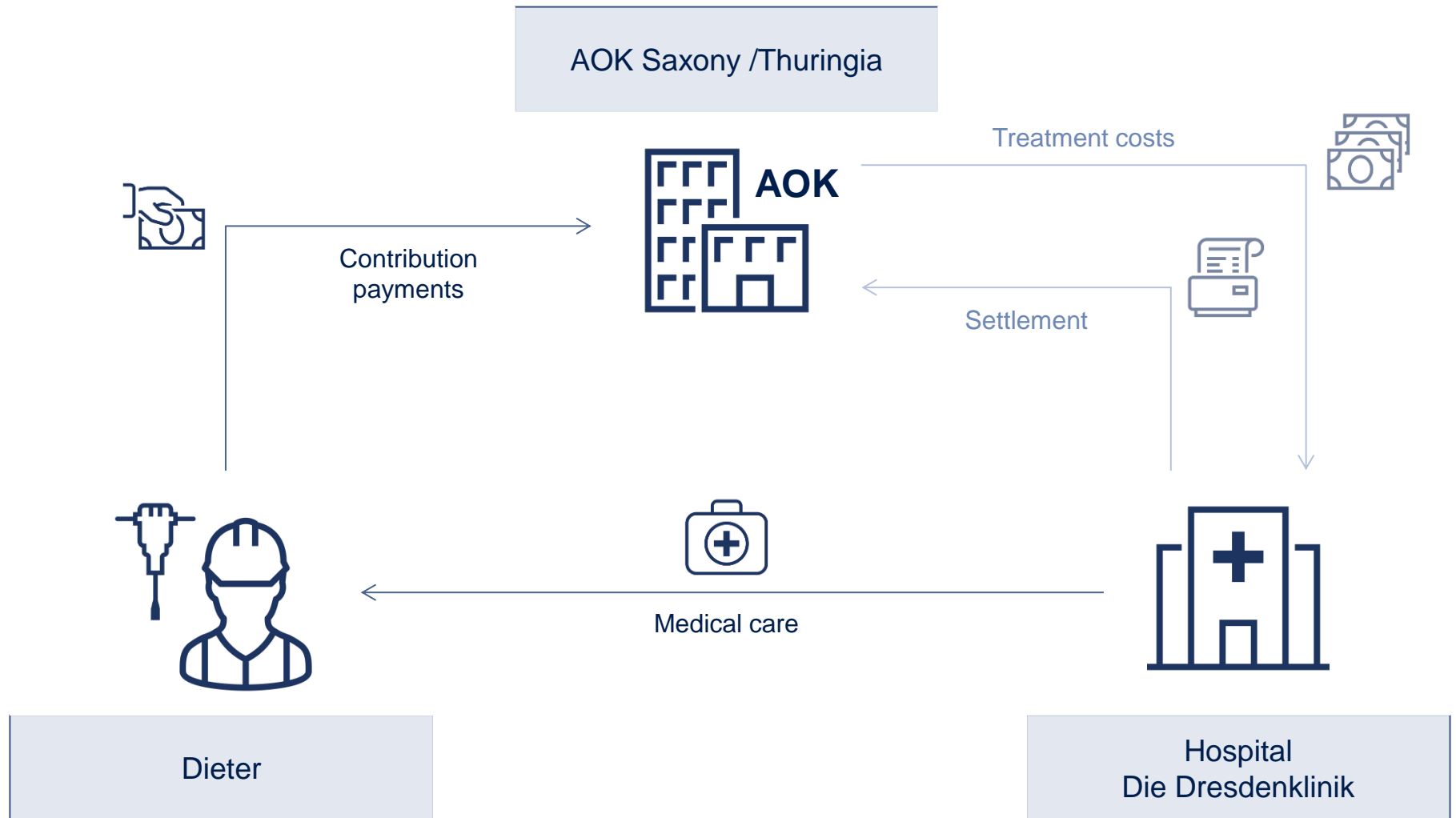
# Our healthcare system
## Who shapes Dieter's medical care?

**State**
- Federal ministries/ -authorities
- State ministries

**Self government**
- Associations (Health insurances, doctors, clinics)
- Decision-making body (Federal Committee)

**Individual players**

```
            Payers
           ↗      ↖
          ↓        ↓
   Patients  ←→  Service providers
```
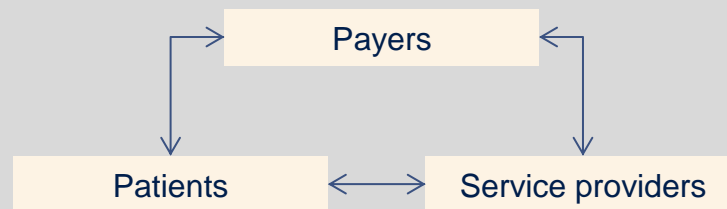
**SGB V**   **KHG**   **KHEntgG**

**InEK** — **Institut für das Entgeltsystem im Krankenhaus**

**Inpatient Care in acute care clinics**

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# Dieter's medical treatment is compensated with 6042 €: How does the payment system work?

## Encoding Dieter's case

### Diagnoses

- Fracture of calcaneus (PDX)
- Soft Tissue injury (SDX)
- Lymphedema (SDX)

#### ICD-catalogue

- S92.0 (PDX)
- S91.84(SDX)
- I97.8 (SDX)
- T84.1 (SDX)
- E03.9 (SDX)

### Procedures

- Imaging diagnostics (CT)
- Surgical treatment of talus and calcaneus

#### OPS-catalogue

- 3_205
- 3_990
- 5_787.1t
- 5_787.3t
- 5_797.1t
- **5_797.3t***

## Assigning Dieter to a Related Group

### Further characteristics

- Age, gender
- Ventilation, discharge reason
- Comorbidity, procedures

### Grouper**

### Related Group (DRG): I20B

Group of patientes with
- Similar clinical characteristics
- Similar resource consumption

#### DRG-catalogue

Cost weight = 1.843

(Average standard case: 1)

## Calculating the revenue of Dieter's case

### State-wide base rate

- Base price for DRG services
- Annual fixation (State-wide level)
- Successive approximation planned
- Saxony: 3,278.19 €

### DRG-revenue:

**1.843 x 3,278.19 € = 6042 €**

(In NRW: 1.843 x 3,355.00 € =6184 € )

| I | Major Diagnostic Category |
|---|---|
| 20 | Procedures/ Partitions |
| A | Severity |
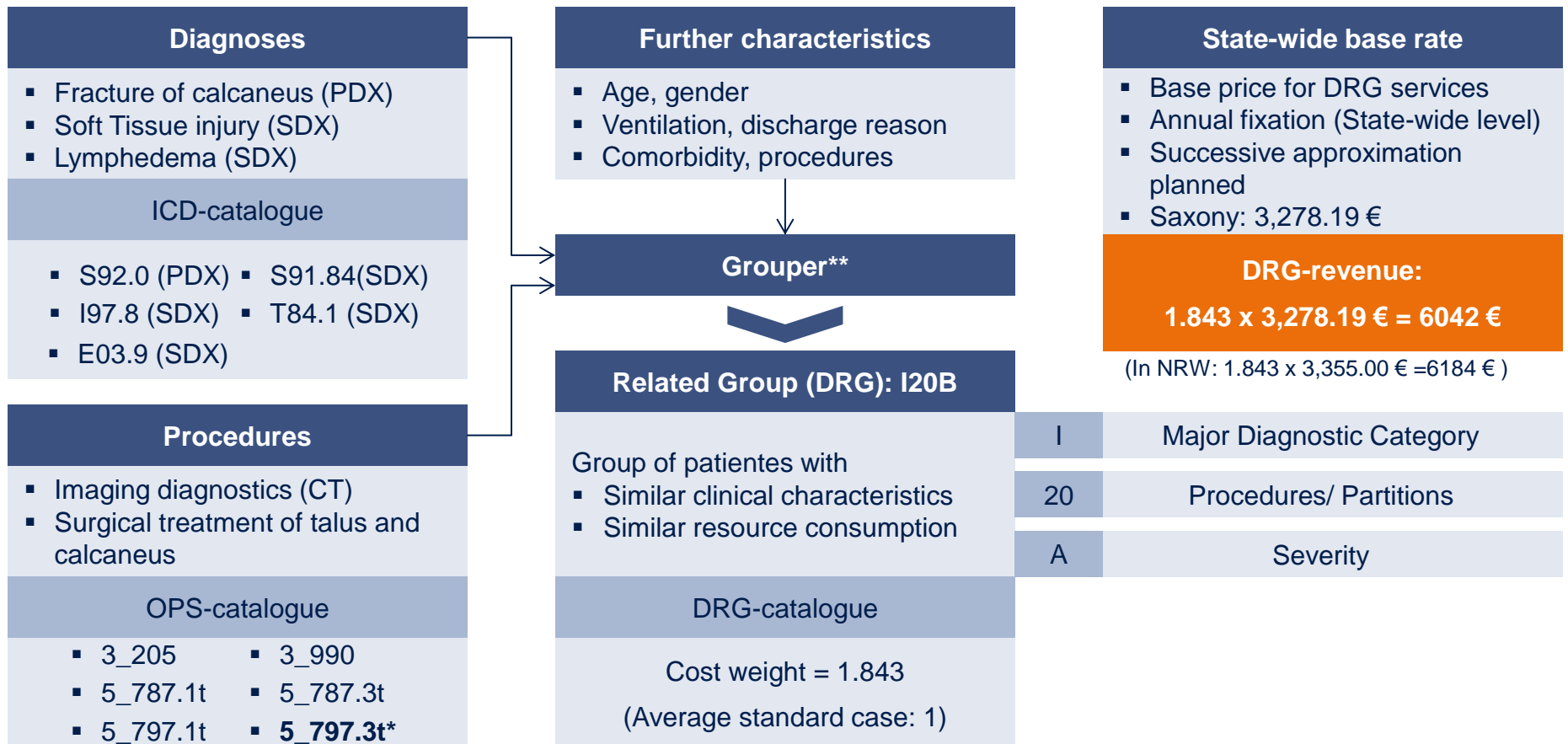
* Offene Reposition einer Fraktur an Talus und Kalkaneus: Durch Platte: Kalkaneus
** pure if then else tree, no statistics

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# Cornerstones of the DRG-system:
# Is Dieter's medical treatment cost-neutral for the hospital Bergmannsheil?

## Current figures

- DRGs: 1.210
- ICD-Codes: > 10.000
- OPS-Codes: > 30.000
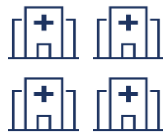
## DRG-calculation

InEK calculations are based on cost informations of benchmark hospitals

## Performance-focused compensation

Hospitals are remunerated in accordance to the rendered service, not in accordance to the actual costs



Revenue

Short-term | Normal | Long-term

Dieter: 6042 €

Costs

Revenues

Length of stay (in days)

1+LLOS — Dieter: 3d

ULOS — Dieter: 20d

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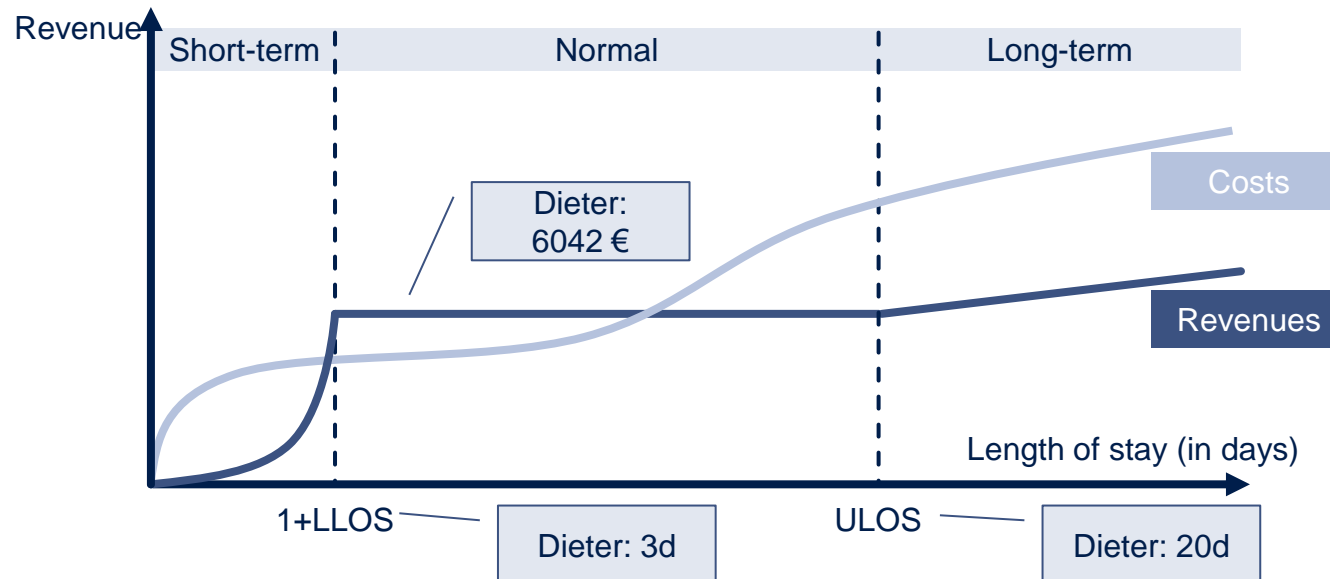
# Dieter's case turns into a nightmare - Part 1: Long-term patient

| Dieter becomes a long-term patient | |
|---|---|
| | **Problem** |
| | Dieter's length of stay is 20d (> ULOS) |
| | **Reason** |
| | Dieter has been waiting for MRI for 5 days |
| | Decubitus: infection of hand due to late change of intravenous access and wrong antibiotic |
| | Dieter can't enter his house with a wheelchair (repair works on driveway) |
| | **Consequence** |
| | The costs of Dieter's treatment exceed the revenue |
| | Dieter's case is checked by MDK |

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# Dieter's case turns into a nightmare - Part 2: Incomplete Documentation

## Dieter's patient file is incomplete

### Problem

Dieter's diagnoses / procedures were not fully documented

### Reason

Dieter's vertigo not diagnosed

Dieter's diabetes not recorded in his patient file

Artificial ventilation after admission not recorded

### Consequence

Loss of revenues for the hospital

In case of a complete documentation AOK would have paid ~21000 € (instead of 6042 €)

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# Dieter's case turns into a nightmare – Part 3: Missing discharge management

## Dieter's time of discharge has not been organized

### Problem

Delay of Dieter's time of discharge

### Reason

No appointments with specialists regarding the need of support after discharge

Prescription of the wheelchair overdue, home not suitable for wheelchairs

Medical report for application for rehab treatment not yet done

### Consequence

Dieter's length of stay extends

Dieter's costs of treatment exceed the hospital's revenue

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# Dieter is not alone…

**Length of stay**

- Analysis of real data
- 2014 – 2016 patient data
- Possible CL- / LL-rates of about 40%

- Legislature/Federal Arbitration Office: Patient has right of DM
- Required: efficient process for medical consultation, questionnaires, medication plan, risk classification, etc.
- DKG-Estimation: Additional 100.000 working days per year *

**Discharge**

**Revenue**

- Survey* examination year 2013: 205 clinics (3.2 Mio. patients)
- Examination quota: ~12%
- Expenditure of time: 71 minutes / case
- Revenue reduction: 1.4 billion EUR

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# Need for optimization of these three areas



**Estimation of length of stay:**

Target variable: Indicator of long-term patients

Features: Patient data ➔ analogy with credit risk model

**Securing revenues**

Target variable: correct DRG

Features: patient data, similar cases, valuation, risk classification

➔ Risk forecast & optimization

**Discharge management:**
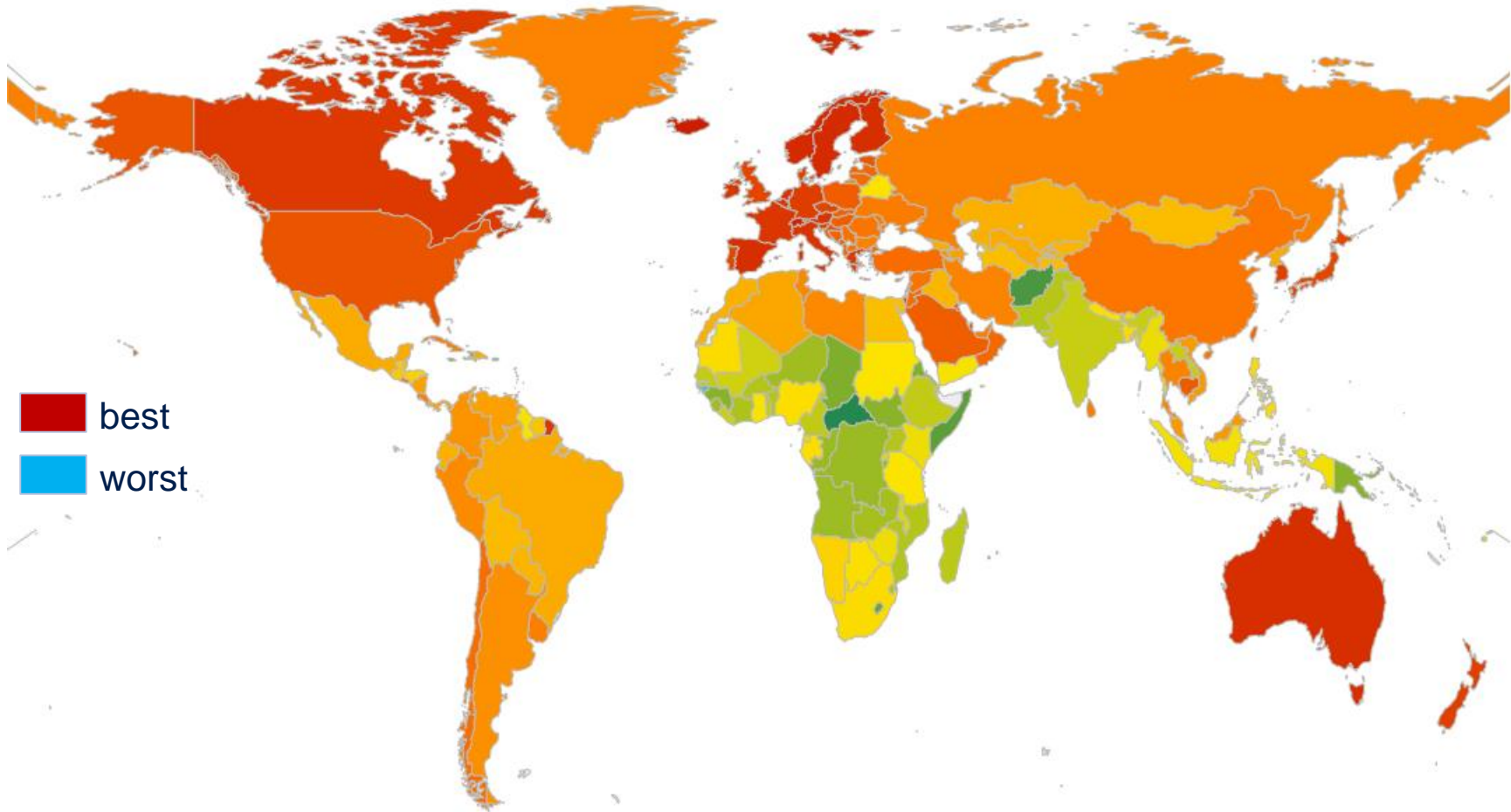
Target: process efficiency, overview

Features: patient flow paths incl. risks (activity-log-file), interfaces,

➔ Risk assessment
reporting & process modelling

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# Problems and why we need to start digitalisation now!

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# The world coloured by the *Healthcare Access and Quality Index* (HAQ-Index)



best

worst

Situation in Germany looks fine. Really? Is it sustainable?

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# Germany lags behind its expected HAQ-Index

| Rank | Country | HAQ-Index |
|------|---------|-----------|
| 1 | Andorra | 94,6 |
| 2 | Island | 93,6 |
| 3 | Schweiz | 92 |
| 4 | Norwegen | 90,5 |
| 4 | Schweden | 90,5 |
| 6 | Australien | 89,8 |
| 7 | Finnland | 89,6 |
| 7 | Spanien | 89,6 |
| 9 | Niederlande | 89,5 |
| 10 | Luxemburg | 89,3 |
| 11 | Italien | 88,7 |
| 12 | Irland | 88,4 |
| 13 | Österreich | 88,2 |
| 14 | Belgien | 87,9 |
| 14 | Frankreich | 87,9 |
| 16 | Kanada | 87,6 |
| 17 | Brunei Darussalam | 87,4 |
| 18 | Griechenland | 87,0 |
| 19 | Singapur | 86,7 |
| 20 | **Deutschland** | 86,4 |

1. Andorra

Germany's potential

6. Australia

18. Greece

**20. Germany**

Germany's rank (20 of 195) is okay, generally speaking

But its *theoretical* HAQ-Index (based on state of development) is much higher!

The gap indicates deficits in Germany's healthcare **system**

Source: Research conducted by the University of Washington (published in *The Lancet*) evaluated the mortality of a specific set of 32 diseases, for which cures do exist.
(http://www.spiegel.de/gesundheit/diagnose/gesundheitsversorgung-deutschland-belegt-weltweit-platz-20-a-1148313.html)

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# What are problems in the healthcare sector?

| Problem |
|---|
| Difficult: good care with decreasing number of (stressed, low-paid) specialists handling a increasing number of patients |
| Failure caused by stress (missed catheter, wrong antibiotic, interpretation of image/finding, current resistances...) |
| **Target: Create sustainably good working conditions for a sufficient number of specialists to ensure future care** |

| Root of the problem |
|---|

In Thuringia **care needs** will **rise by about 50%[1] by 2035**

Skills shortage (too few up-and-coming young specialists and occupational change) due to

- Poor payment, bad working conditions (also digital):
  - Excessive bureaucracy → **48 mio provision of aids[2] („Hilfsmittelanträge") – paper work!**
  - Digitalisation backlog→ confusing systems, guidelines/standard recommendations not uptodate (e.g. resistances)

- High increasing **costs** in the **healthcare** sector: **4213 €** per inhabitant (11.3% of GDP), i.e. an increase by 4.5% in 2015[3]

- High administrative costs - **administrative expense ratio 23%[4] (industry 6%)** – caused by
  - duplication of effort by sectoral thinking and rigid structures with lack of integrity and transparency
  - data protection
  - Federalism
  - no competition for investments in the dual system

1:Source: *https://www.thueringen.de/imperia/md/content/tmsfg/stabsstelle/fachkraeftestudie_pflege_2030_2014-02-20.pdf*
2:Statista (2017), 3: destatis. 4: BMG KV45-Statistik

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# Why must we start change now?

Costs are increasing every year. See right side in billion Euro

Politics begin to recognize the importance of this topic.

Financial resources are presumably available soon

In order to avoid losing contact to the international development.



Chart legend:
- Einnahmen (earnings)
- Ausgaben (spendings)
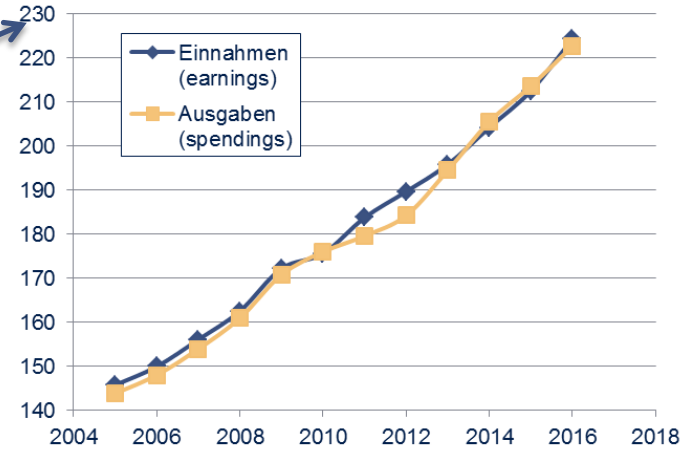
## Estonia

» national, mandatory insurance scheme
» minimum service quality requirements (e.g. waiting times)

Digital pioneer: 1998 GPs were moved out of hospital without records!

## Norway

» free healthcare for children under 16
» very low but upfront share payed for almost all services

Aims to become world's e-health leader by 2025

## United States

» system fosters consumer-led culture
» risk-averse practices
» highest cost in developed world

E-health revolution is on its way, approximately halfway finished

Source Einnahmen/Ausgaben in Germany: https://www.bundesgesundheitsministerium.de/fileadmin/Dateien/3_Downloads/Statistiken/GKV/Kennzahlen_Daten/KF2015Bund_Juli_2017.pdf

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# How to solve the problem of digitalisation of the healthcare sector?

Things we need to await:
» Politics - laws:
  › accept backlog of digitalisation → on the way
  › clarify tradeoff between stagnation and data protection
  › cross-party and cross-"Bundesländer"-discussion

» Politics – money:
  › investments at the right place
  › encourage competition in the dual system (investments, innovations… )

Things we can do:
» Support with integrated artificial intelligence and predictive analytics
» Explain and release fears: support not to replace, in the long run the only chance
» Help in stress situations and reduce routine work load by digitalisation

We support medical professionals with an integrated, intelligent. and individual solution, that helps to better communicate with each other.

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# Digital future: (Big) data, models, and smart-data technology?

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# The Problem – Data – Model – Puzzle: How can smart technology use data to solve problems?

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# The Problem – Data – Model – Puzzle:

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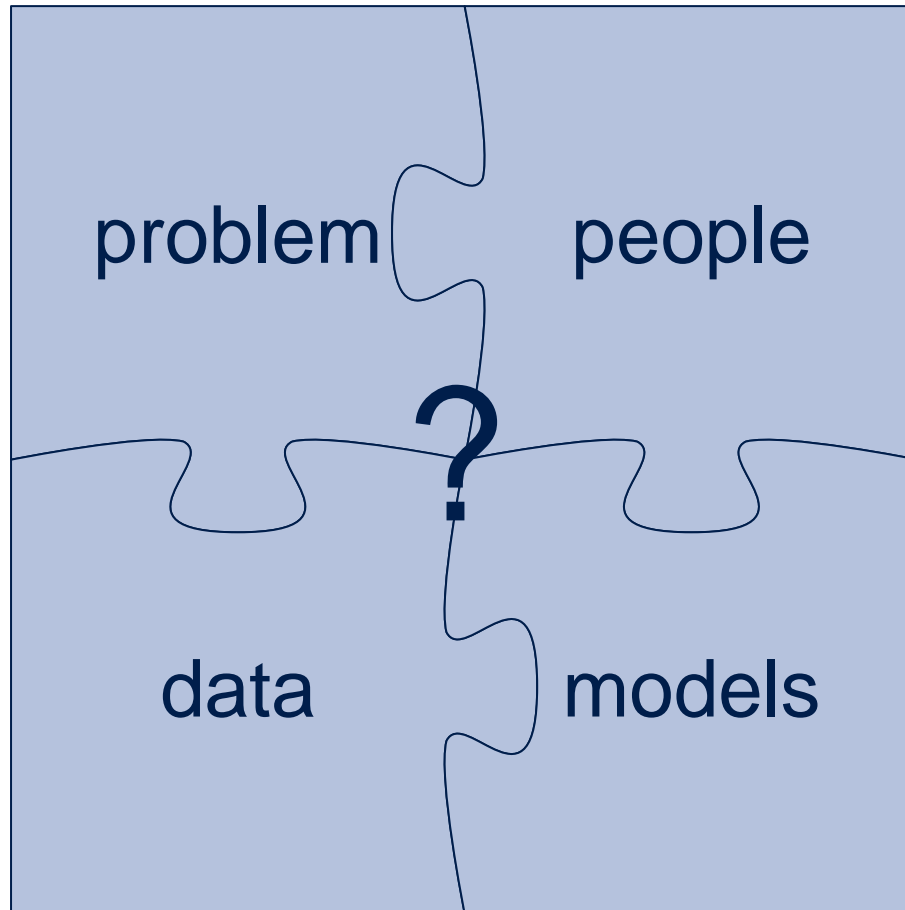
Which and how existing kinds of raw (big) data can be transformed and structured to answer relevant questions

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# Some kinds of raw data existing in healthcare sector:
# How can it be streamlined to obtain understandable high-level structure?

**"§21-Data" (Billing)**
Standardized, very good quality:
functional selection (combination) of tables

**"MDK-Data" (Bill checks)**
Partly standard software, diverse quality:
analyse sources / collecting process, find
functional/representative rows/columns

**"DM-Data" (care conditions)**
Some software, individual formats
→ find sources for conditions and
labels (papers!*) by analysing care
processes/discharge planning

**"New-Medicine" (impact study)**
Depends on study: to
see if a new pill has
an effect (byeffects?)

...

**"Tumour-Data" (CT, MRT etc.)**
Standardized: image
analysis / pattern
classification

**WORK IN PROGRESS**

**"Infection-Data" (micro biology)**
Mostly clinic individual data sets:
find data relevant **to categorize**
infection types (which antibiotic),
understand regulations

**"Hygiene-Data" (process mining)**
Mostly clinic individual data sets:
find data relevant to set up or
change intravenous access,
understand regulations

**+** Text on paper:
*laboratory data, fever?, X-ray findings*

**+** Text on paper / in a KIS-data:
*Activity log data*

*digitalisation by hand is necessary
MDK = medical service of the health insurances reviews and reports if the bill fits diagnosis and procedures of the patient (only file check), DM=discharge management

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# Big Data, but which data (subset) helps to clarify the concrete problem and has the potential to give answers?

**"§21": Find potential Long-Lier**
Features: diagnosis, procedures, sex, age etc
Label: long (costlier) lier*, risk patient & news

**"MDK": Find potential inquiries, losses**
Features: as §21, area, department etc.
Labels: potential inquiries ("PD"), lawsuit
"Y": estimate potential loss ("LGD")

**"New-Medicine"
(impact study)**

**"DM": post hospital needs**
Features: as §21, dekubitus, able to
go to bathroom… etc
Labels: post hospital needs**,
discharge date, numbers,…

**"Tumour-Data" (CT,**

**"Infection-Data" (micro biology)**

BIG
DATA?

**"Hygiene-Data" (process mining)**

WORK IN PROGRESS

WORK IN PROGRESS

So far no usage of Big data algorithms after manual structuring. Features are formed to be "high-level".

\* LL=yes if length of stay > ULOS(DRG), \*\*(yes/no, action)

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# New Market, known problems?
# Example „MDK": Solve clinical questions with methods used in finance

| clinics | ⇄ | **Ask professionals** | ⇄ | methods |

**How can patient data and a drill down of the clinic situation be visualized?**
→ Statistics and interactive display of patient data as web app using R-Shiny

**Will there be an inquiry, (later lawsuit) for this case? What is the potential income (reduction)?**
→ PD-like Scoring: to estimate probability of an inquiry. Clustering + LGD-like model to estimate success of inquiry and potential case/clinic income (loss)

**(E.g. if MDK-PD is high). Were all secondary diagnosis and procedures be encoded?**
→ A machine learning algorithm to find similar cases with potential other probable diagnosis

**How can a patient-monitoring look like? How can human and artificial intelligence be joined?**
→ Selection of relevant news. Relevance is measured by similar risk patients. Live integration of feedback of experts and their manual patient risk estimates.

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Which (combined) models exist for which problem?
How to find the best one?

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# Guidelines/rules/ trees /programs vs. artifical intelligence and learning?

| **1** | Decisions by traditional rules (programming) |
|---|---|

» Rules directly used by humans (learning a 2nd language), rules are derived from past experience (e.g. impact studies)
» Rules programmed by humans, humans use programs

» Humans have to improve rules manually (e.g. studies)

Input data
Output data
Human
Program
Computer

| **2** | Decisions by (machine) learning from patterns |
|---|---|

» Humans intuitively decide as experienced herself best in similar cases (learning mother tongue)
» Machines learn from data "experience" and decide as data experienced best in similar cases
» Machine learning improves with more data or human reviews of the quality of the proposed decision

Input data
Output data
Training data
Computer
Program
Computer
Human

Order by degree of information

Veterinary
yes — test & isolate
no — Visit in risk country
yes — ...
no — 

test & Isolate    test    no test

E.g. standard recommendations for antibiosis

Combination possible

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# Which models (combinations) can answer our questions?

**"§21": Find potential Long-Lier**
Scoring (logistic regression) + expert feedback or similar cases with nearest neighbour

**"MDK": Find potential inquiries, losses**
Scoring (logistic regression) and similar cases with nearest neighbour
(what is near?!)

**"DM": post hospital needs**
- Trees, scores, e.g. BRASS-Index
- neural networks
- combinations
   At first: digitalize papers!

**"New-Medicine"**
**(impact study)**

**...**

**"Tumour-Data" (CT, MRT etc.)**

**"Infection-Data" (micro biology)**
- text analytics → big data?
- clustering
- ...
- combinations

WORK IN PROGRESS

**"Hygiene-Data" (process mining)**
- text analytics → big data?
- clustering
- ...
   combinations

WORK IN PROGRESS

▶ A Model must fit the problem and the data. Usually there are several alternatives.

* LL=yes if length of stay > ULOS(DRG)

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# How to find out which model (combination) does perform best?

**Find measure to be optimized:** measure should consider bias, variance, i.e. goodness of fit but no overfitting by model complexity

**Validation procedure:** always don't forget to leave a subset for validation aspects… e.g. cross validation

**Trade-off between fitting and complexity:** training error and validation error should be optimal

**Use functional input from experts** ("is age relevant, if included in DRG?")

…

**Measure of goodness of fit:** significance, power, correlation, Gini, ROC, AIC, stability,…

**How to optimize choice of hyper parameters: e.g.** complexity, but also p and q in an ARMA model → Some tricks and tuning software package

Finding a best model is a trade-off between fitting training data and complexity (and potential overfitting). A well-chosen measure and validation data set as well as expert feedback are necessary.

\* LL=yes if length of stay > ULOS(DRG)

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# Which models perform best?

**"§21": Find potential Long-Lier**
Combination of models and including expert feedback

**"MDK": Find potential inquiries, losses**
In progress

**"DM": post hospital needs**
In progress

**"New-Medicine"
(impact study)**

**...**

**"Tumour-Data" (CT, MRT etc.)**

**"Infection-Data" (micro biology)**
In progress

WORK IN PROGRESS

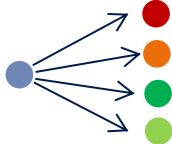**"Hygiene-Data" (process mining)**
In progress

WORK IN PROGRESS

> Models cannot fully replace common sense and human intelligence. So radiologists will be still needed in 20 years. But we can support them to reduce shortage of medical professionals.

\* LL=yes if length of stay > ULOS(DRG)

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# Healthcare examples

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# Supervised learning example: Predict hospital stay status

| | **Raw Data**<br>> 100K patient cases | | **Algorithm** | | **Output** |
|---|---|---|---|---|---|
| **1** | | **2** | | **3** | |

**Raw Data** (1)

Four **labeled outcomes** in regard of length of stay in hospital:
- Long-Lier  🔴
- Cost-Lier  🟠
- Normal-Lier  🟢
- Short-Lier  🟢

**Available inputs (→ features):**

» Diagnoses: >15K possible diagnoses

» Procedures: > 30K possible procedures

» Demographic information (age, sex, postal code)

» Other information (e.g. hospital department, weekday of admission, DRG)

**Algorithm** (2)

» **Given**: a set of labeled observations

» **Goal**: find a function f which can be used to assign a label to the new unseen case (observation)

» **Statistical Methods**:
  › (logistic) regression
  › Shrinkage methods (lasso and ridge regression)
  › Nonlinear methods: regression splines and smoothing splines
  › Classification (K-Nearest Neighbors)

» **Model Accuracy:**
  › Out-of-time and out-of-sample tests

**Output** (3)

» For each new case  🔵

  › Compute the probability to belong to one of the four groups



  › Decision rule (probability-thresholds)

> Machine Learning ensures efficient identification of cost-intensive medical cases such as long- or costliers

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# Problem: Actively steer length of stay of patient 10000002

Inefficient processes lead to a high long lier risk

**Name**
Dieter Kaschinsky

**Age**
53

**Place of residence**
Dresden

**Family status**
unmarried

**Diagnosis**
calcaneus fracture
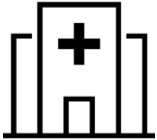
**Treatment**
open reposition

**Further informationen**
MRT is supposed to be made shortly before discharge

**Problem**
Early planning of stay, i.e. treatment and medical necessary length

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# Procedure without and with CaseCheckPro: (Actively) steer length of stay

**Classical Procedure**

**Risk**

Mr Kaschinsky will be a long lier as MRT will have been postponed

⚠ Patient distress and decreasing satisfaction

⚠ Personal distress

⚠ Income risk (MDK check)

**Using CaseCheckPro**

**Solution**

Mr Kaschinsky is predicted as a potential longlier in CCP, alerted in a list and compared to similar cases

🔑 Early prediction of discharge date and alerted longlier risk

🔑 Active length-steering + early planing of actions and treatments

🔑 Process improvements, reduction of work load

*Any resemblance to a clinic is purely coincidental.

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# Longlier-Scoring: What is the probability that Dieter becomes a longlier?

**Model: Longlier-Scoring**

Department

Admission

DRG

main diagnosis

other diagnosis

procedures

Postal codel

returner

↓

Logistic regression

|
LL-Score
|

Density estimation

↓

LL-Probability

**Data: Dieters LL-Probability**

Surgical ward

Sunday

I20B

S92.0

S91.84, I97.84, T84.1

3_205, 3_990, 5_787.1t, etc.

01099

Yes

↓

82%

**Parallels: credit scoring**

Patient
⟷
Credit client

Patient will be longlier
⟷
Client default

Patient attributes
*Diagnosis, procedures, age, etc.*
⟷
Credit risk-factors
*amount, maturity, profession, etc.*

LL-Score
⟷
credit Score

Longlier-Probability
⟷
Probability of default (PD)

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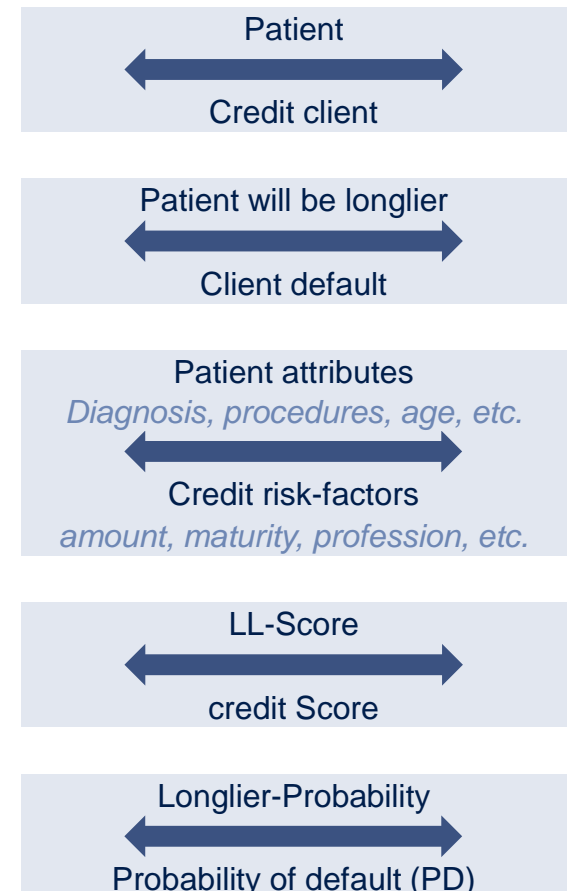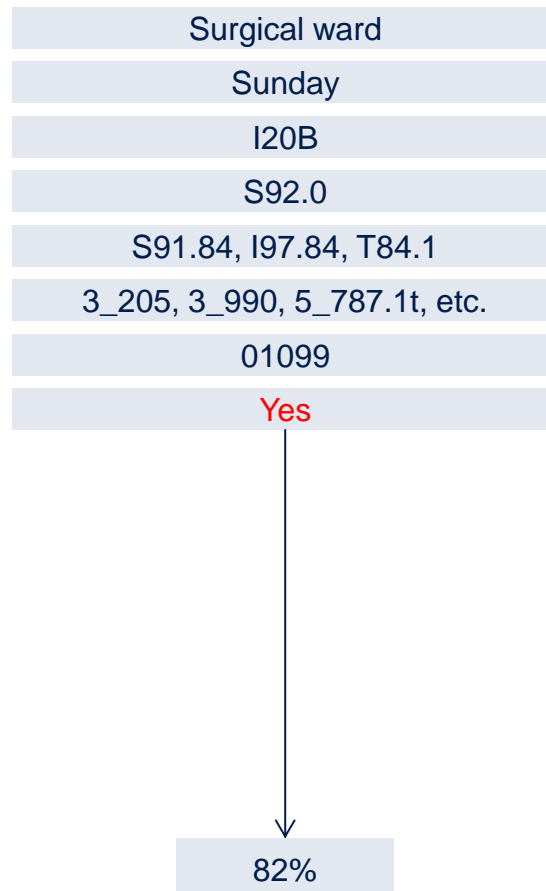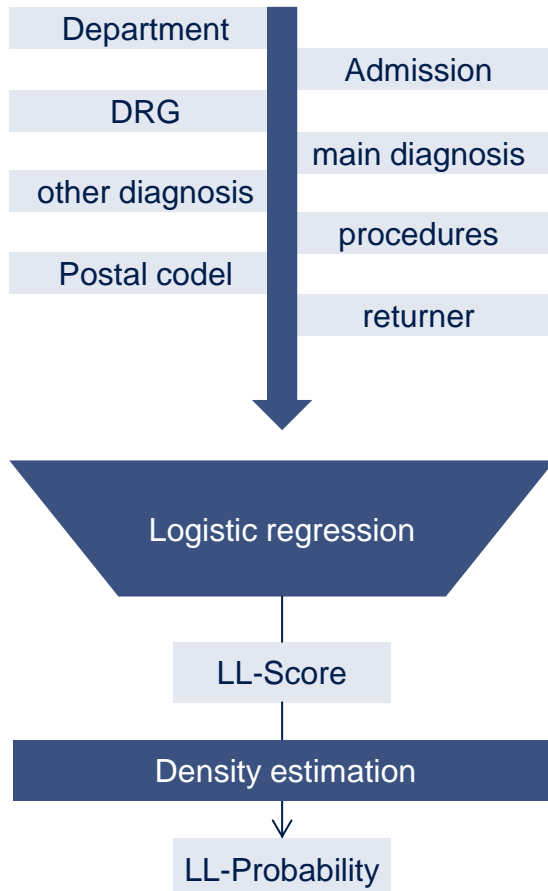
# Application in "CaseCheckPro" (Screenshot):
# Probabilities of stay status & estimated length of stay (blue rectangle)
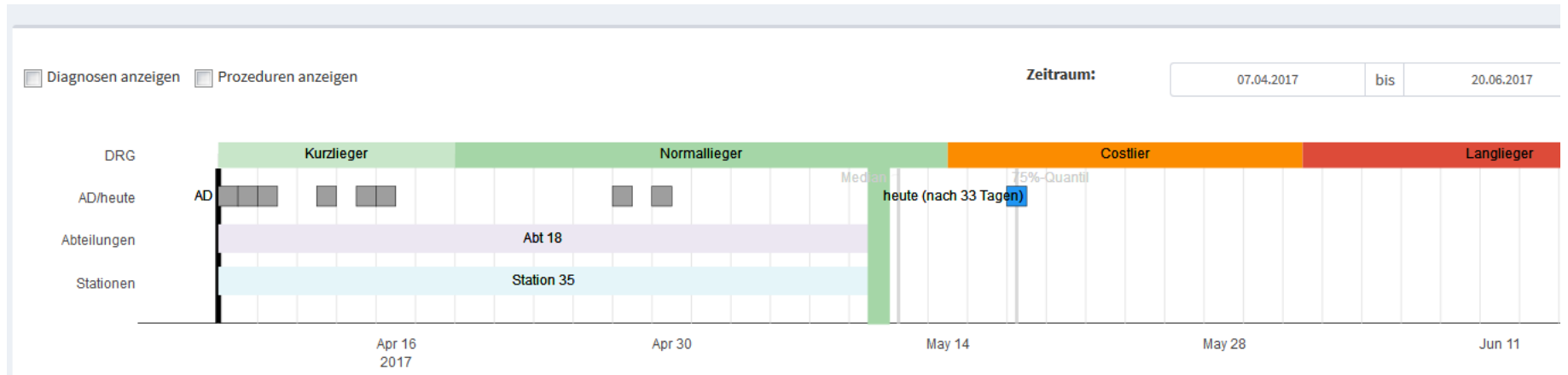
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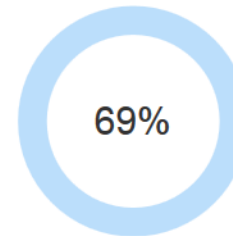
# Need of nursing care will increase by almost 50%[1] in Thuringia until 2035: It is crucial to sustain good working conditions to ensure future care!

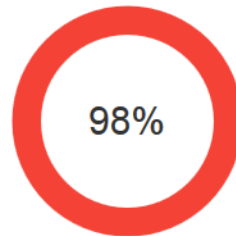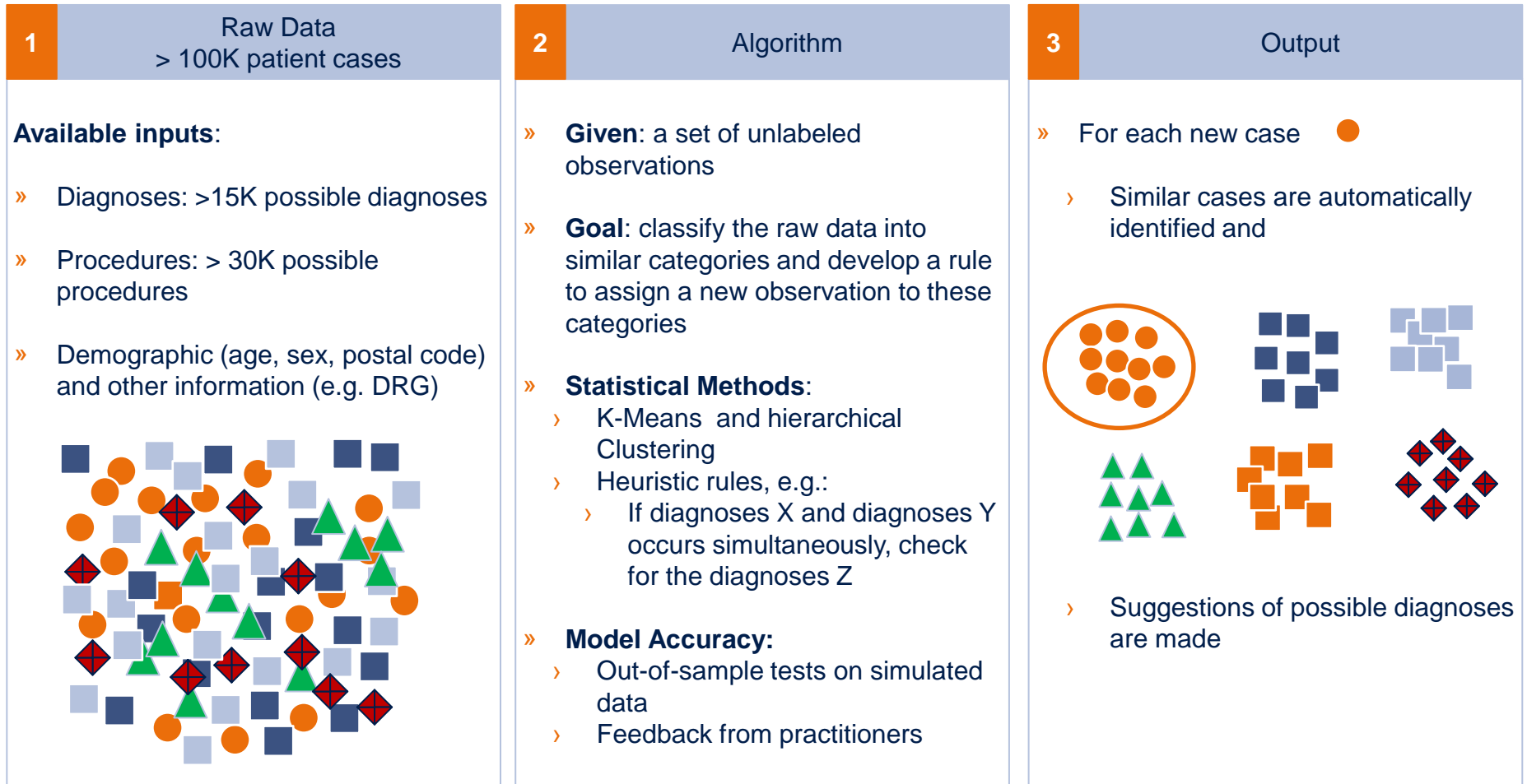| | Questions of current professionals | Our answers |
|---|---|---|
| **work load in 2017** | We work hard to ensure very good care for all patients. How should that work in future with 50% more patients? | Efficient processes in order supported by predicted analytics are the basis that you can still concentrate on every individual patient. |
| **overload in 2035?** | In future, will I be burdened even more while going from one new to tool to the next new one? | Yes, a **transformation causes extra work load** in the beginning. No, **in the long run**, you and future staff will be happy that you went this step to **reduce remote work** load far away from patients. |
| **The solution: Smart-Data?** | Will I be replaced? How should the reduction of work load be achived by mathematics? | No, **support** instead of replacement. The right and predictive information via smart-data helps that you can **optimally apoint your valuable** time to patient welfare |
| **Applications** | How do you solve burdens like cross-disciplin communication or requirements about length of stay, waiting hours, quality and documentation? | Our overall patient coordination gives you, e.g. an interdisciplinary status and prediction of long length of stay/waiting hours as well as appropriate actions |
| **Demo and example** | Our longlier rate is fine, what is the benefit of your longlier estimation? | Via the identification of potential longliers and similar cases you need less time for the same or better LL-rate. |

1 *https://www.thueringen.de/imperia/md/content/tmsfg/stabsstelle/fachkraeftestudie_pflege_2030_2014-02-20.pdf*
2 *In money units , with CCP and 40000 cases you get a slightly reduced LL-rate from 10% to 9,5% and around 1,4 Mio € more income, which you can use for patients' welfare*

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# Unsupervised learning example in HealthCare:
# Identify similar cases and predict (undetected) diagnoses

| **1** | Raw Data<br>> 100K patient cases | **2** | Algorithm | **3** | Output |
|---|---|---|---|---|---|

**1 — Raw Data > 100K patient cases**

**Available inputs**:

» Diagnoses: >15K possible diagnoses

» Procedures: > 30K possible procedures

» Demographic (age, sex, postal code) and other information (e.g. DRG)

**2 — Algorithm**

» **Given**: a set of unlabeled observations

» **Goal**: classify the raw data into similar categories and develop a rule to assign a new observation to these categories

» **Statistical Methods**:
› K-Means and hierarchical Clustering
› Heuristic rules, e.g.:
› If diagnoses X and diagnoses Y occurs simultaneously, check for the diagnoses Z

» **Model Accuracy:**
› Out-of-sample tests on simulated data
› Feedback from practitioners

**3 — Output**

» For each new case ●

› Similar cases are automatically identified and

› Suggestions of possible diagnoses are made

> Machine Learning ensures efficient identification of similar cases and makes suggestions of possible (undetected) diagnoses

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# Application in "CaseCheckPro" (Screenshot): Similar cases & possible diagnoses



Tagesreport vom **10.05.2017 13:44 Uhr** für Fallnummer 382▮

**Fallinfo** (Klicken zum Verbergen)

Dieser Fall:

Ähnliche Fälle aus der Vergangenheit:

| | | **Fallnummer** |
|---|---|---|
| **HD:** | I61 - Intrazerebrale Blutung | 395 |
| **DRG:** | A09C - Beatmung > 499 Stunden oder > 249 Stunden mit int. Komplexbeh. > 2352 / 1932 / 2208 P., mit komplexer OR-Prozedur oder Polytrauma oder int. Komplexbeh. > 1754 / 1656 / 2208 P. oder mit komplizierender Konstellation oder Alter < 16 Jahre | 397 |
| | | 391 |
| **PCCL:** | 4 | 389 |
| **Abt./Stat./Zim-mer:** | Intensivmedizin/Schwerpunkt Chirurgie (HA3618) / Station 35 / Zi 065 | |

## Erlösmanagement

**Zu simulierende Nebendiagnosen:**  −

NDs mit Tabellen- oder Plot-Klick wählen

Simulation mit diesen NDs starten

### Patienten mit dieser HD hatten meist folgende ND-Dreisteller:

| ICD 3-Steller | | bereits codiert? | Wahrscheinlichkeit |
|---|---|---|---|
| I10 | Essentielle (primäre) Hypertonie | j | 63.64% |
| G81 | Hemiparese und Hemiplegie | n | 39.30% |
| E87 | Sonstige Störungen des Wasser- und Elektrolythaushaltes sowie des Säure-Basen-Gleichgewichts | j | 35.83% |
| R47 | Sprech- und Sprachstörungen, anderenorts nicht klassifiziert | n | 28.88% |
| J96 | Respiratorische Insuffizienz, anderenorts nicht klassifiziert | j | 24.60% |
| I48 | Vorhofflimmern und Vorhofflattern | n | 23.80% |
| D68 | Sonstige Koagulopathien | n | 21.39% |

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# Benefits and limits of digitalisation

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# What are limits of big data and smart-technology in the healthcare sector?

People

Old systems

Data protection

Politics

Brain wash of common sense – to be at computer's mercy?

AI can fail, but it is valued differently (compare self-driving cars)

… other ideas?
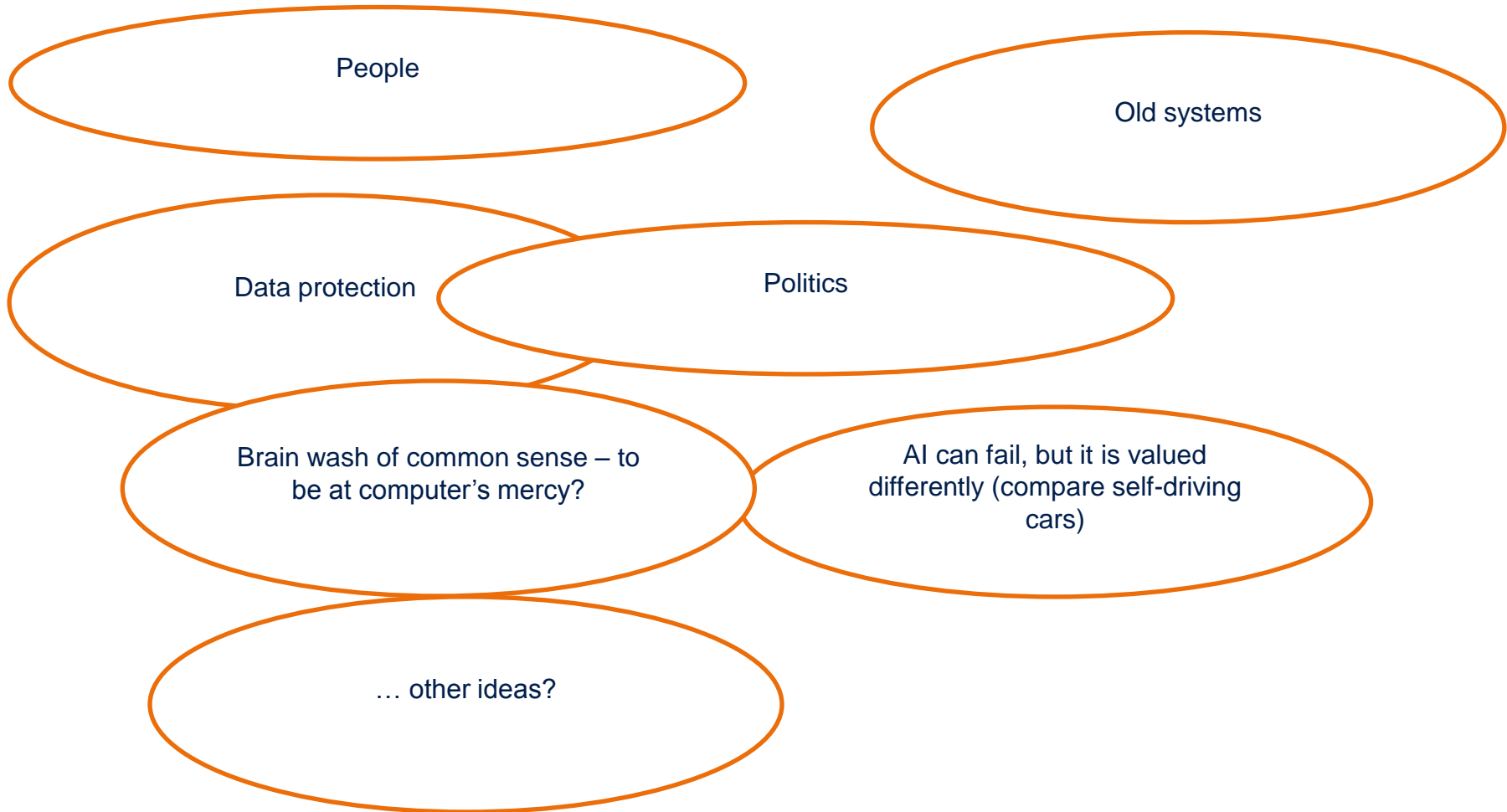
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# What are benefits of big data and smart-technology in the healthcare sector?

Personal and Patients are satisfied

More time

Less distress of personal and patients

More safety and less failure

Less income risk and process efficiency

Sustainable, i.e. more money for good medical care in the long term

Informed patients and personal
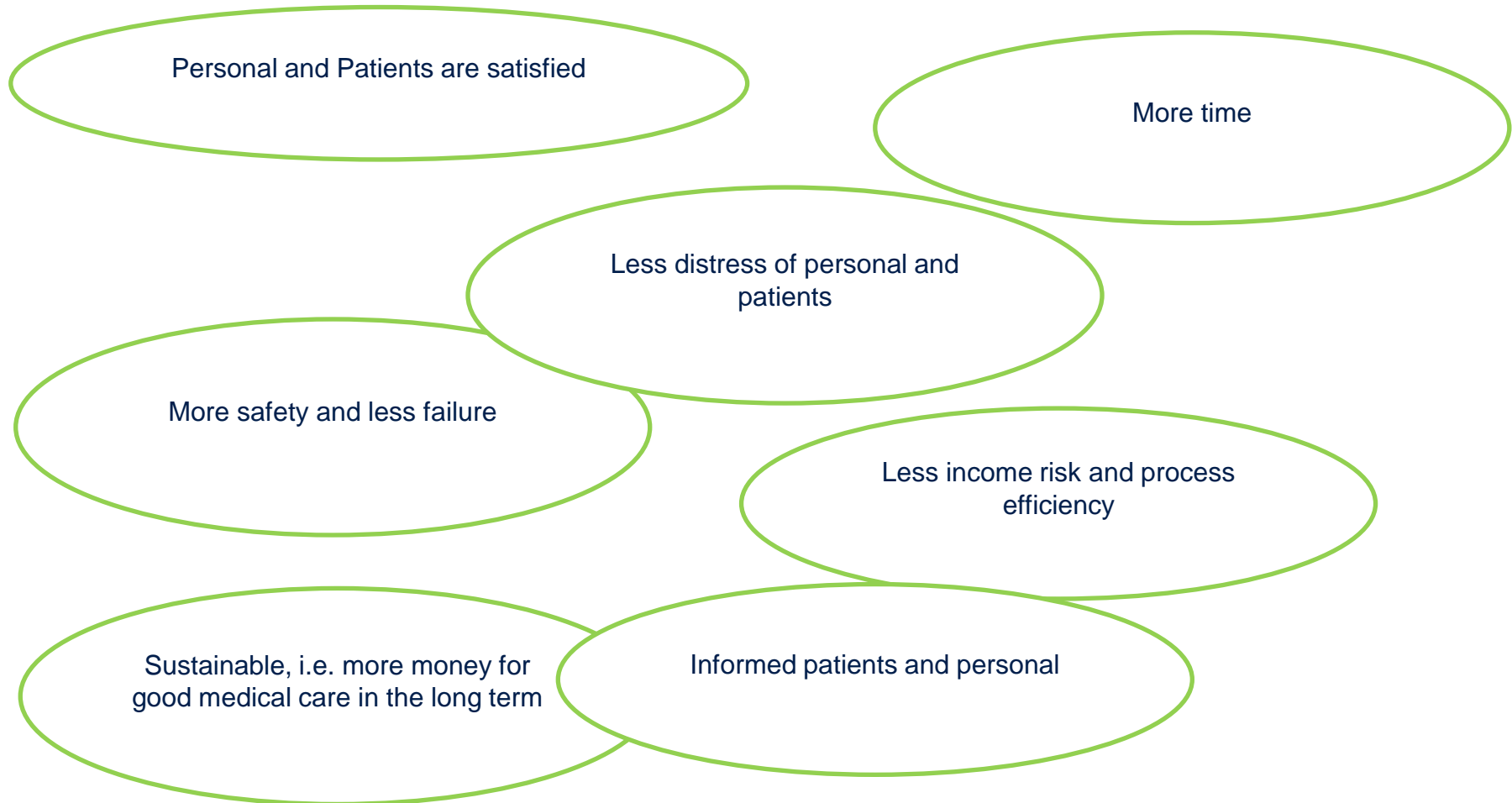
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So why is d-fine interested in the health care market?

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# Our idea: human and artificial intelligence complement each other
# Experts und computer learn from each other via an exchange of experience



1. The computer generates per click news from past (training) cases
2. The expert sees the critical case on demand and acts
3. The expert reviews quality of the news and risk of the case
4. The computer complements training data by reviews and so improves risk estimation and news generation

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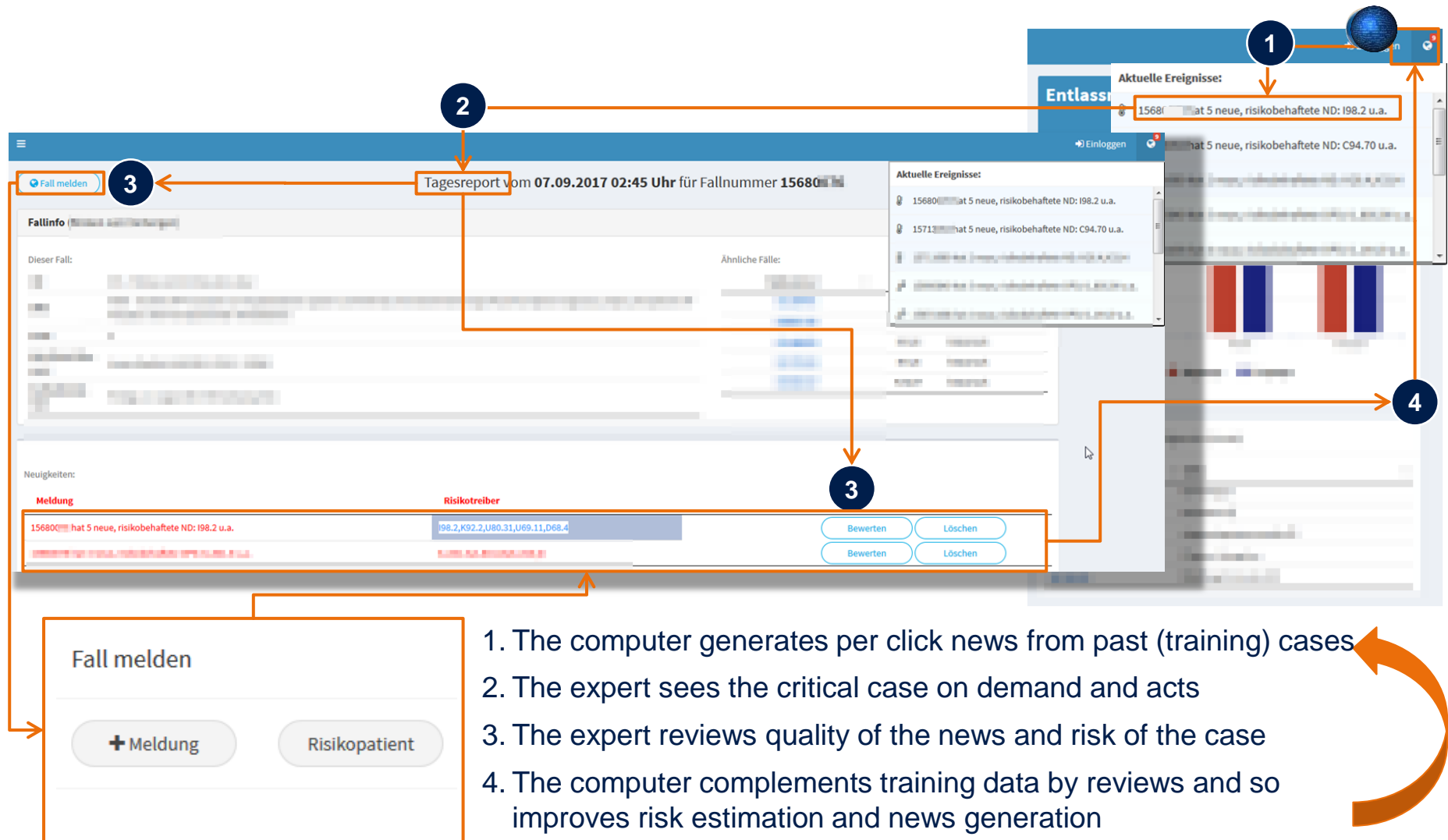
# CaseCheckPro is a service package from A to Z
## Consulting + Frontend + Backend



**Consulting**
processes,
risk drivers,
application

**Webtool**
lightweight,
interoperable

calibrated,
mathematical
**models**

**Big / Smart-Data**
Algorithms

$$\text{logit}(P) = \ln\left(\frac{P}{1-P}\right)$$

```
TARJAN(Node* node)
e.visited ← true
de.index ← indexCounter
.push(node)
for all successor in node.successors do
    if !node.visited then TARJAN(successor)
    end if
    node.lowlink ← MIN(node.lowlink, successo
end for
if node.lowlink == node.index then
    repeat
        successor ← stack.pop()
    until successor == node
    if
tion
```

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# CaseCheckPro is unique in the market
## Through people with expertise in problem solving, process and data science

**Our unique selling point**

Combination:
- » quantitative **consulting** for (risk) management
- » **clinic-knowhow** (consus)

**Integrated and intelligent tool** to be individually fitted into your system landscape and interdisciplinary (risk) management

**Mathematical Modelling** of risk drivers and effects

Prediction via **Smart-Data** und algorithmic

Wide and deep expertise in
- » **consulting** and analysis
- » **problem s**olving
- » **implementation**

**In distinction to…**

- » standard product with less possibility to adjust
- » traditional GUI

- » KIS
- » RIS
- » PACS

System to fully support operative of specific activities

Own secondary data capture and data warehouse

Consulting is limited to product and its properties

KIS=Krankenhausinformationssystem, RIS=Radiologie Informationssystem, PACS=Picture Archiving and Communication System→Bildarchivierungssystem

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