

Digital veterinary epidemiology: mathematical modelling of disease spread, infodemiology and infoveillance, telemedical clinical trials with sensors

Andrzej Jarynowski

A. Jarynowski^{1,2} V. Belik²

¹Interdisciplinary Research Institute, Wroclaw/ Aidmed, Gdańsk (Poland)

²System Modeling Group, Institute for Veterinary Epidemiology and Biostatistics, Freie Universität Berlin (Germany)

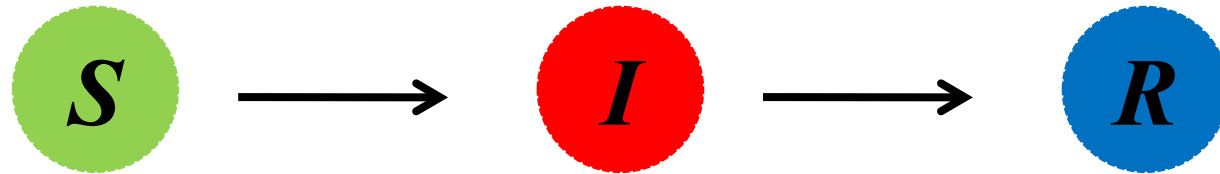


Advances in computing power, together with the amount of data obtained from disease surveillance, registries, sensors or digital traces enable machine learning, complex system analytics and standard statistical tools as well as computer simulation to be applied to the field of Veterinary Epidemiology. I will show 3 case studies:

- 1) modelling,**
- 2) infodemiology,**
- 3) sensors**

1) Analysing and modelling infectious diseases notification events via spatio-temporal epidemiology in the context of human behaviour and mobility is crucial for understanding i.e. ASF (African swine fever) spread. We have compared statistical regression (GLM) and Machine Learning (XBoost) against a heuristic approach (quasi-gravity epidemiological SIR model solved with computer simulations) in forecasting ASF propagation in Poland.

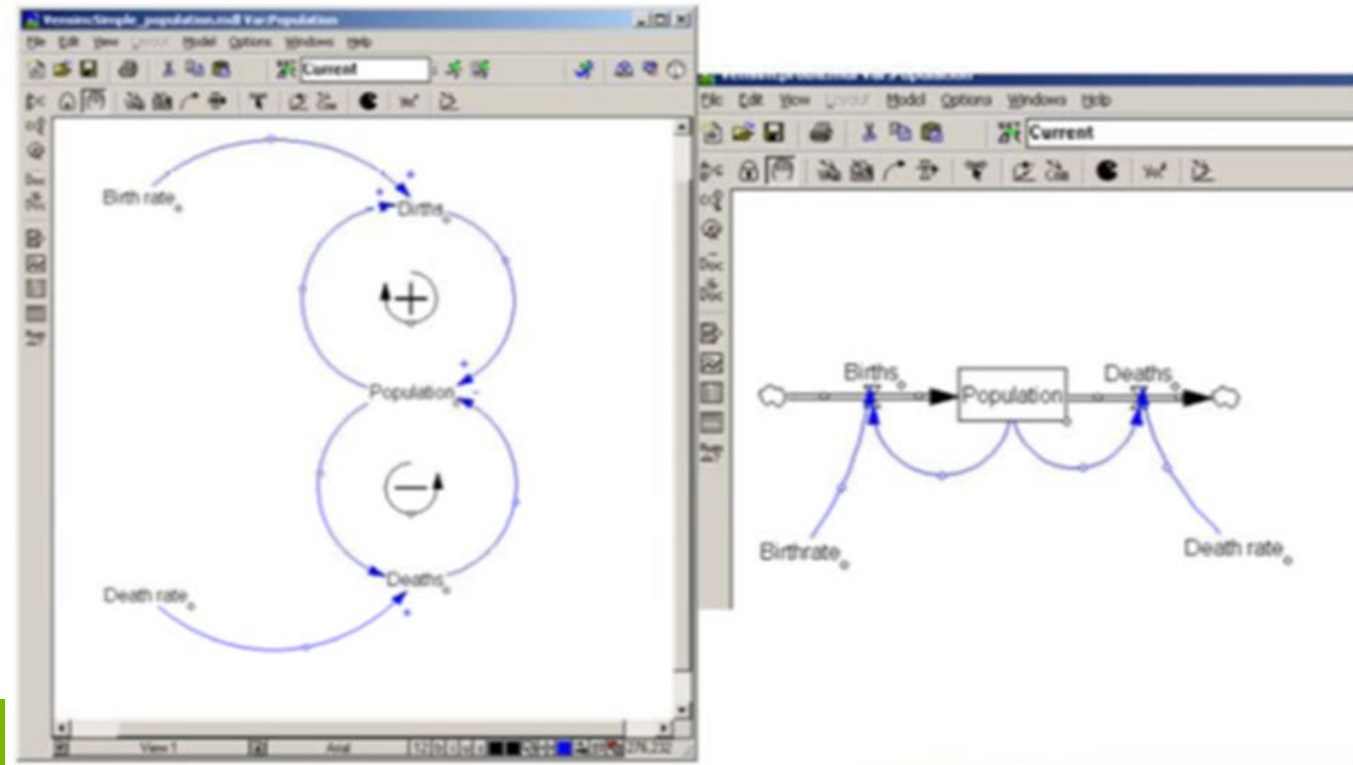
Differential equations (system dynamics) were the first to be applied to describe and predict phenomena, but recently even more frequent have been **agent-based models** and **machine learning** approaches.



Susceptible (S), Infectious (I), Removed (R)

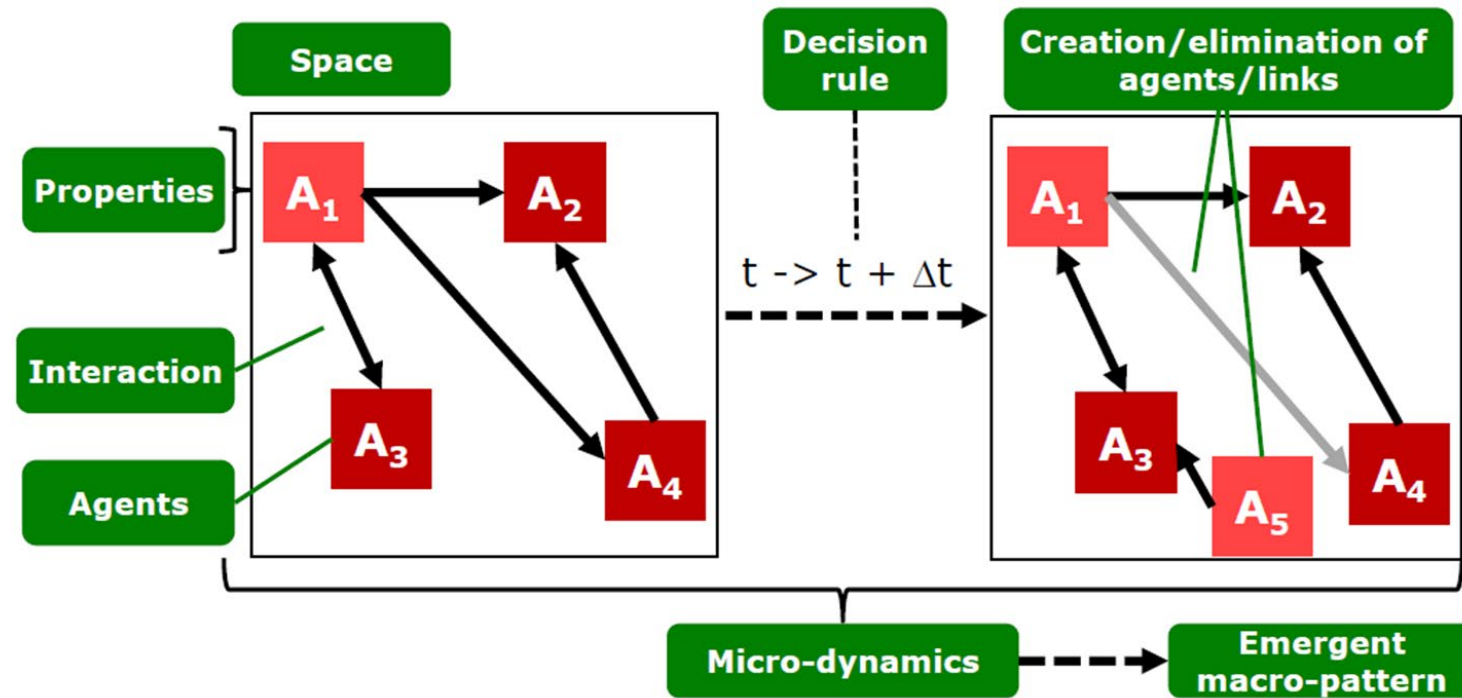
System Dynamics (SD)

The main idea in SD is to draw up a set of differential equations representing social phenomena. The model (equations or diagrams) can be solved by numerical or approximative procedures, easily available with several types of computer software used for SD, such as Vensim, Dynamo, iThink or Stella. Their graphical notation allows non-mathematicians such as sociologists to build and solve sets of differential equations. The dynamical variables are represented as stocks and rates of change as flows.



Agent-based models (ABM)

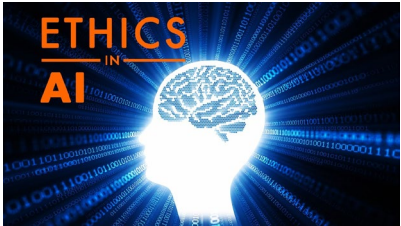
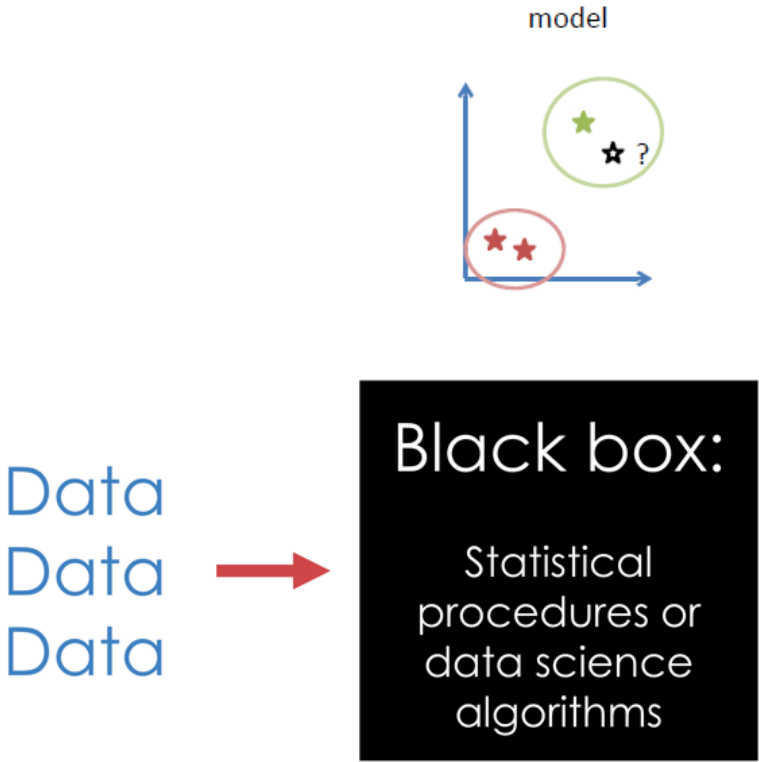
ABM is a computational technique used for experiments with artificial systems populated by agents which interact in non-trivial ways. This is probably the most common approach to modelling by sociologists. Available toolkits include Netlogo, Swarm, RePast or MASON. In NetLogo, the turtle is a representation of an agent (an autonomous, interacting entity), while a patch is the elementary spatial unit in the grid. The goal is to imitate real patterns by running (often computerised) ABM under different treatments and conditions



Machine Learning and Artificial Intelligence

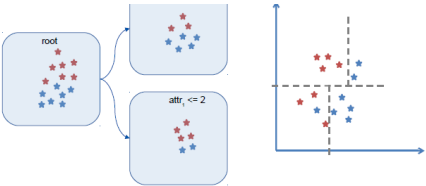
One can analyse the data sets (survey, register-based, time series, spatial, panel, longitudinal data, etc.) and (re)construct (simulate processes) with similar characteristics (e.g. distributions), to predict future states.

A different modelling approach is data exploration, where prior knowledge about interaction is unnecessary.



Results

	Machine Learning	Phenomenological
Model	Blackbox, nonparametric, easy to add new attributes with complicated interactions.	Fixed parametric equation inspired by „mechanics“ of the process.
Goal	Provide accurate predictions	Understanding „mechanics“, select from competitive models
Quality	Validation	AIC, BIC, DIC, Bayes Factor



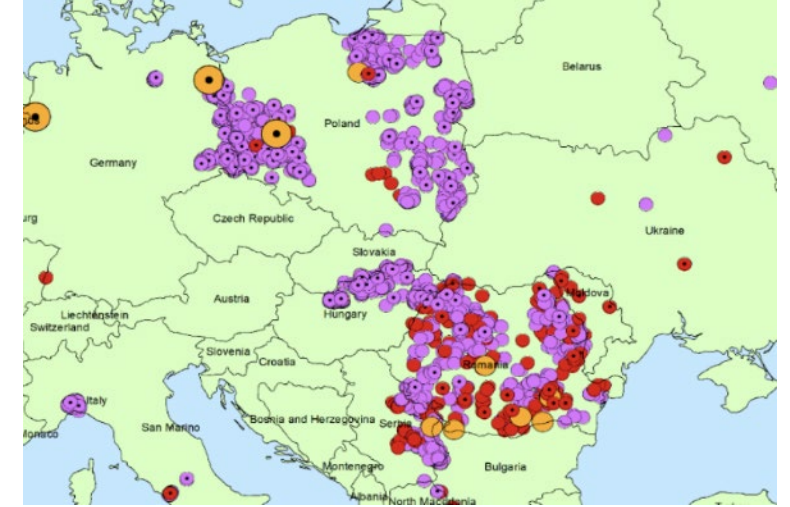
DYNAMIC CAUSAL MODELLING OF COVID-19

<https://covid19forecasthub.eu/visualisation.html>



Differential equations (system dynamics) were the first to be applied to describe and predict phenomena, but recently even more frequent have been **agent-based models** and **machine learning** approaches.

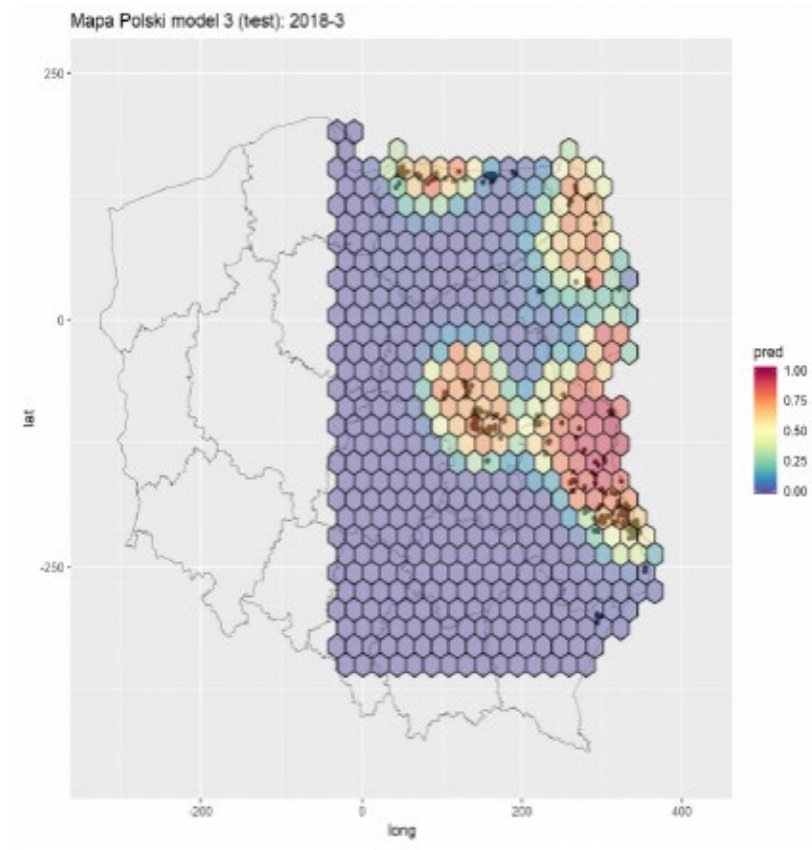
“For the first time in history, global consumption of poultry meat has exceeded the pork (. . .) the main influence of this change in consumption is the crisis caused by the African Swine Fever” 2019
FAO



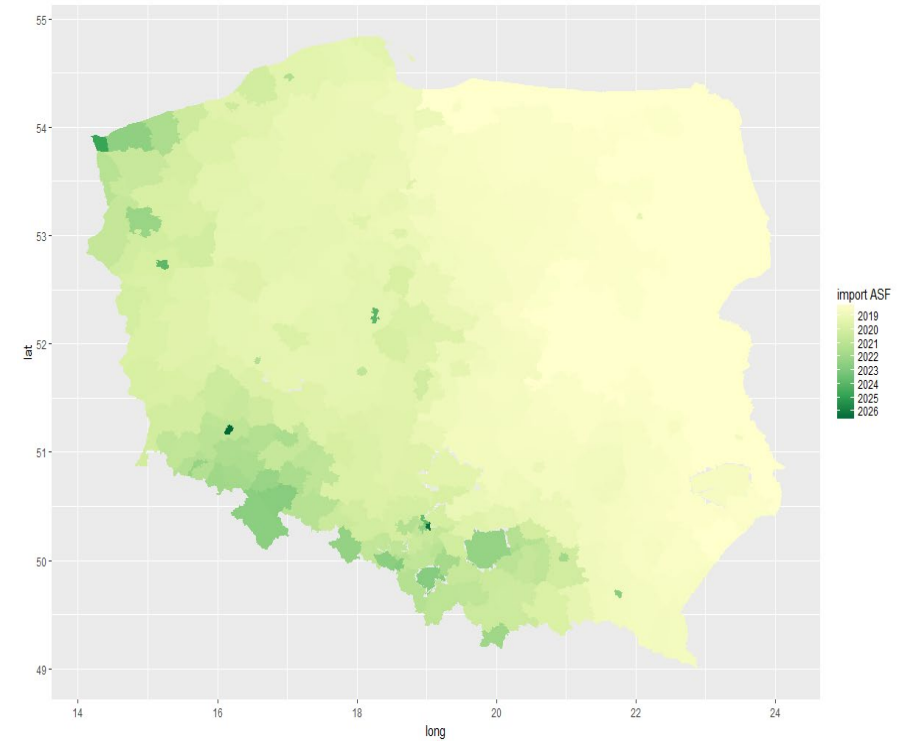
ASF “is probably the most serious animal disease the world has had for a long time, if not ever” 2018
Dirk Pfeifer, world class veterinary epidemiologist

The pork shortage in China caused by African swine fever could contributed to the spillover of SARS-CoV-2 from animals to human

ML

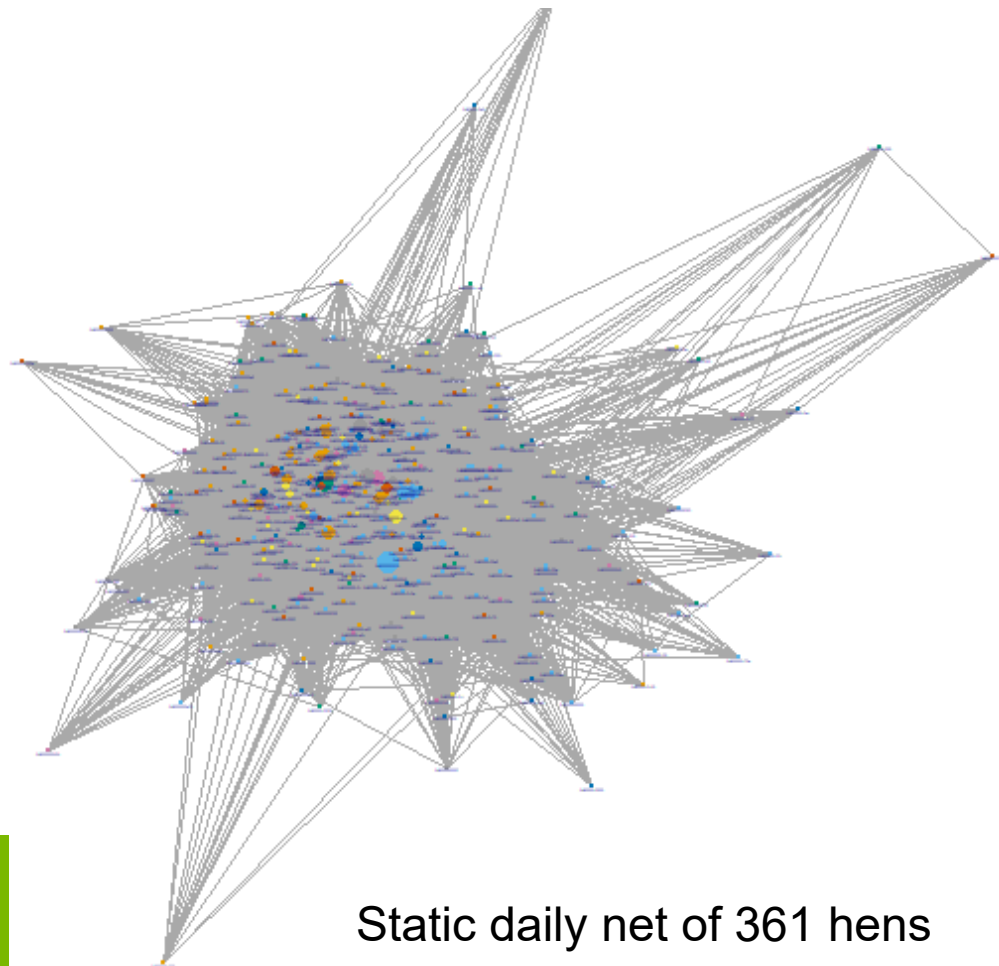
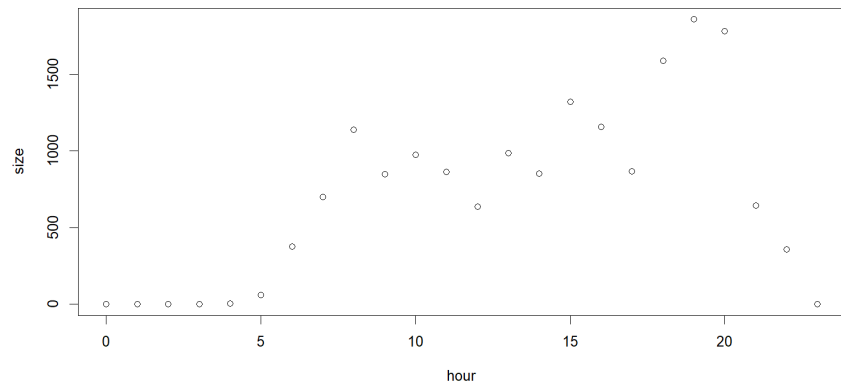


Agent based Model



We confirmed that ML is powerful in predicting short-term local transmission of ASF knowing simple proxies of pig farming structure, WB habitat and density of human population. Long distance jumps have been much more difficult to predict however, Agent based model seems to give a good qualitative picture of the long and medium term most paths of propagation.

Size of net (No. edges) for each hour



Static daily net of 361 hens

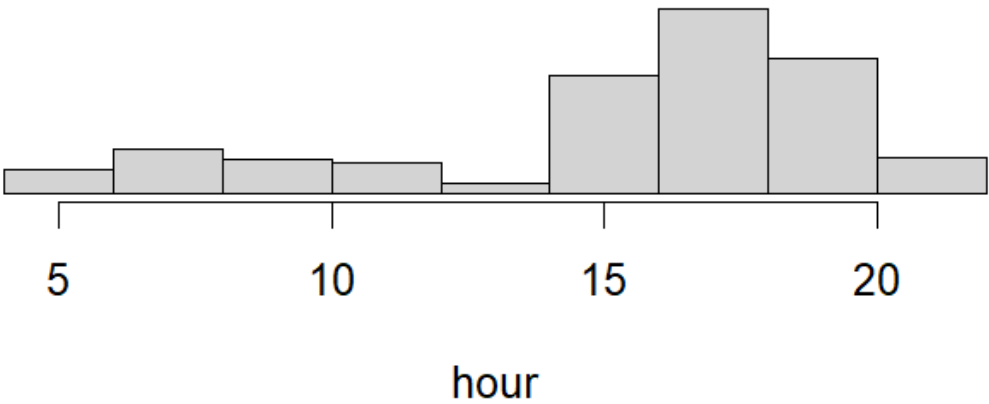
2 antennas, 1 day, connection if in the same RFID Antenna range, duration in sec, time of contact in hourly interval

RFID Antenna

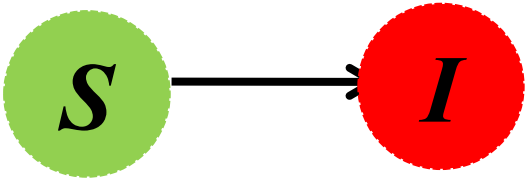
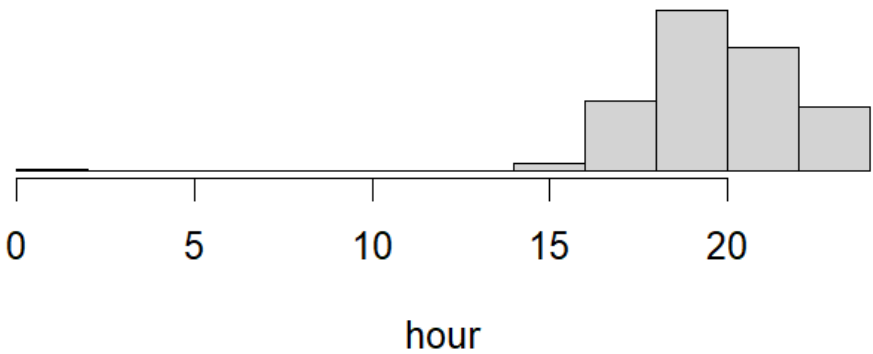


RFID tag

Hourly incidences seed as central node



Hourly incidences seed as periferal node



beta = 0.25/h



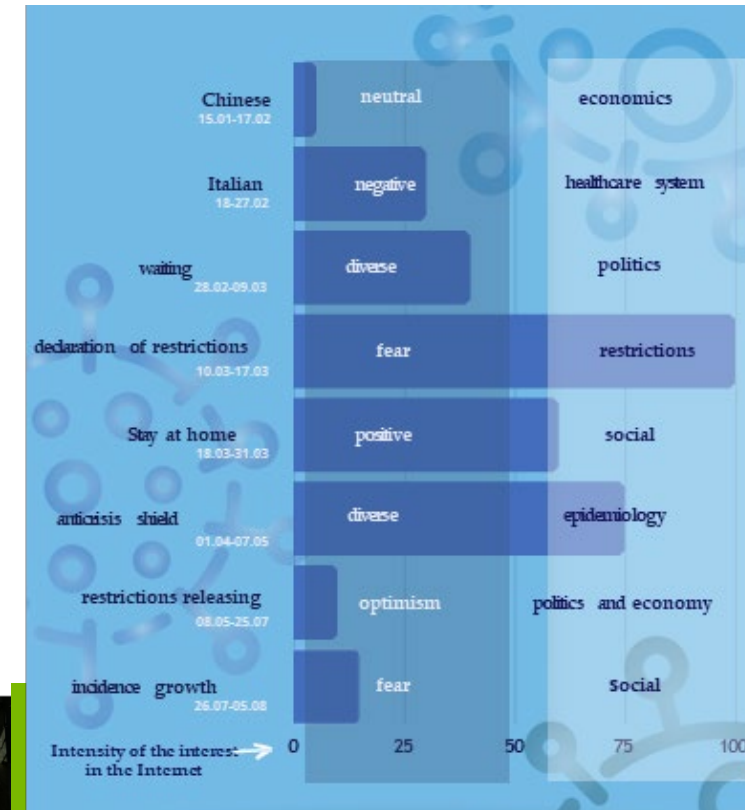
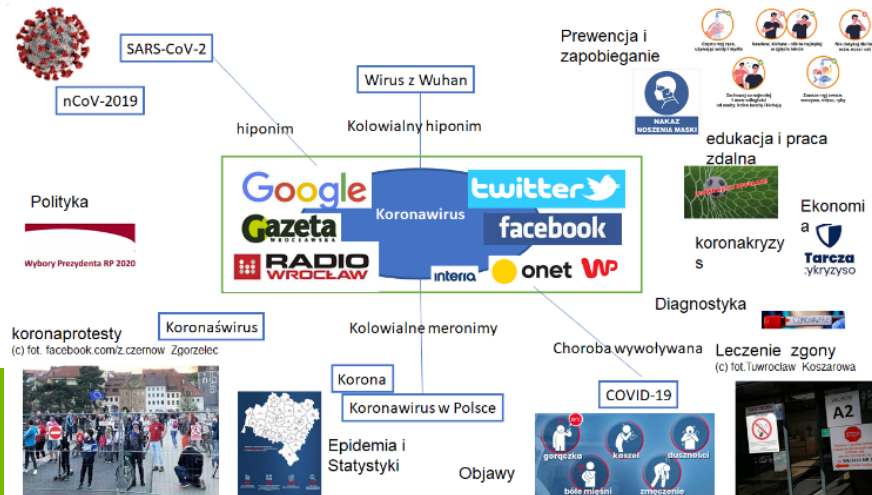
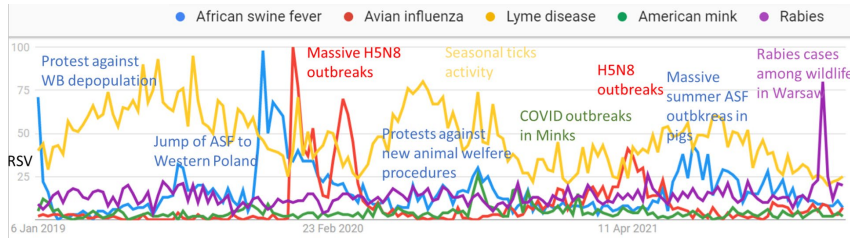
Infections paths

2) Social (new) and traditional media listening is a known tool and has already been adopted by FAO and WOAHA (OIE) in addressing veterinary public health issues. There is almost 100-1000-fold higher interest (i.e. No. articles/No. search daily/ No. tweets) in humans rather than animal diseases. I will also present how real time listening to social media helped in crisis management and supported the hypothesis on the biological cause of the massive fish kills during the Oder river disaster in August 2022.

Infodemiology

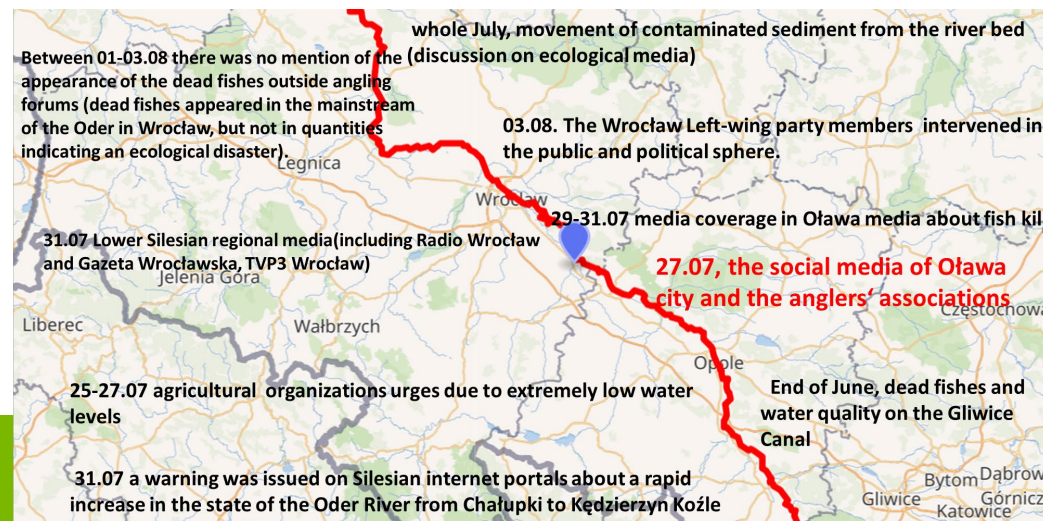
Infodemiology is concerned with the study of the demand (e.g. search engine queries) and supply (social media content creation or commenting) trajectory of information, which was strongly articulated during the COVID-19 pandemic.

Monitoring actual (real-time) and declarative attitudes should, in the WHO's view, be a priority for local decision-makers.



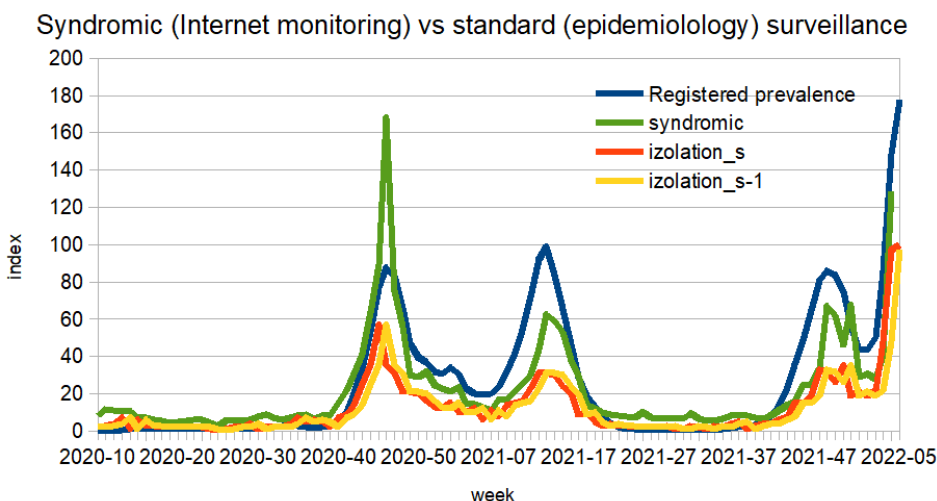
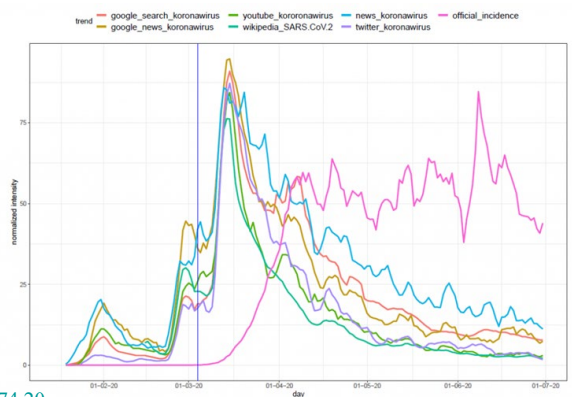
Infoveillance

Epidemiological surveillance deals with the analysis of web content to predict medical phenomena. Its most important advantage is the possibility of early warning (e.g. participatory reporting), or forecasting or improving estimators of incidence, prevalence or complications. Moving syndromic surveillance to the internet has great relevance (estimating the scale of health problems, early warning of events).

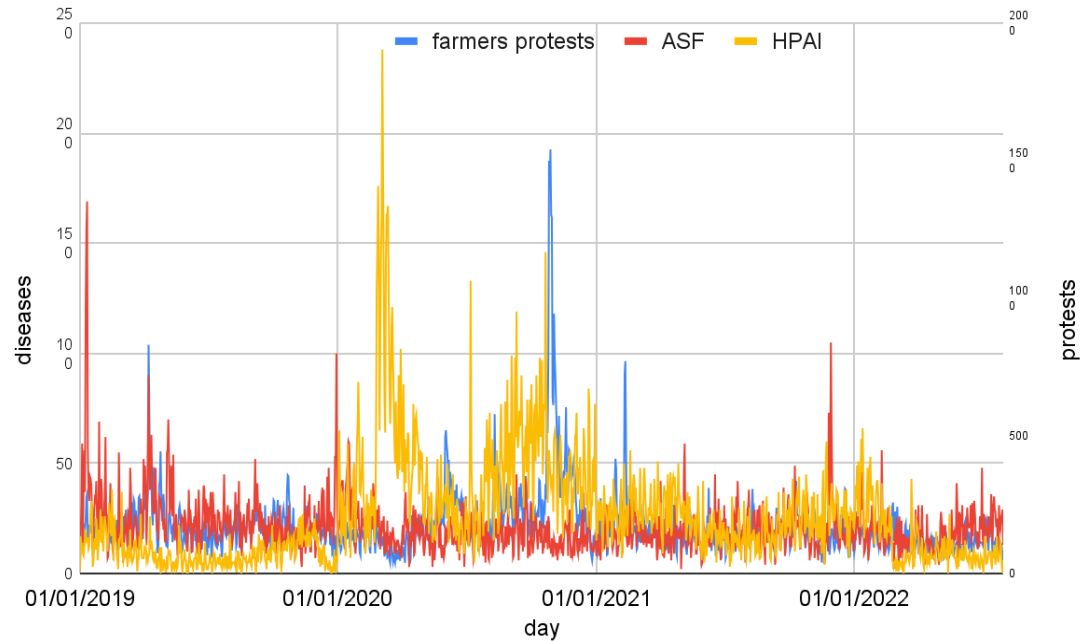


History of Infodemiology and infosurveillance

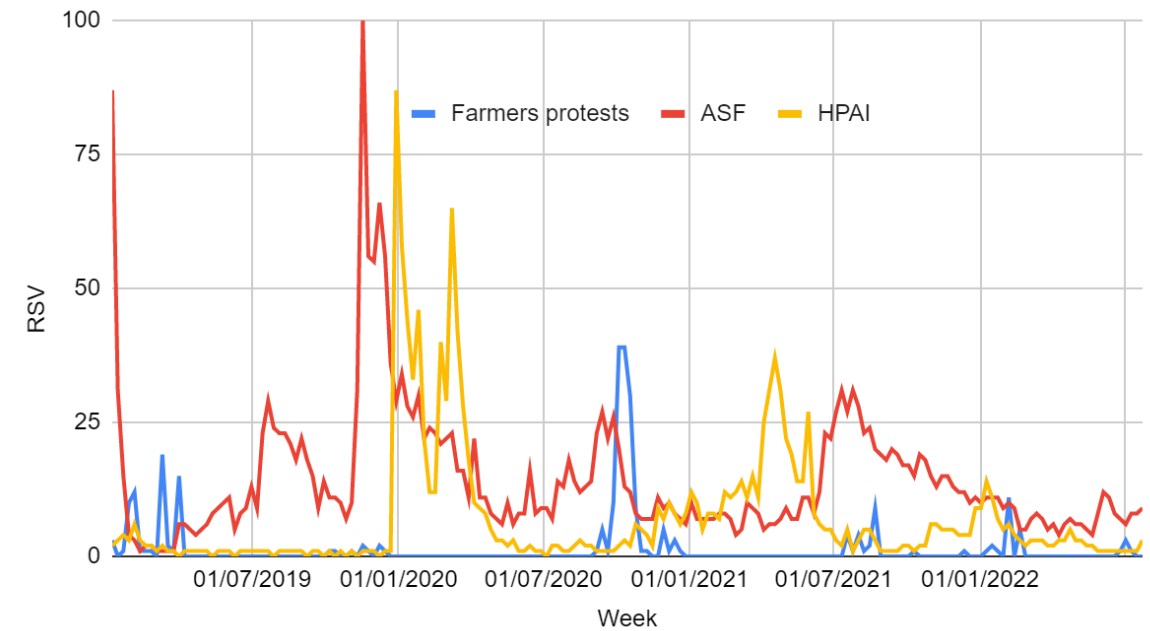
- ▶ Google Flu Trends (2010) - syndromic infosurveillance using ILI keywords.
- ▶ Infosurveillance in prediction/forecasting COVID-19 infection dynamics worked far below expectation in Europe for publicly available dataset (i.e. Lamos, Vasileios, et al. "Tracking COVID-19 using online search." NPJ digital medicine 4.1 (2021): 1-11.), but seems to work with much more precise dataset in China (i.e. Guo, Shuhui, et al. "Improving Google flu trends for COVID-19 estimates using Weibo posts." Data Science and Management 3 (2021): 13-21.)
- ▶ High expectation, little predictive power (low digitalization rates and lack of availability of individual records in Western societies?)



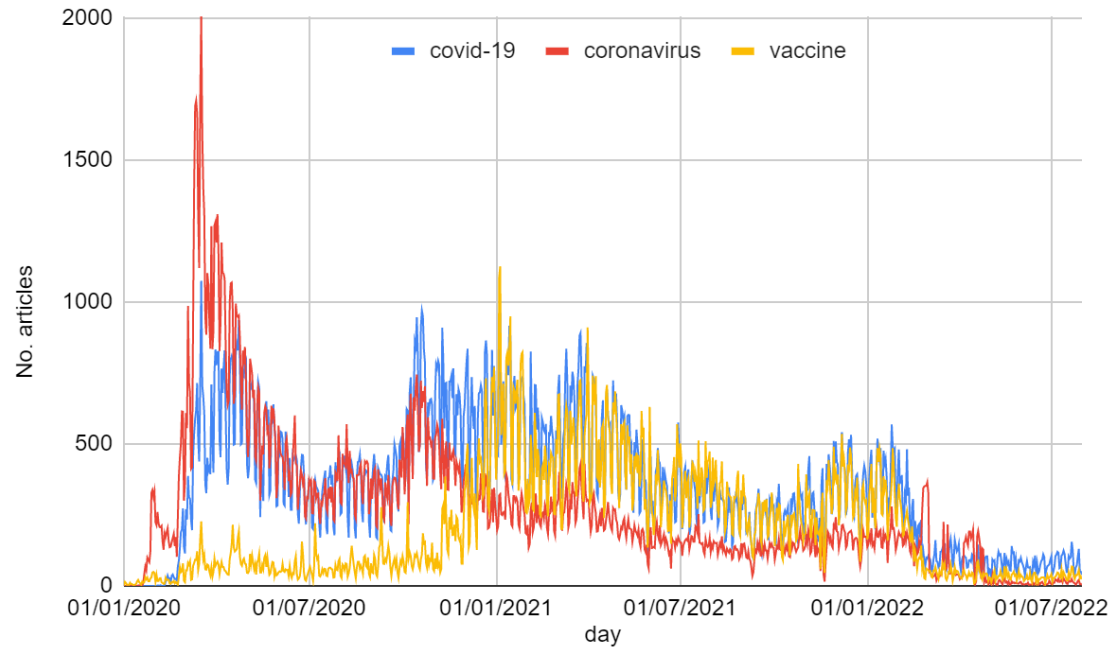
Digital traditional media: farmers protests, ASF and HPAI daily topics occurrence



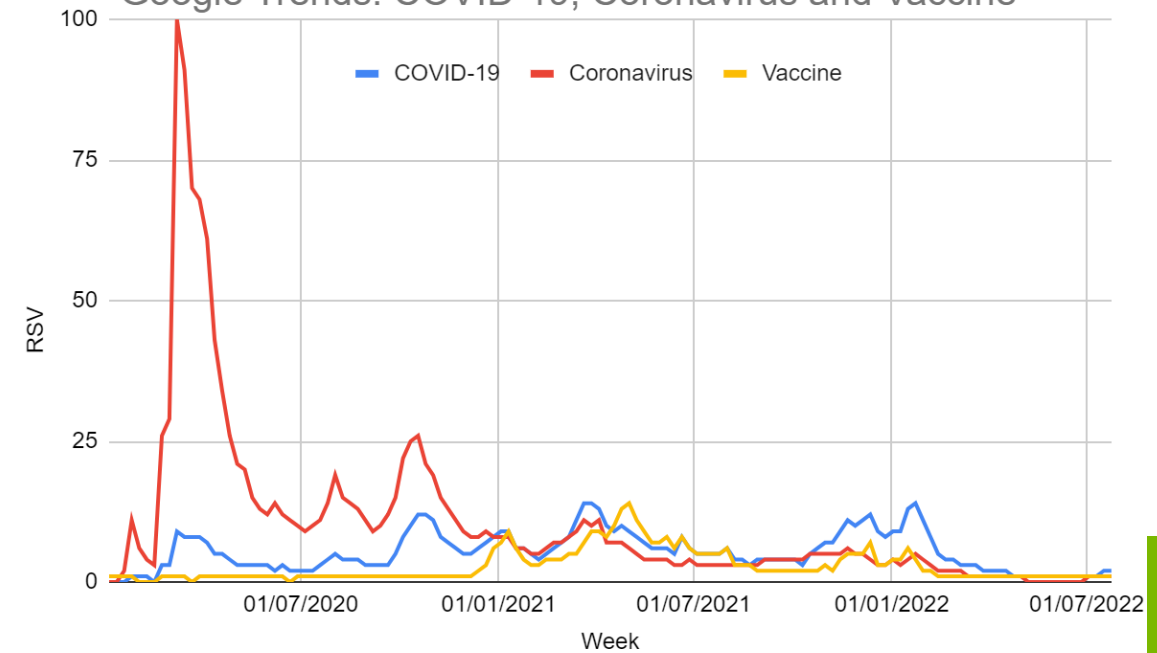
Google Trends: ASF, HPAI and Farmers protests



Digital traditional media: vaccine, coronavirus and covid-19 daily topics occurrence



Google Trends: COVID-19, Coronavirus and Vaccine

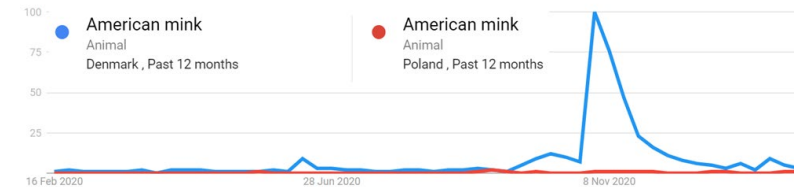


Summary interest across selected terms (disease) and medium

term(topic)/summary interest	weekly RSV Google Search (01.2020-07.2022)	daily No. article (01.2020-07.2022)
COVID-19	713	330390
Coronavirus	1368	255620
HPAI	2.2	29857
ASF	3.3	17893

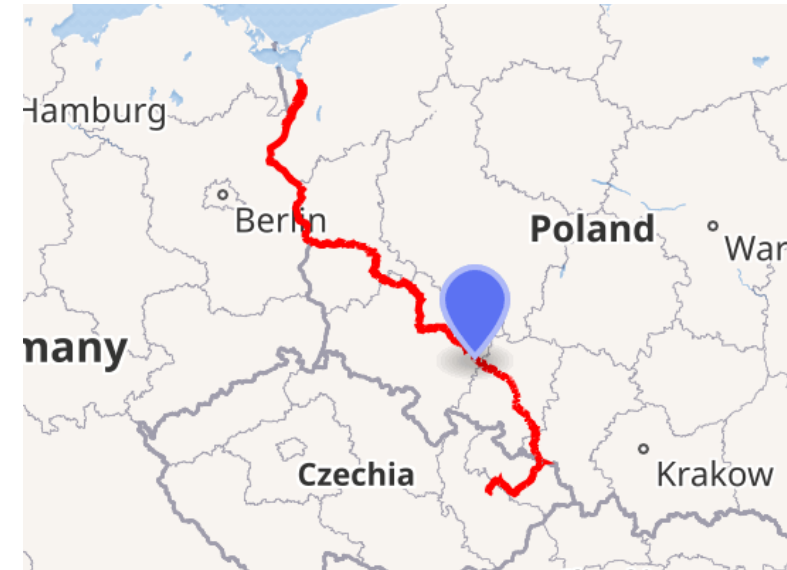
Totally different **perception: almost 1000 fold higher interest in human than animal diseases** (No. search weekly)

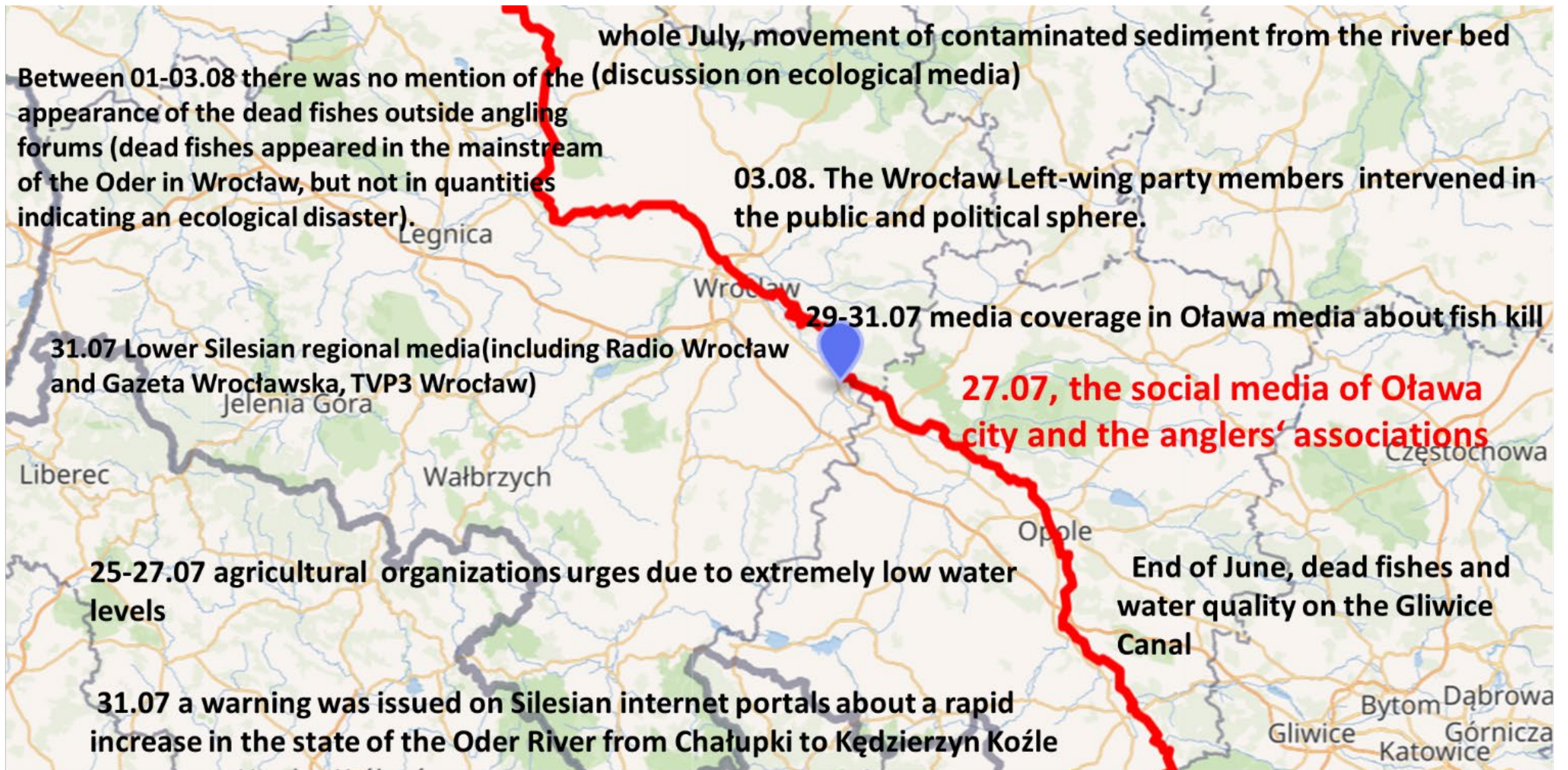
Slightly different **perception almost few/dozens fold higher interest in human than animal diseases** (No. articles daily)



Oder river disaster

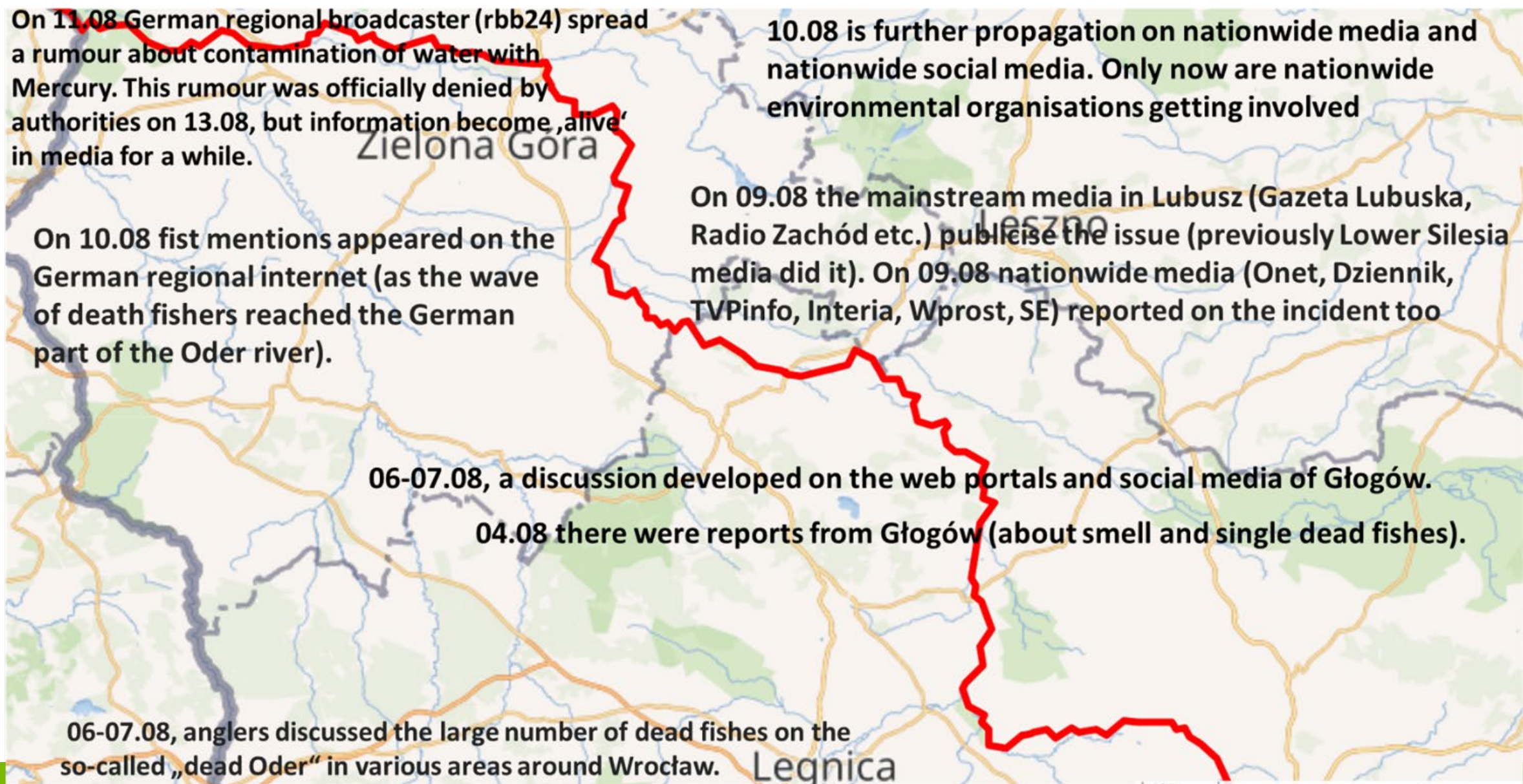
Situation at Odra/Oder was caused by multiple factors, but primary reason of fish kills were toxins produced by Golden Algae. Crisis management requires international cooperation in this case. The problem appear between Opole Region Lower Silesia, then river passes large city of Wrocław, then move through Lubusz region it reaches the German (Brandenburg)–Polish border, and then drains along the border through Western Pomerania Province into Szczecin Lagoon shared between Poland and Germany (Mecklenburg-Vorpommern) which is linked with the Baltic Sea.





http://interdisciplinary-research.eu/wp-content/uploads/2022/08/odra_wroclaw.pdf

<https://blogs.fu-berlin.de/infodemic-corona/2022/08/19/oder-river-disaster-in-media/>



On 11.08 German regional broadcaster (rbb24) spread a rumour about contamination of water with Mercury. This rumour was officially denied by authorities on 13.08, but information become 'alive' in media for a while.

Zielona Góra

10.08 is further propagation on nationwide media and nationwide social media. Only now are nationwide environmental organisations getting involved

On 10.08 fist mentions appeared on the German regional internet (as the wave of death fishers reached the German part of the Oder river).

On 09.08 the mainstream media in Lubusz (Gazeta Lubuska, Radio Zachód etc.) publicise the issue (previously Lower Silesia media did it). On 09.08 nationwide media (Onet, Dziennik, TVPinfo, Interia, Wprost, SE) reported on the incident too

Leszno

06-07.08, a discussion developed on the web portals and social media of Głogów.

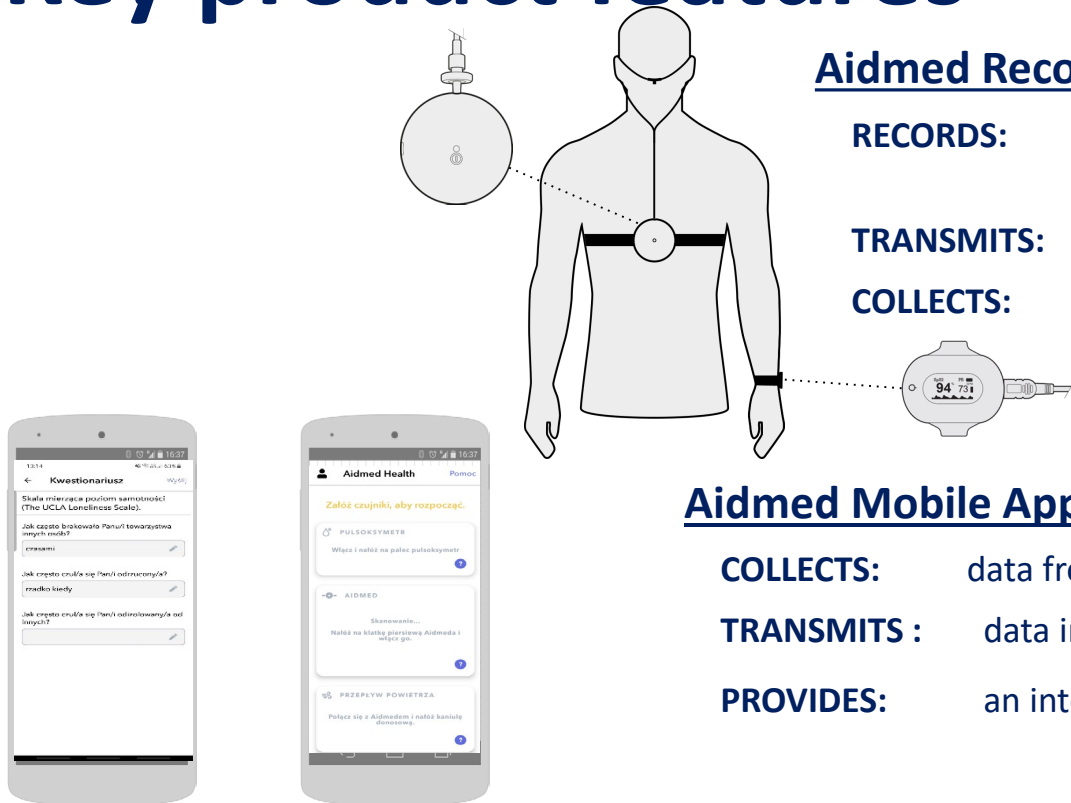
04.08 there were reports from Głogów (about smell and single dead fishes).

06-07.08, anglers discussed the large number of dead fishes on the so-called „dead Oder“ in various areas around Wrocław.

Legnica

3) Aidmed sensors system consisting of a wearable recorder (nasal airflow, ECG, heart rate, respiration rate, body position and movement, snoring and coughing, temperature, oxygen saturation) connected to a smartphone app (with action plans, surveys and biofeedback games) and a dedicated analytical web panel (with individual care plans, alarms, functional tests using artificial intelligence). System was dedicated to humans (i.e. in distinguishing autonomous system response in Long-COVID from standard pulmonary and cardiac deterioration), however some trials on animals (i.e. to detect horse colic, to measure welfare of cows or to observe drugs adverse events in pigs) were also performed.

Key product features



Aidmed Recorder Functionality:

- RECORDS:** nasal airflow, ecg, respiration, chest movements, patient activity level&position, snoring and cough sound level, skin temperature
- TRANSMITS:** data in real-time to AIDMED mobile app
- COLLECTS:** all data without cables (except nasal cannula)

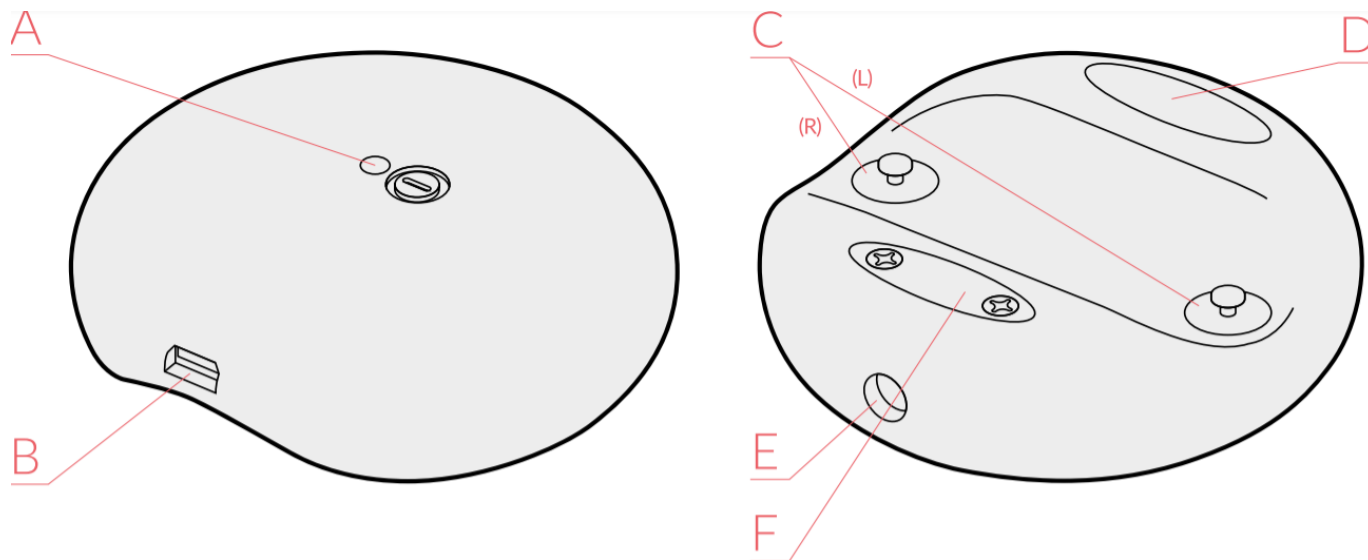
Aidmed Mobile App:

- COLLECTS:** data from AIDMED Recorder and wireless fingertip SpO2 sensor; from any BT enabled device
- TRANSMITS :** data in real-time to AIDMED Telemedical system
- PROVIDES:** an interactive patient guide on how to use AIDMED, questionnaires

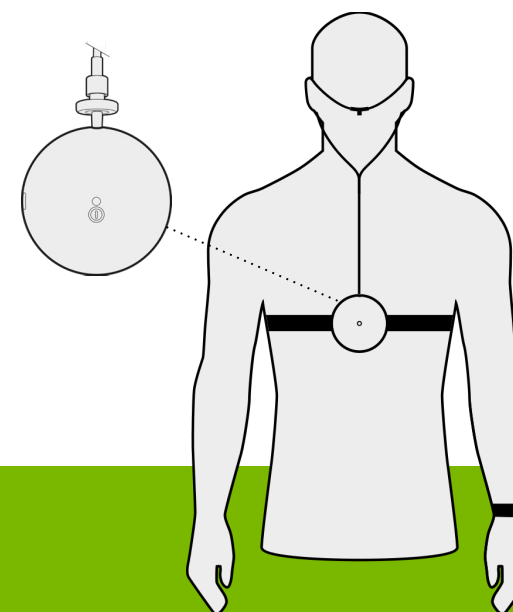
Aidmed.ai Telemedical System:

- COLLECTS:** data from AIDMED MOBILE APP
- PROVIDES:** visualization of data; signal processing and AI based analytics of ECG and Sleep Apnea; reports for the patient and physician; ability to manage devices, patients, user, access rights

Sensor



- A. Start, stop, reset, user event button
- B. USB charger port
- C. ECG & respiration (bioimpedance) electrodes:
- D. Thermometer
- E. Air flow sensor
- F. ECG Stabilising electrode
- + Microphone, 9-Axis Motion Sensor, Bluetooth



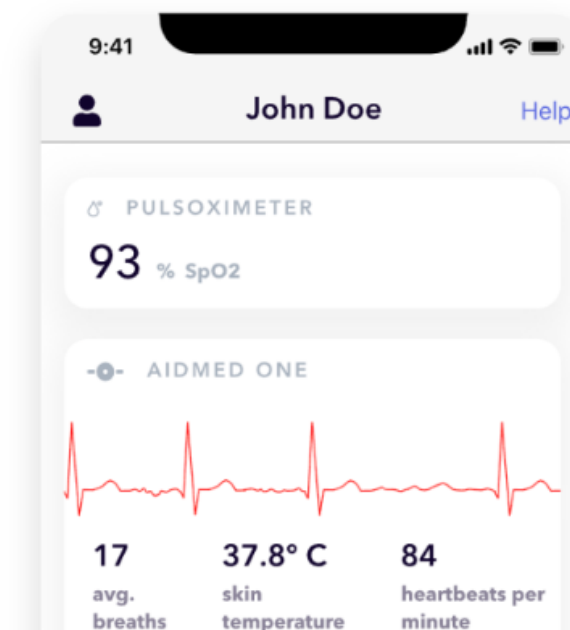
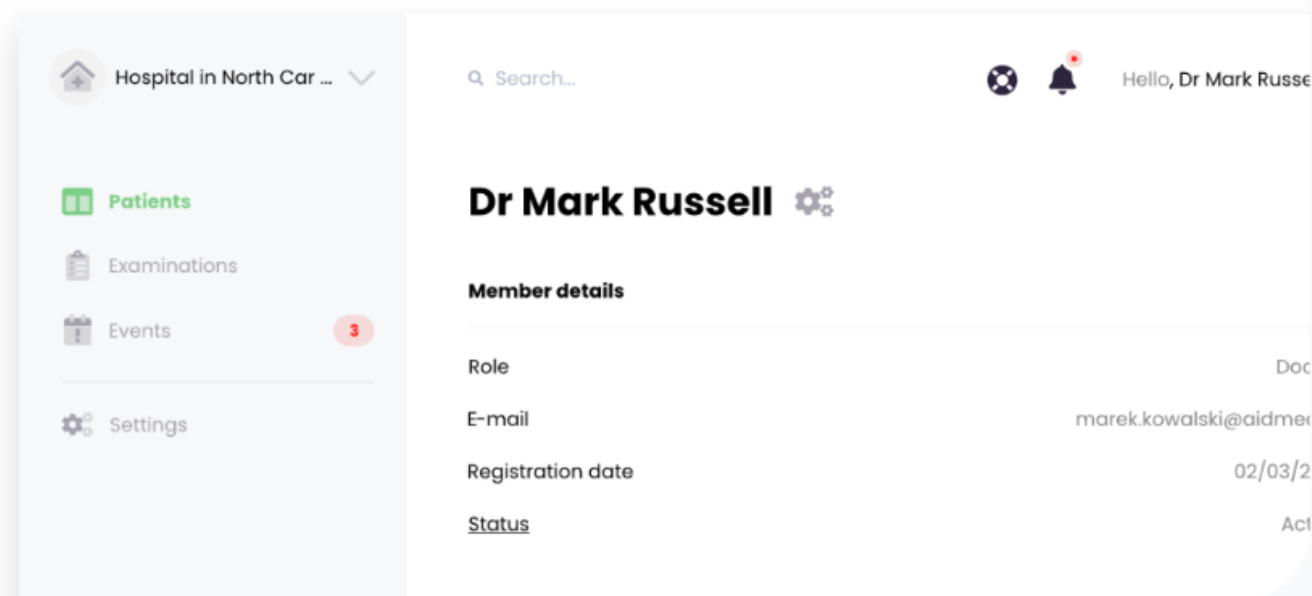
Key product features

Aidmed Cloud

Manage your clinic from anywhere. With insightful overviews and flexible tools, you can design specific patient care pathways and build rich reports.

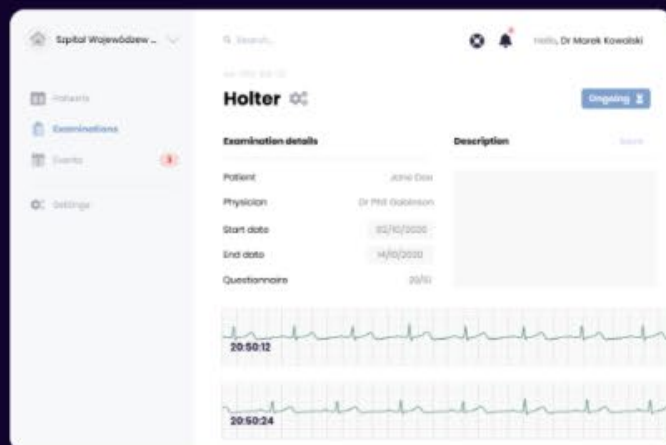
Aidmed Health

Patient's companion app supports data transmission and filling scheduled questionnaires.

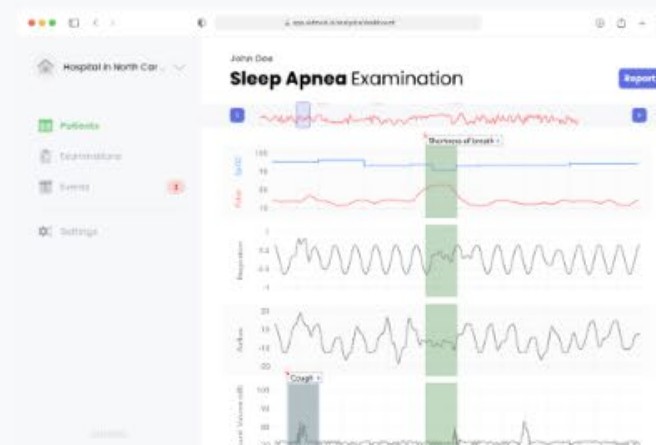


Physician/Vet generates report depending on the patient's medical case.

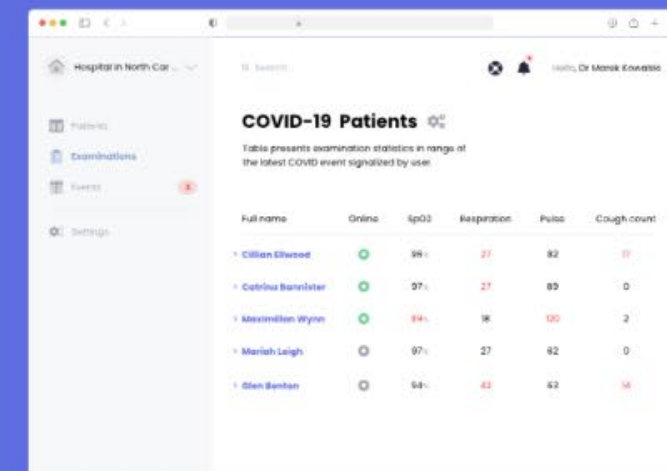
ECG



Sleep Apnea



COVID-19 Dashboard



COVID-19 Clinical Trial Case Study

Funded by Medical Research Agency to build big dataset of biosignals from non-hospitalised patients with long-COVID and provide automated guidance.



Facts

- 👤 400 patients with acute COVID, long-COVID and with chronic pulmonary or cardiac disease for control, 10-14 days of observations.
- 👤 Biosignals registration: 15 min x 3 per day, some registration during and after exercise (to see response for physical activity) + Questionnaires on health issues.

Objectives

- 👤 Validation of AIDMED telemedical solution in COVID-19 home care.
- 👤 Develop guidelines for the rehabilitation & management of COVID and pulmonary patients using AI models.

Key takeaways

- 👤 The study is still active and already numerous patients have been diagnosed for Chronic Pulmonary Diseases using AIDMED's technology and received hospital care.
- 👤 The technology allows to efficiently diagnose patients at home that would not have received care due to a limited access to standard diagnostics.

Strap?



DFG

Deutsche
Forschungsgemeinschaft

Freie Universität



Berlin

-O- AIDMED

—



cost

Length of
strap? Animal
anxiety?



Shirts?



DFG

Deutsche
Forschungsgemeinschaft

Freie Universität



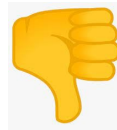
Berlin

-O- AIDMED

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Animal will adopt



cost



Stickers?



DFG

Deutsche
Forschungsgemeinschaft

Freie Universität



Berlin

-O- AIDMED



No uncomfortable
wrap or shirt



Need for shaving,
Pain upon disposal





Who benefits from using Aidmed?

Veterinary researchers

- 👉 Ease of use for diagnosis
- 👉 Real time data
- 👉 Reduced workload with auto-analysis
- 👉 AI features (i.e. Horse colic)
- 👉 developing AI for the pattern of movement of the animals,

Animal behaviorists

- 👉 Reduced cost of working with animals with biofeedback
- 👉 Ability to track animal activity with biosignals
- 👉 Surveys to be filled by animal owners

Pharma

- 👉 Collection of data from animal models during clinical trial
- 👉 Real time Case report form (CRF)

Digital veterinary epidemiology

