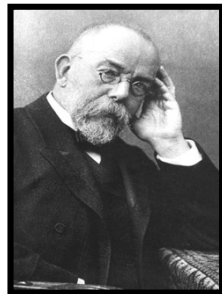




AI for Public Health

Prof. Dr. Lothar H. Wieler
Geneva, 29.05.2019

The Robert Koch Institute (RKI) 1891-2017



**Robert Koch (1843 – 1910)
Director until 1904**



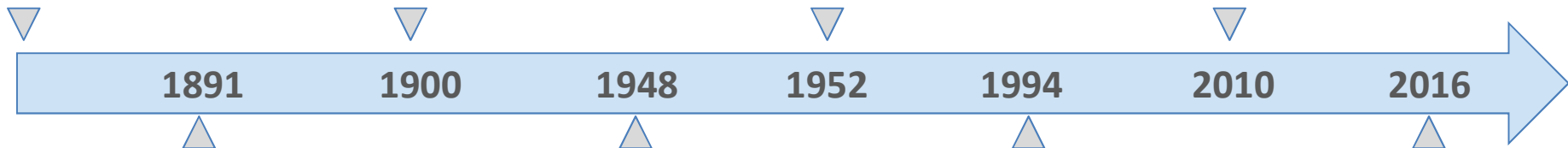
New site in Berlin



**Integration into the new
Federal Health Office**



**RKI is named the national Public
Health Institute**



**Royal Prussian Institute for
Infectious Disease**



**Reorganization as Robert
Koch-Institute**



**Independent Federal Public
Health Institute
for Infectious + Non-
Communicable Diseases**



125th anniversary

Key Functions

Detect – Evaluate – Act

1200 employees (~450 researchers)



Identification/evaluation

- High prevalence diseases
- Diseases of specific PH-related political significance



Communication/Cooperation

- Partners in scientific sector
- Public Health service
- Health care sector



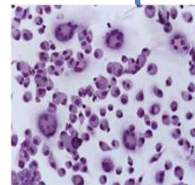
Epidemiological intelligence

- Communicable diseases
- Outbreak management
- Non-communicable diseases



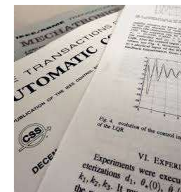
Consultation/Recommendation

- Political decision makers
- Physicians
- Local health authorities



Research

- Collaboration with national & international partners
- Currently >100 externally funded research projects



Publications

- National & international
- >500 peer-reviewed publications / year
- National health reporting

Centre for International Health Protection (ZIG) and Informationcenter for International Health Protection (INIG)

- ZIG launched in January 2019
 - Sustainable development of core global health competencies at RKI
- INIG
 - Internationale Collaborations: Support of international partners, coordination of international missions
 - Public Health Intelligence (PHI): Epidemiological information about communicable and non-communicable diseases
 - Planned for PHI: Methodical development (social media, artificial intelligence, deep learning)





International Association of National Public Health Institutes



- Coordinating body to empower National Public Health Institutes
- 110 members from 93 countries (and growing)
- Swift, comprehensive Public Health cooperation across borders
- Measurable improvements in outbreak surveillance and response for Ebola, Zika, and other urgent threats
- Knowledge and data sharing (SNAP-GHS)

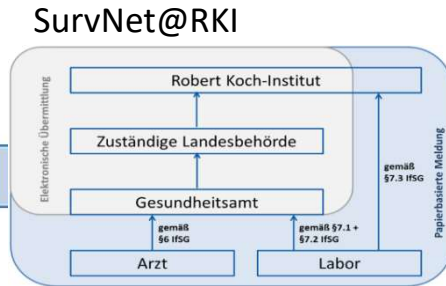
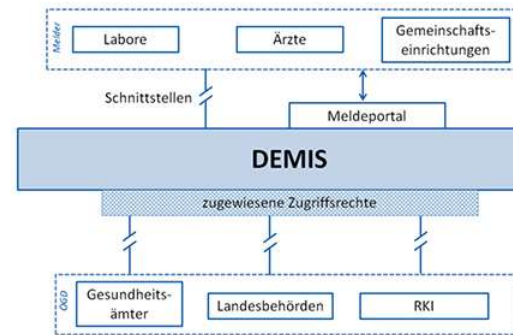


How can we use AI in Public Health ?

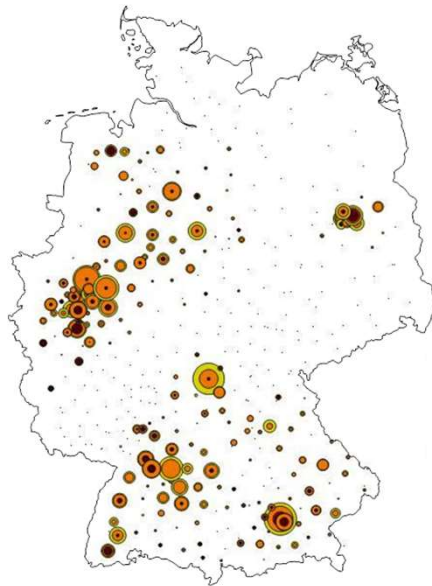
Health Surveillance at RKI



AI based on large established health data collections offers immense potential for future health surveillance



AI for Disease Outbreak Detection



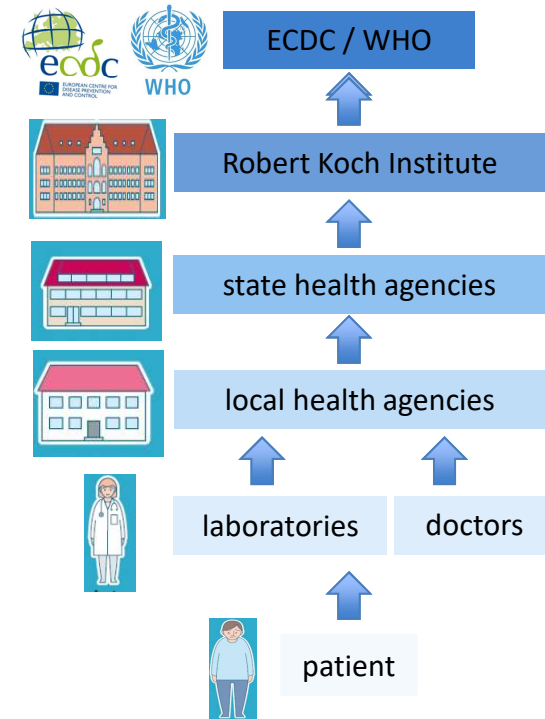
Notifiable pathogens (Infection Protection Act)

IfSG §7.1

Adenoviren	Ebolavirus	Lasavirus	Rickettsia prowazekii
Bacillus anthracis	EHEC	Legionella spp.	Rubellavirus
Bordetella pertussis	Francisella tularensis	Leptospira interrogans	Salmonella Paratyphi
Bordetella pertussis	FSME-Virus	Listeria monocytogenes	Salmonella Typhi
Borrelia recurrentis	Gelbfiebervirus	Marburgvirus	Salmonella, sonstige
Brucella sp.	Giardia lamblia	Masernvirus	Shigella sp.
Campylobacter sp.	Haemophilus influenzae	Mumpsvirus	Trichinella spiralis
Chlamydia pneumoniae	Hantaviren	Mycobacterium tuberculosis	Varizella-Zoster-Virus
Clostridium botulinum	Hepatitis-B-Virus	Mycobacterium tuberculosis O 1 und O 139	Vibrio cholerae
Corynebacterium diphtheriae	Hepatitis-C-Virus	Neisseria meningitidis	Yersinia enterocolitica
Coxsackievirus B1	Hepatitis-D-Virus	Norovirus, Stahl	Yersinia pestis
Cryptosporidium parvum	Hepatitis-E-Virus	Poliovirus	
E. coli	Influenzaviren	Rabiesvirus	

- Early outbreak detection for fast *intervention*
- Forecast of outbreak severity for *reaction*

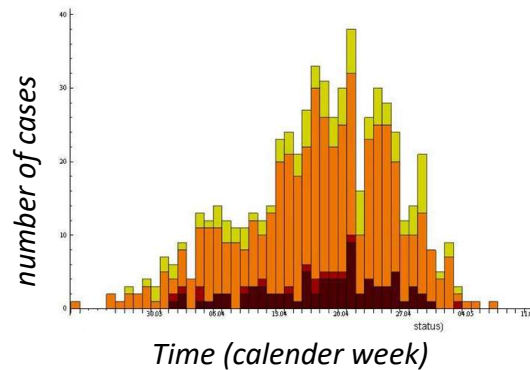
German Reporting System



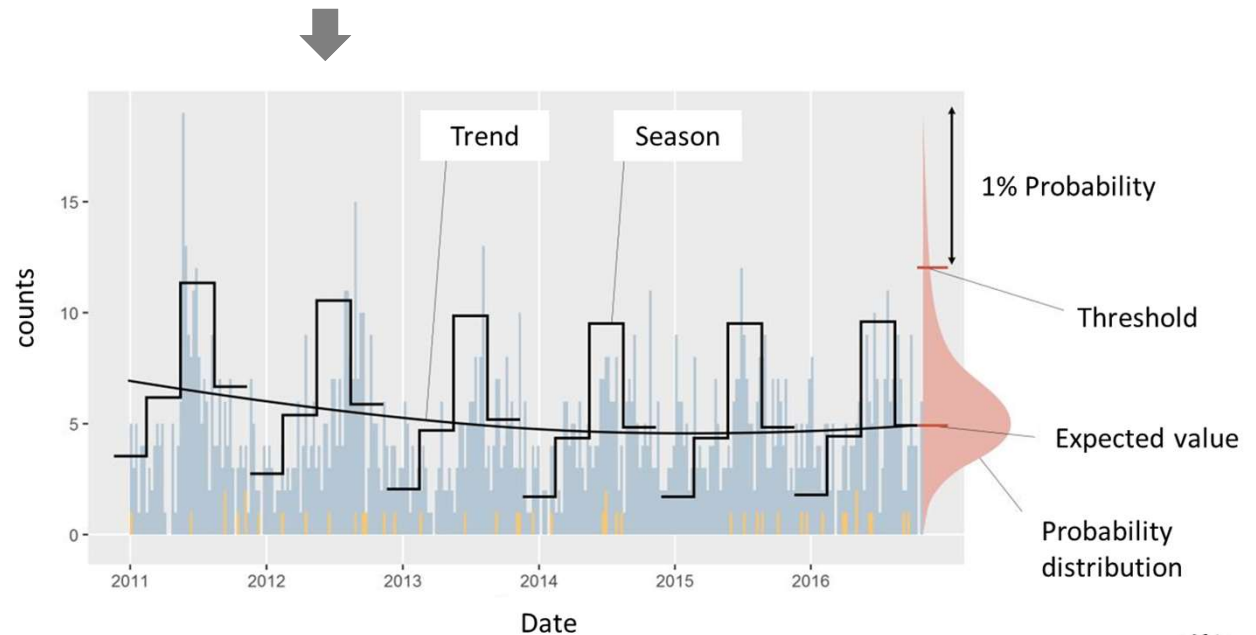
Surveillance of > 80 pathogens and > 400 counties recording ~ 500.000 cases/year detection ~ 20.000 outbreaks/year

Infectious Disease Outbreak Detection

- Aggregate case data by time into timeseries



- Outbreak detection model
 - Warning system of emerging diseases
 - Forecasting severity of seasonal diseases



Dashboard of Influenza Severity (Oct'17 - May'19)

indicator type
 Transmissibility

cumul from:
 CW40 epi1

display season
 2018/2019

number of seasons
 2

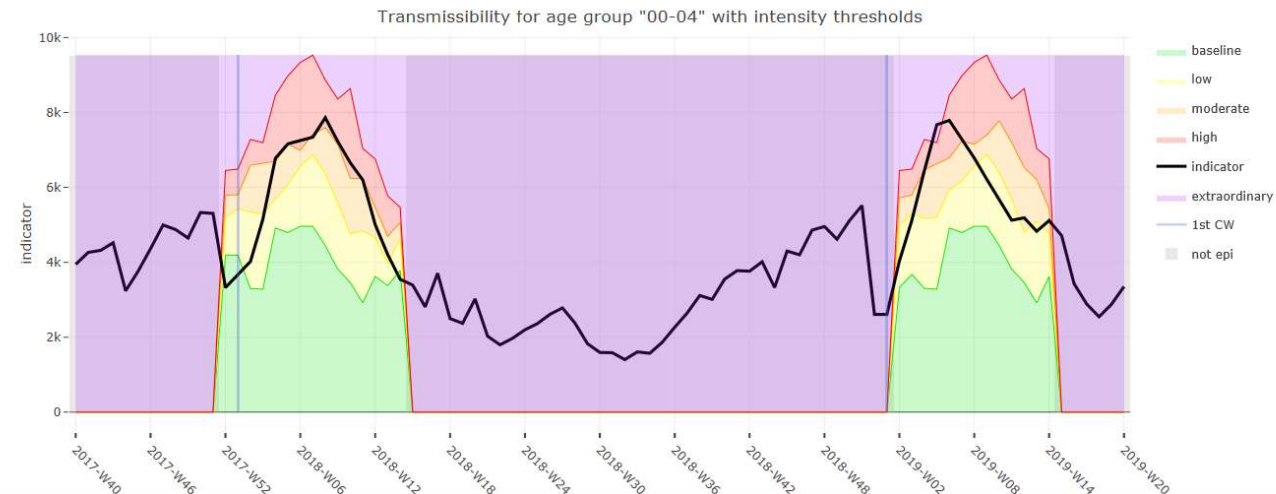
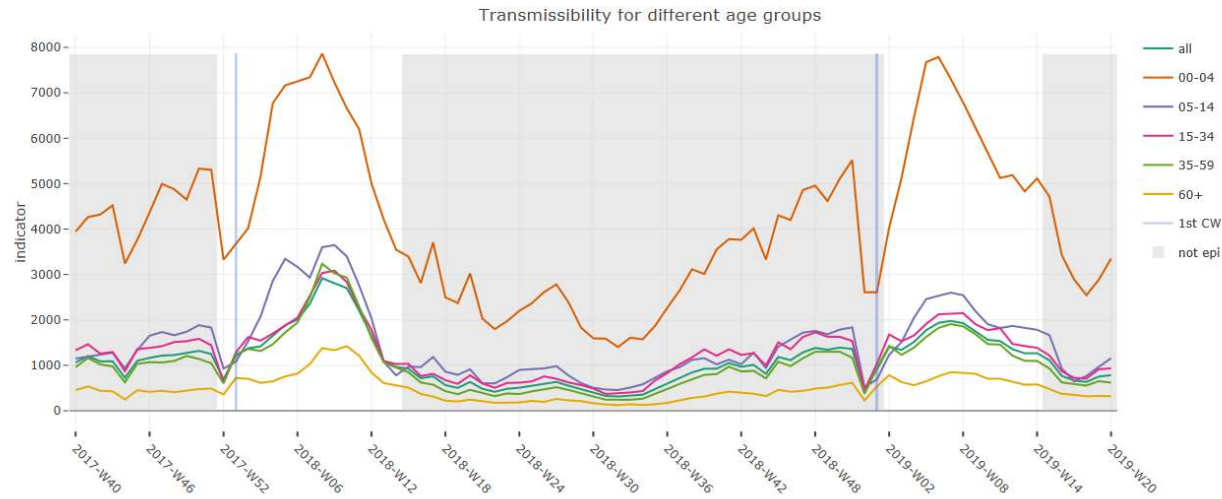
display date range
 2017-10-02 to 2019-09-29

display age group
 00-04

show only epi weeks

Epi options <

Intensity thresholds <

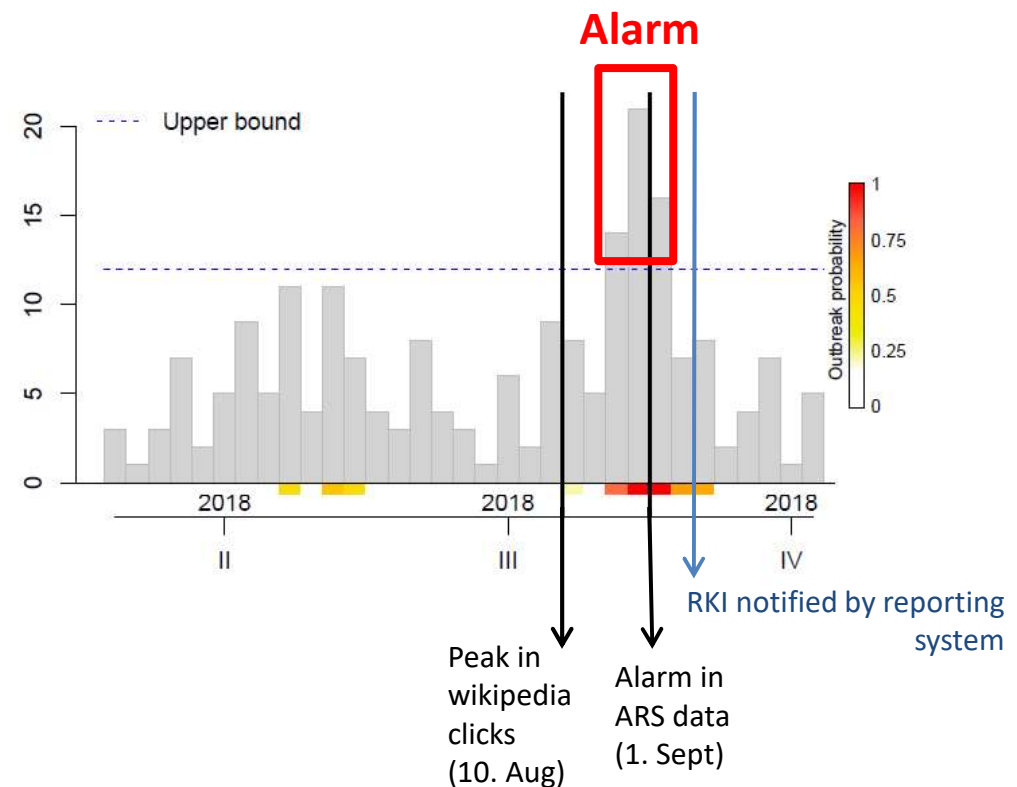


Integration of Real-time Data Sources using AI

- Antibiotic Resistance Surveillance (ARS)
- Near-real-time routine data from emergency departments and hospitals (ESEG)
- Online sources (google trends, wikipedia clicks)
- ADA-app (symptom checker)

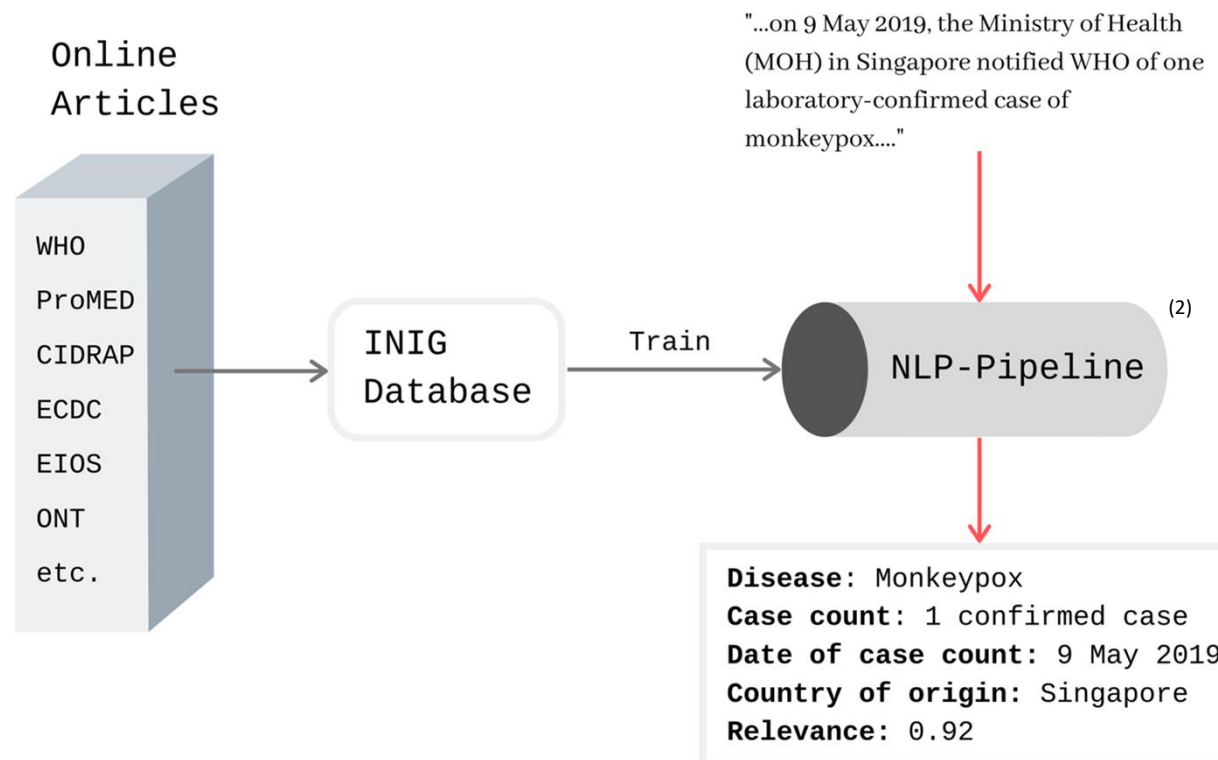
→ Improve early detection of emerging diseases

Outbreak case (2018): *Burkholderia cepacia*



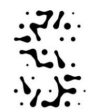
AI for International Health Reports

- “More than 60% of the initial outbreak reports come from unofficial informal sources[...].”¹



¹ <https://www.who.int/csr/alertresponse/epidemicintelligence/en/>

² Auss Abbood, Thesis "Automatic Information Extraction and Relevance Evaluation of Epidemiological Texts Using Natural Language Processing"





Enter an URL : SUMMARIZE

Get WHO DONs
Get Promed Articles
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CSV
Excel
PDF
Print

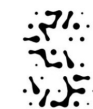
Search:

Disease	Country	Confirmed Cases	Date Of Case Count	Relevance	Input Date	Source
Ebola hemorrhagic fever	Democratic Republic of the Congo	312	05, March, 2019	0.44	2019-Mar-14	https://www.who.int/csr/don/7-march-2019-ebola-drc/en/
Lassa fever	Federal Republic of Nigeria	5	14, February, 2019	0.72	2019-Mar-7	https://www.who.int/csr/don/14-february-2019-lassa-fever-nigeria/en/
poliomyelitis	Independent State of Papua New Guinea	1369	01, January, 2005	0.9	2019-Mar-7	https://www.who.int/csr/don/27-february-2019-polio-indonesia/en/

Disease	Country	Confirmed Cases	Date Of Case Count	Relevance	Input Date	Source
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Showing 1 to 3 of 3 entries Previous 1 Next

Auss Abbood, Thesis "Automatic Information Extraction and Relevance Evaluation of Epidemiological Texts Using Natural Language Processing"



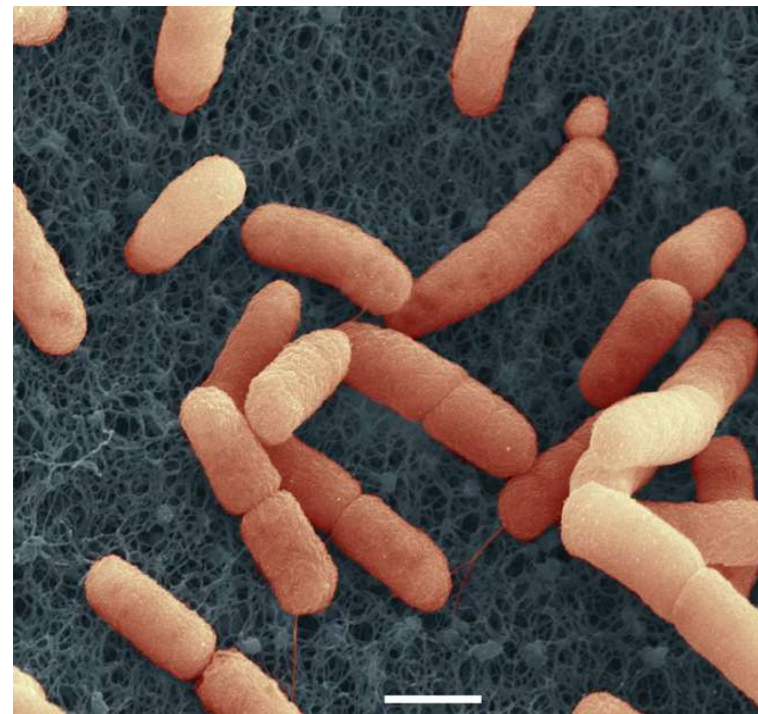
SIGNALE

AI for pathogenicity assessment

- Biosecurity threats
- **Natural or engineered**
- State-of-the-art in pathogen detection:
DNA sequencing

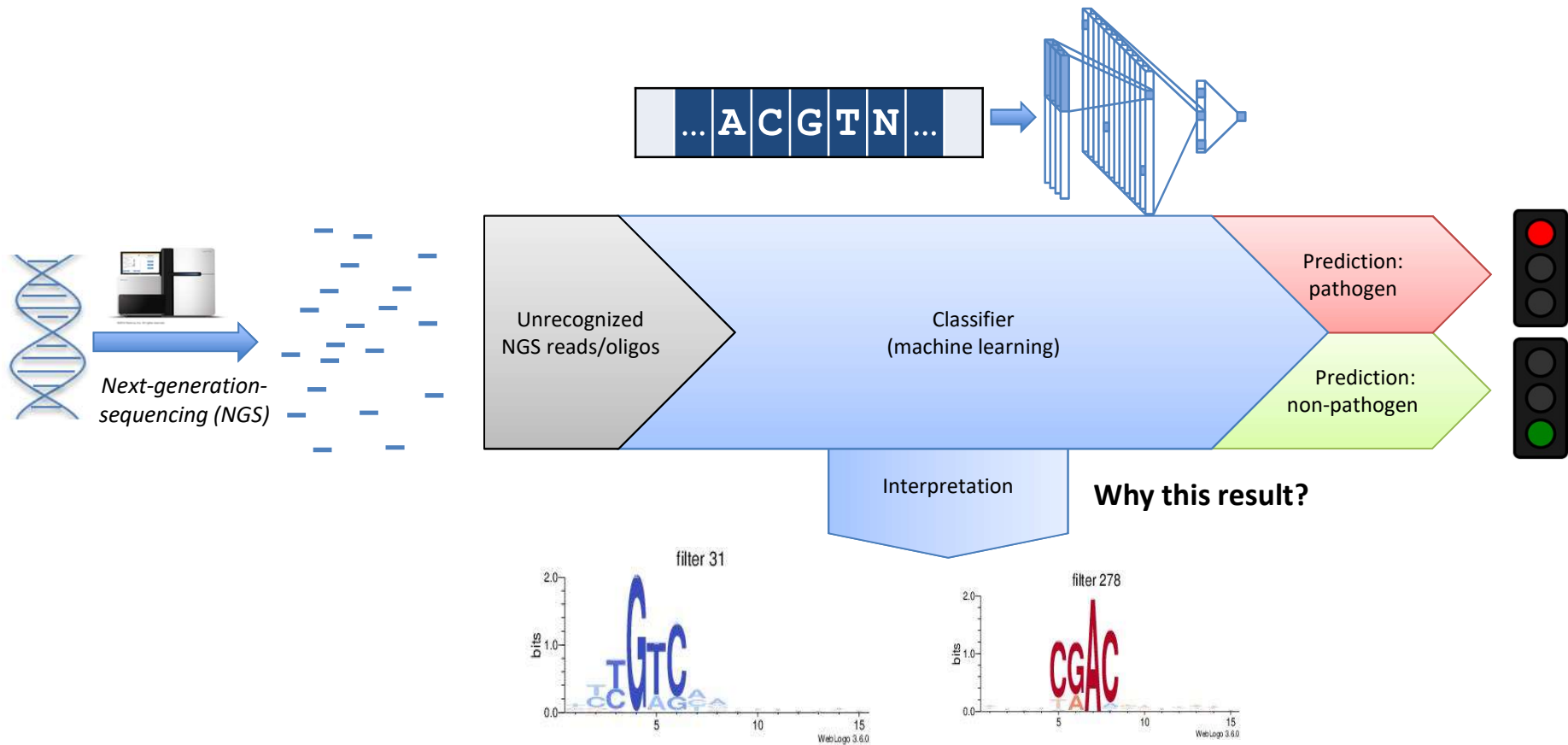


known threats



EHEC bacteria, O104:H4 outbreak strain. Scanning electron microscopy. Bar: 1 μm . Source: Gudrun Holland, Michael Laue/RKI

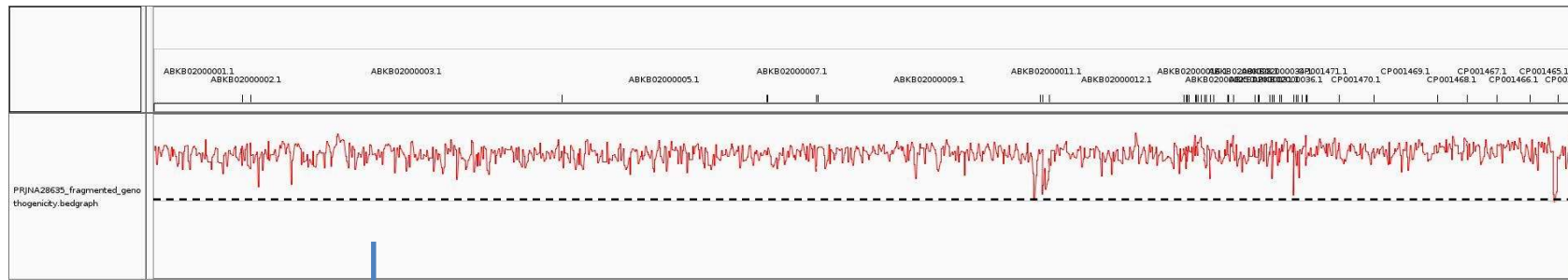
Deep learning for pathogen potential prediction



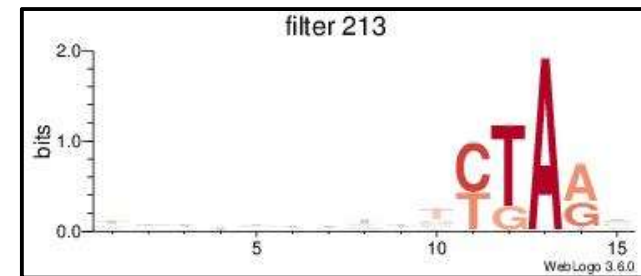
Bartoszewicz *et al.*, 2019, <http://dx.doi.org/10.1101/535286>

Interpretable pathogenicity analysis

Borrelia spielmanii A14S (Lyme disease) genome



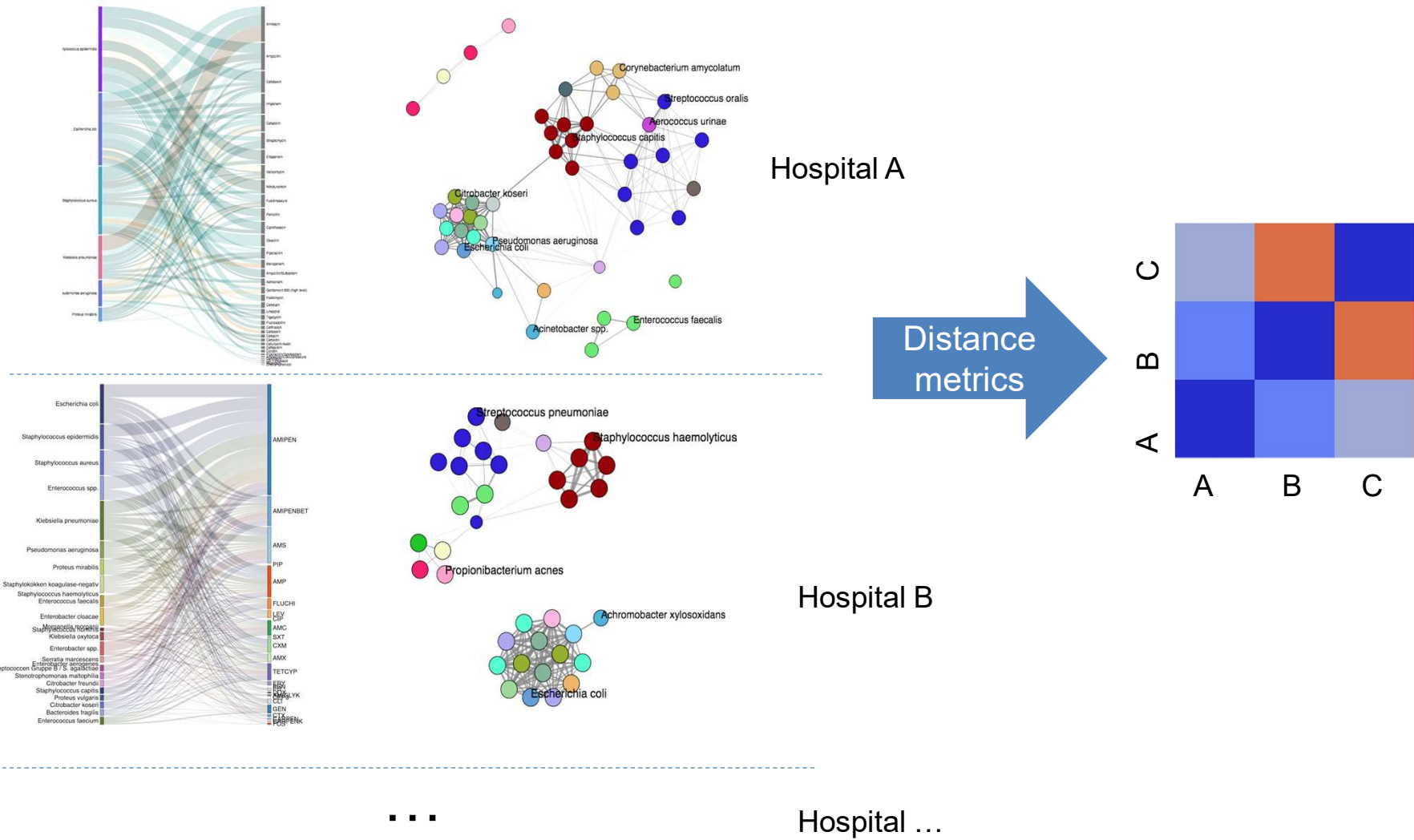
Rank	Gene	Mean score	Mean score outside
1	rpsQ	0.913	0.797
13	recD	0.873	0.796
68	recB	0.822	0.797
69	mfd	0.822	0.797
290	tRNA-Cys	0.552	0.797



- Biological process**
- cellular response to DNA damage stimulus
- DNA repair

Bartoszewicz *et al.*, 2019, <http://dx.doi.org/10.1101/535286>

Structural Differences in Hospital-Specific Networks



AI for non-communicable disease surveillance: comparing clusters

1. Fast food/convenience foods

Breaded fish
Soft drinks
Coffee Sports/energy drinks
Breaded poultry
Fast food Fried potatoes
Breaded meat
Black/green tea Frozen meals

3. Healthy foods

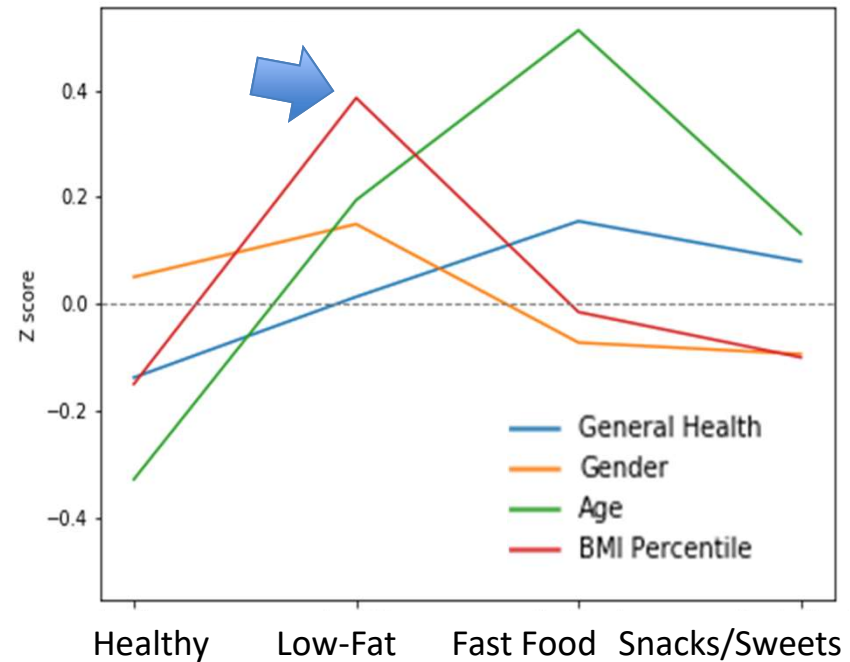
Quark/yogurt Fruit juice
Wholegrain bread Tap water
Cooked potatoes Butter
Honey/jam Fruit/herbal tea
Cooked vegetables
Fish Salad/raw vegetables
Milk Fresh fruit
Frozen vegetables Pasta/rice

2. Low-fat/diet foods

Cooked vegetables Salad/raw vegetables
Diet drinks Fish Fresh fruit
Diet products Cooked potatoes
Margarine Cream cheese Mineral water
Low-fat cream cheese
Cooked fruit Wholegrain bread Poultry
Low-fat quark/yogurt
Quark/yogurt Frozen vegetables
Cheese Low-fat cheese

4. Sweets/fatty foods

Meat Cakes Soft drinks
Breaded meat
Pudding Fast food
Cookies Canned vegetables
Eggs Snack foods
Fried potatoes
Breaded poultry Nut-nougat cream Pancakes
Chocolate Nuts Sweets
Ice cream White bread



Demographics

General Health Index

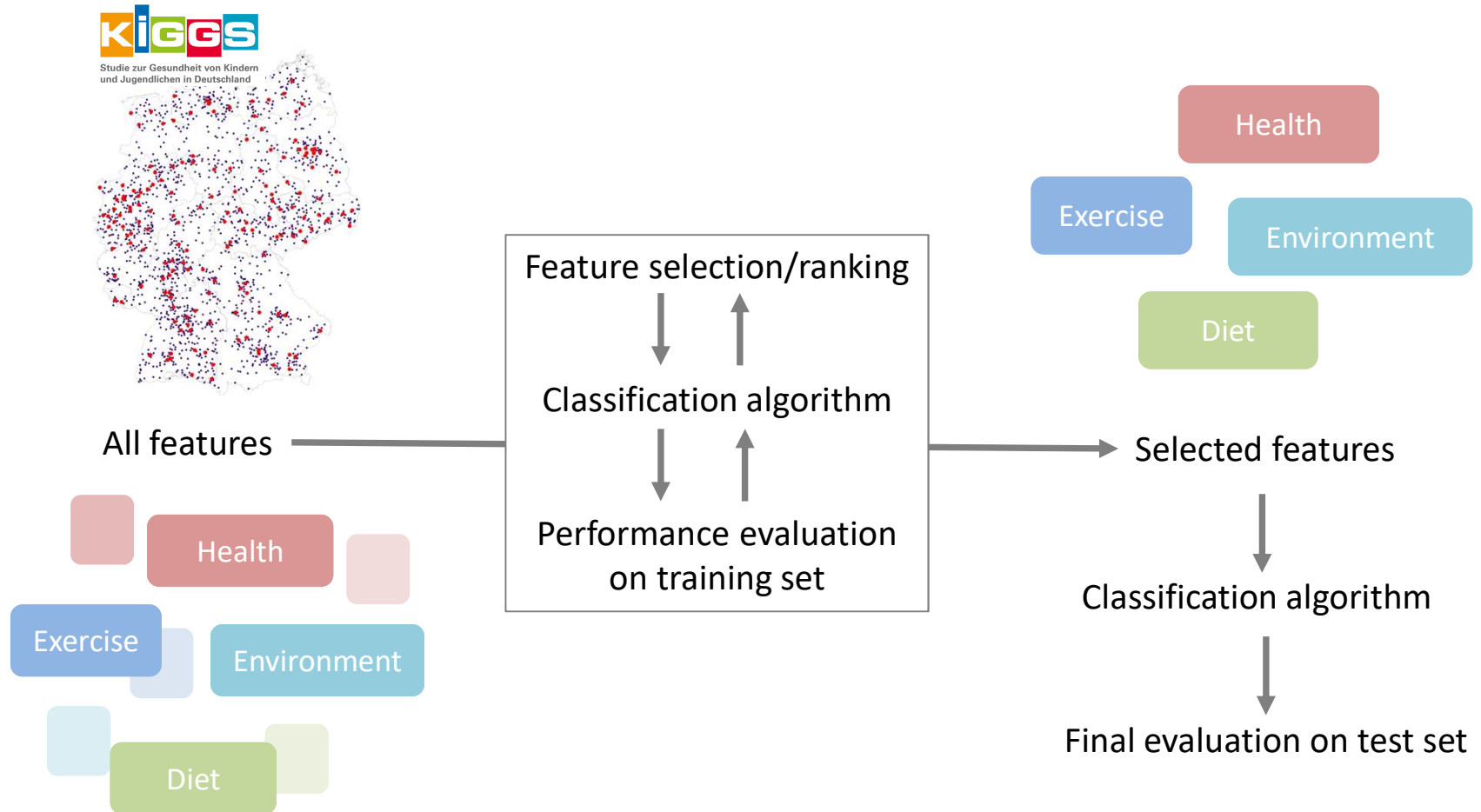
- low = good
- high = bad

Gender

- low = boys
- high = girls

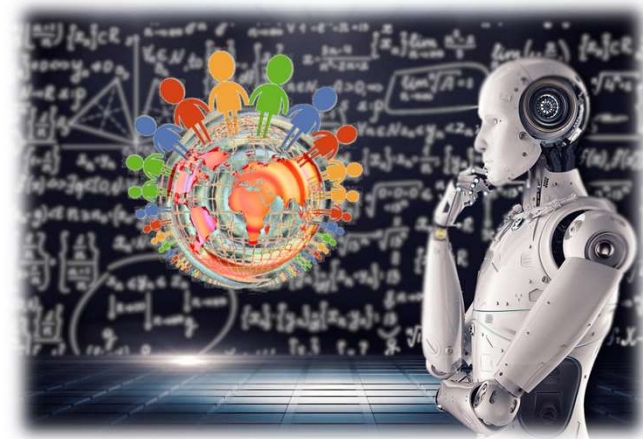
Work by A. Rose *et al.*

AI for non-communicable disease surveillance: feature selection



Quality Requirements

- Robustness and manipulation safety for AI-based Public Health applications
- Explainable AI
 - For deep insights on influential factors
 - Acceptance of Public Health decision making
- Generalization



Source (Modified): www.vpnsrus.com; Pixabay.com, district round arched

Die Entwicklung des Robert Koch-Instituts
The Development of the Robert Koch Institute

Thank you very much for your kind attention!



1891	1900	1912	1942	1945	1952	1978	1991	1994	2010	2015
<p>1891</p> <p>Gründung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>1900</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>1912</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>1942</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>1945</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>1952</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>1978</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>1991</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>1994</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>2010</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>	<p>2015</p> <p>Eröffnung des Kaiserlichen Gesundheitsamtes in Berlin</p>

RKI-Archive

