Rethinking Data and Evidence in Medicine, Rethinking Causality and Empiricism in Philosophy?

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EHEN projects

The 9 EHEN research projects address issues such as exposures to air quality, noise, chemicals, urbanisation, and health impacts and are funded by the EU's Horizon 2020 programme for research and innovation.

HEDIMED

LONGITOOLS

REMEDIA

ATHLETE

EPHOR

EXIMIOUS

EQUAL-LIFE

EXPANSE

HEAP

European Human Exposome **NETWORK**

Editorial | Published: 24 January 2023

Rethinking evidence in medicine

Systematic reviews

Critically appraised topics (evidence syntheses)

Group recommendation

Critically appraised individual articles (articles, synopses)

Guidelines

RCTs

Cohort studies

Case-controlled studies
Case series/reports

Background information/expert opinion

AI-based deep precision medicine

EMR, personal history

Natural history data

Wearable technology

RWD

Biosensors

Image data

All inputs (social, behavioral, environmental, genetic)

Panomics (genomics, microbiomics and so on)

World medical literature in real time

Personalization

Deep learning

Nutrition

Research data

PRO-based data

Research data

All medical data +IoMT

All lab data

Data fusion

Population/epimiological data
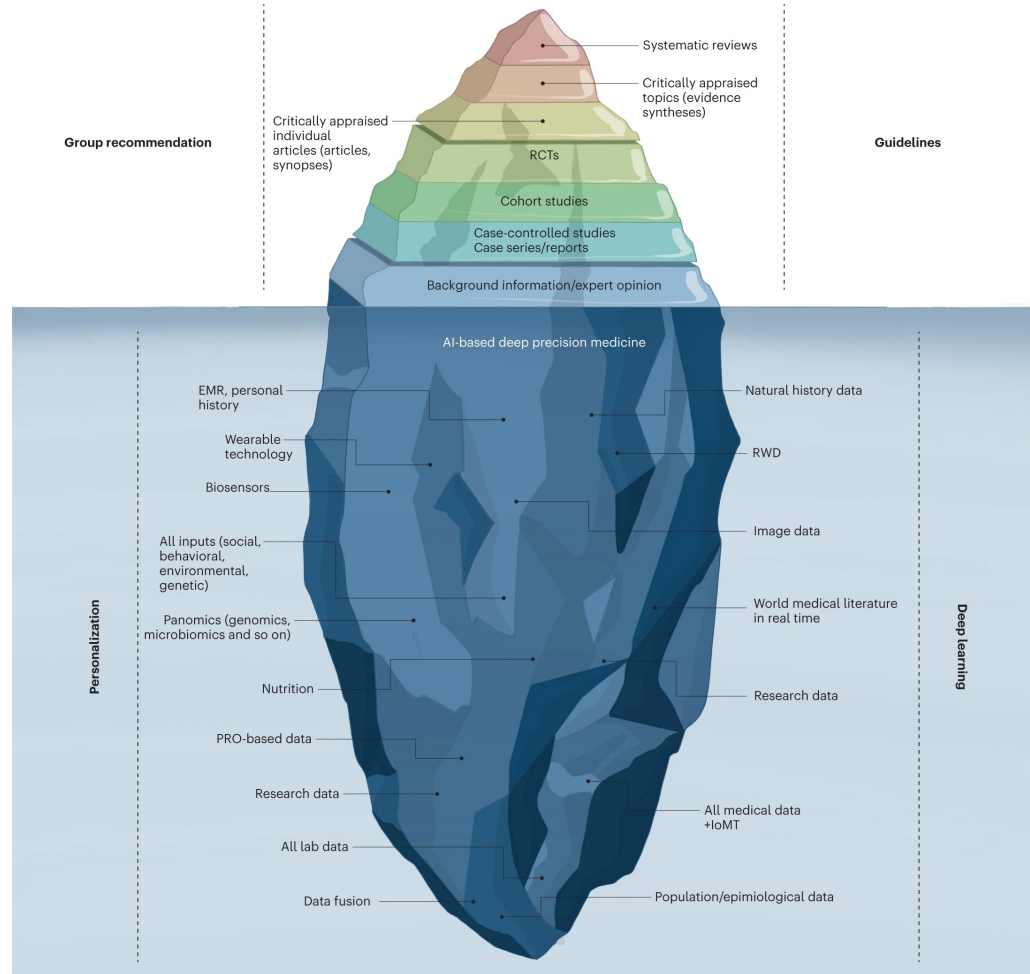
Wearable Digital Health Technology

Stephen H. Friend, M.D., Ph.D., Geoffrey S. Ginsburg, M.D., Ph.D.,
and Rosalind W. Picard, Sc.D.
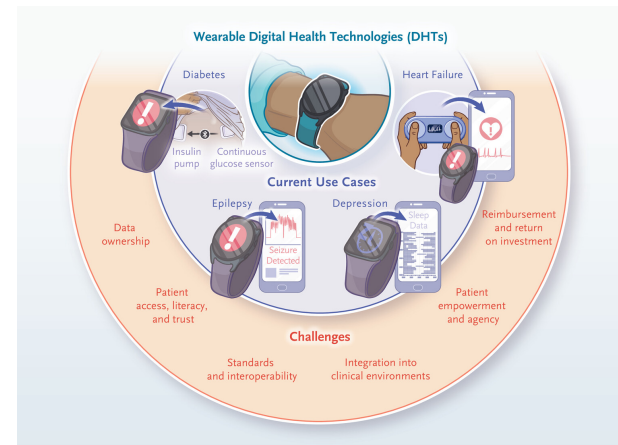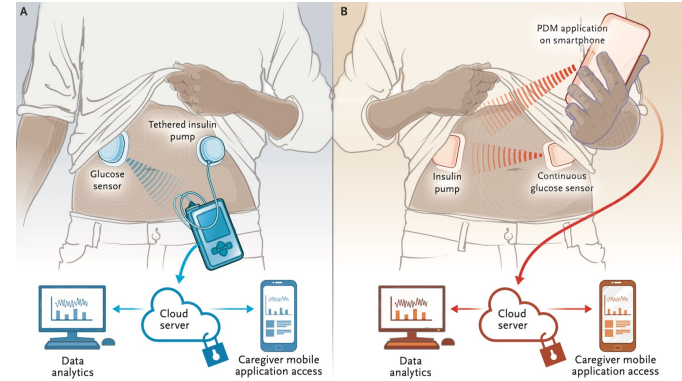
- Movements that push in the direction of new and more data.
- Specific approach to causal inference: to fill in the gaps of causality and causal inference we need more and new data.
- Empiricist stance with great results in epidemiology and medicine as well as in philosophy of science and causality.
- But good reasons to limit this stance and identify boundaries for standards of data collection and classification of evidence.

Rethinking evidence in medicine

The NEW ENGLAND JOURNAL of MEDICINE

Wearable Digital Health Technology

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European Human
Exposome *NETWORK*

1. New data from deep within our bodies: the exposome
2. New data close outside our bodies: wearables
3. A new empiricism for causality in medicine?

Rethinking evidence in medicine

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European Human Exposome NETWORK

1. New data from deep within our bodies

- Push for more focus on data from within our bodies in epidemiology.
- Molecular data and molecular epidemiology:
  - Extension of genomics and omics approaches in the public health and population health context
  - Way to study internal components of exposure, identify early responses to exposure and produce exposure profiles
  - Part of a wider trend towards the 'molecularisation' of medicine (Boniolo and Nathan, 2017)
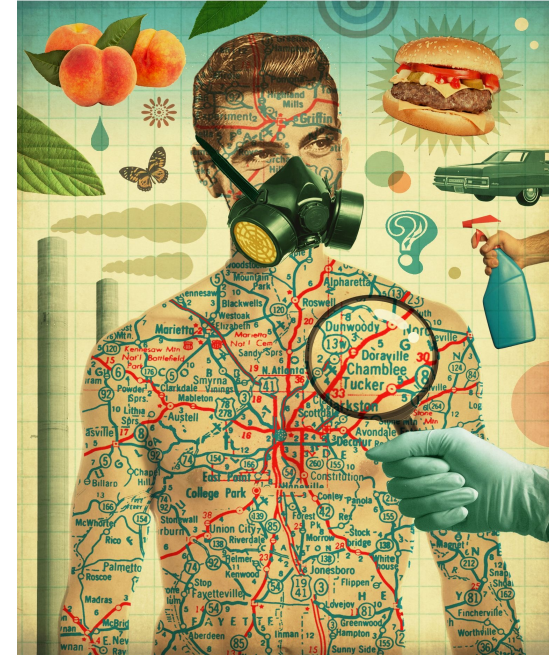
1. New data from deep within our bodies

- Emerging paradigm and repertoire: the exposome (Canali, 2022).
- Introduced in 2005 as the totality of exposures individuals experience in a specific point in time and cumulatively throughout a lifetime (Wild, 2005).
- Since the early 2010s increasing and specific funding with dedicated programmes in the EU and research centres and units in the US.
- Currently: European Human Exposome Network (EHEN) established in Europe to develop the Human Exposome project.
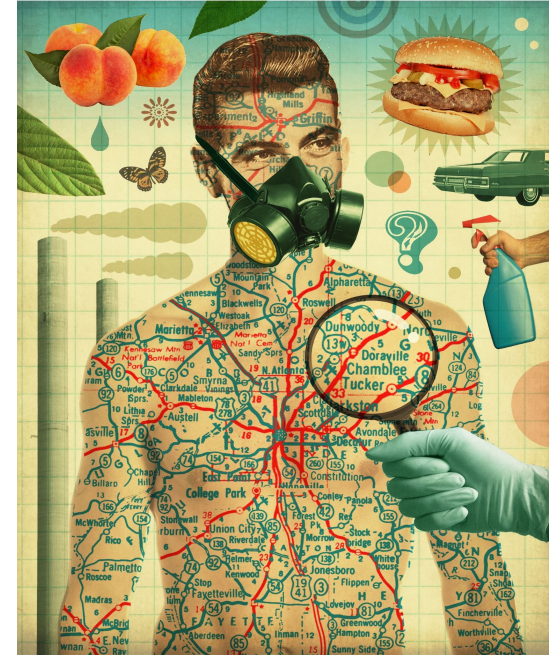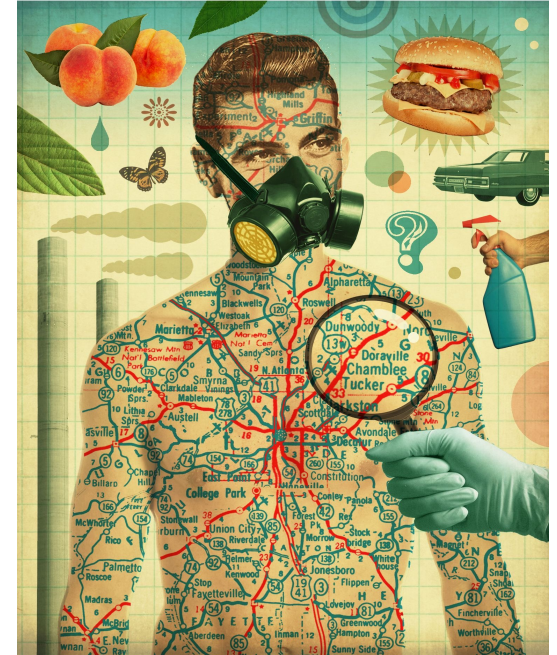
1. New data from deep within our bodies

- The exposome as a movement of data:
  - Use of new data from deep within our bodies (molecular and omics data)
  - Specific mode of integrating data across the environment and health
  - Promise to fill in gaps of causality and causal inference in epidemiology

1. New data from deep within our bodies

- Molecular data as a platform:
    - "Microscopic" focus on internal exposure and omics
    - Drive for more standardised quantification and specification of the environment
    - Match between genomic and environmental evidence (Canali, 2020; Canali & Leonelli, 2022)

1. New data from deep within our bodies

- EHEN:
  - Even more expansion and promises to use molecular data as a basis for the study of population health
  - New imaging techniques, better sampling strategies, digital data and wearable devices, etc.
- E.g. Equal-Life project: integrating molecular data with data on "housing quality, age of building, level of urbanization, crowding, type of neighbourhood, physical safety".
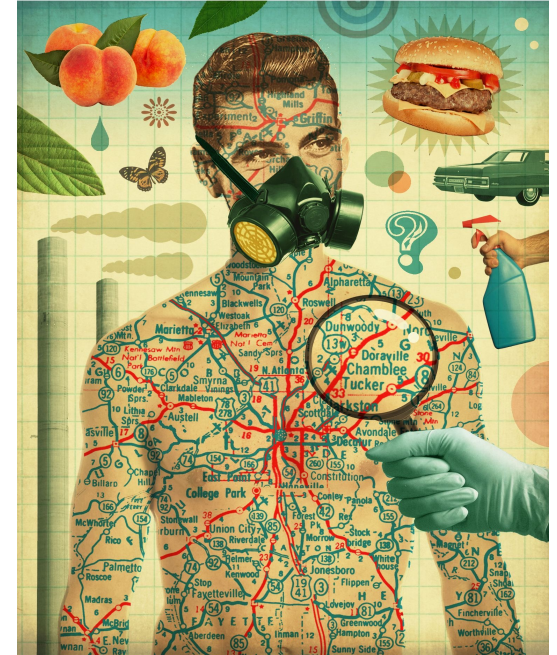
1. New data from deep within our bodies

- Why interesting from the point of view of causal inference and causality in epidemiology and medicine?
- Increasing philosophical work and attention: Phillis Illari, Jon WIlliamson, Federica Russo and many others.

EnviroGenomarkers: The Interplay Between Mechanisms and Difference Making in Establishing Causal Claims

Federica Russo · Jon Williamson

Interpreting Causality in the Health Sciences

Federica Russo and Jon Williamson

Information Channels and Biomarkers of Disease

Phyllis Illari · Federica Russo

1. New data from deep within our bodies

- Strong philosophical interpretation of molecular data:
    - Molecular data used as a way of producing both mechanistic evidence
    - E.g. Molecular data about gene expression and methylation to build a mechanistic explanation tracing exposure to tobacco smoking to cases of disease
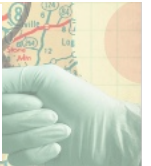
EnviroGenomarkers: The Interplay Between Mechanisms and Difference Making in Establishing Causal Claims

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Information Channels and Biomarkers of Disease

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1. New data from deep within our bodies

- Very significant from philosophical, scientific and policy viewpoints:
  - Merits and applicability of the Russo-Williamson thesis (both mechanistic and difference-making evidence necessary to build causal claims in medicine)
  - Novelty and contribution of molecular data finally reaching for mechanistic and causal terminology, traditionally resisted
  - Understanding of the causal impact of distal and socio-economic causes and intervention thanks to mechanistic evidence
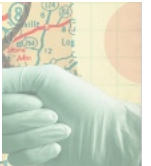

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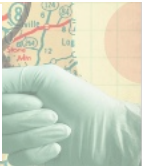
Information Channels and Biomarkers of Disease

Phyllis Illari · Federica Russo

1. New data from deep within our bodies

- Empiricist stance:
  - Causal gaps (environment, socio-economic determinants)
  - Collection of new and more data (molecular and omics data)
  - Promise to fill in these gaps (mechanisms, interventions)
- But more complicated picture perhaps?
  - Specific issues of molecular data and mechanistic evidence
  - More general concerns on the empiricist stance on causal inference

Integrative Approaches in Environmental Health and Exposome Research
Epistemological and Practical Issues
Edited by Elodie Giroux · Francesca Merlin · Yohan Fayet

palgrave macmillan

1. New data from deep within our bodies

- Molecular medicine and the exposome as novelties (Giroux, 2021; 2023):
    - Re-orientation of the biological and the social?
    - Extension of reductionism and lack of holism?
- Questions about mechanistic views (Canali, 2019; 2020):
    - Molecular data enables mechanistic understanding?
    - Molecular data and exposure profiles as difference-making evidence
- Actionability (Russo, 2023; Ratti & Russo, 2024):
    - biomarkers not actionable at public health level
    - unintentional reinforcement of reductionist approaches

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1. New data from deep within our bodies

- Only partial filling in causal gaps:
  - Molecular data can be informative
  - But level of abstraction (population level)
  - Various aspects of mechanisms (activities)

1. New data from deep within our bodies

- New and more data can complicate the causal picture:
  - New notions of socio-markers, mixed mechanisms, etc. (Ghiara & Russo, 2019; Russo, 2023; Caniglia & Russo, 2024)
  - Refinement and blurring of the notion of mechanistic evidence (Bonnin, in preparation)

1. New data from deep within our bodies

- Limitations to the empiricist stance:
  - Case of new data from deep within our bodies
  - More and new data and causal gaps
  - Can more and new data really help here?

2. New data from closely outside our bodies

- Push for more focus on data from outside our bodies.
- Digital health:
  - Digital technologies as tools for biomedical research and clinical care
  - Relation to trends known as precision and personalised medicine
  - Increasing use and availability of digital and information technologies as tools for health and particularly the collection of health data for various purposes

2. New data from closely outside our bodies

- Emerging in this context: wearables.
  - Devices that are worn directly on the body
  - Collect large volumes of data on various aspects of individual health
  - Different functions depending on sensors and types of devices
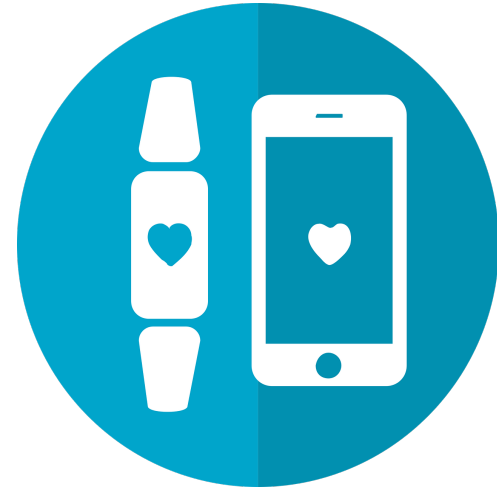
2. New data from closely outside our bodies

- More than 200 million people use smartwatches and 92% of them use them to maintain their health and fitness (Shewale, 2023).
- Increasingly used for research purposes, including studies to test their efficacy and validity, trials exploiting their monitoring abilities.
- E.g. Apple and Fitibit Heart studies (Perez et al., 2019; Lubitz et al., 2022).
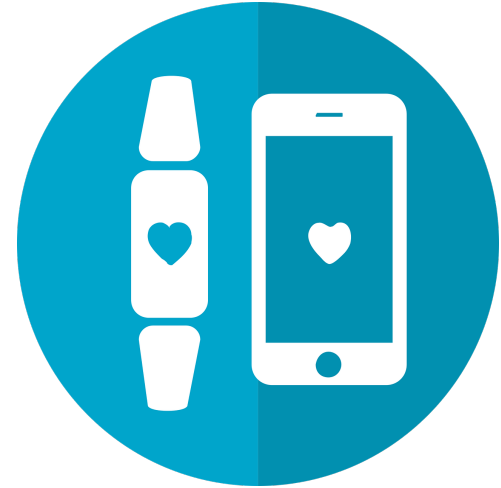
2. New data from closely outside our bodies

- Wearables as a movement of data (Canali et al., 2022):
  - Collection and use of new data from closely outside our bodies
  - Tracking proximate activities and daily activities of individual wearers
  - Extension of attempts to turn more and more aspects in digital traces for research and beyond (Leonelli, 2016)
  - Specific mode of integrating data across health and daily lives and the environment as real-world evidence
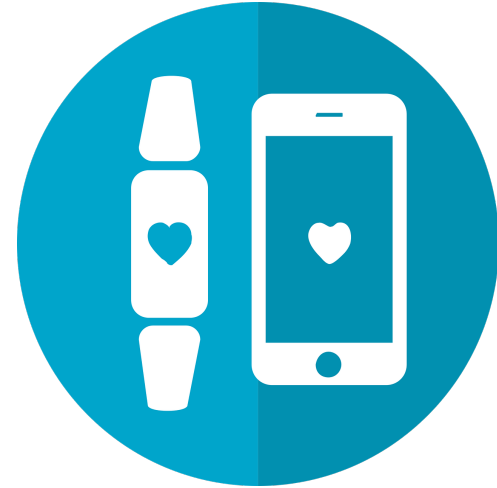
2. New data from closely outside our bodies

- Why interesting from the point of view of causal inference and causality in epidemiology and medicine?
- Increasing attention terms of personalisation, evidence, and causality.

2. New data from closely outside our bodies

- Several key promises for causal inference in medicine:
    - New evidence base with new information of clear causal relevance, otherwise scarce and less impactful (Ginsburg et al., 2024)
    - Key information to understand dynamics "in the real world" (Subbiah, 2023)
    - Personalised and individual level evidence and causality (Serpico & Maziarz, 2023)

2. New data from closely outside our bodies

- Extension and strengthening of causal inference in Evidence-Based Medicine (EBM):
  - Evidence of effectiveness to answer questions on whether intervention and policy in a specific population will work in another (Cartwright, 2012)
  - Various gaps in EBM (Ankeny & Reiss, 2022; Stegenga, Graham, Tekin, Jukola, Bluhm, 2017)
  - New approach to reform evidential standards and create more inclusivity (Celi, 2022)

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PLOS DIGITAL HEALTH

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2. New data from closely outside our bodies

- Empiricist stance:
  - Causal gaps (real-world, EBM)
  - Collection of new and more data (wearables, digital health)
  - Promise to fill in these gaps (effectiveness)
- But more complicated picture perhaps?
  - Specific issues of wearable data and effectiveness
  - More general concerns on the empiricist stance

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2. New data from closely outside our bodies

- Questions on the extent to which wearables can really provide evidence of effectiveness external validity.

- Concerns from the point of view of representativity:
  - Potentially key real-world evidence
  - Expanse of representativity of the general population and information on effectiveness
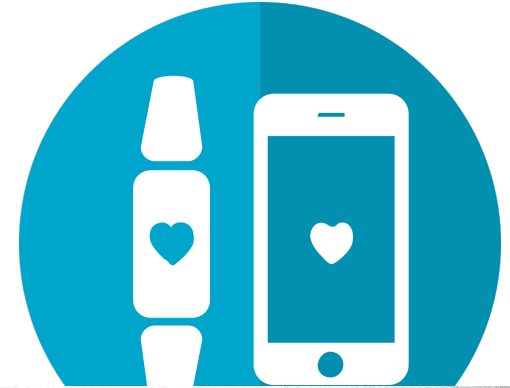
2. New data from closely outside our bodies

- Significant lack of representativity (Holko et al. 2022; Zinzuwadia & Singh, 2022):
  - Some population groups strongly included
  - Others strongly excluded
  - Poor results when using AI models trained on wearable data for excluded groups, e.g. older adults (Canali et al., 2024)
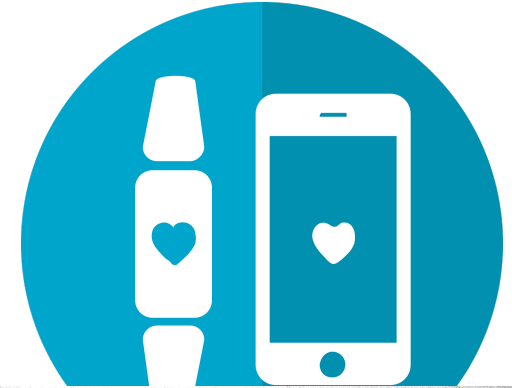
2. New data from closely outside our bodies

- Only partial filling in causal gaps:
  - Digital data can be informative
  - But issues of representativity
  - Trade-offs with representativity and different degrees of support (Reiss, 2015)
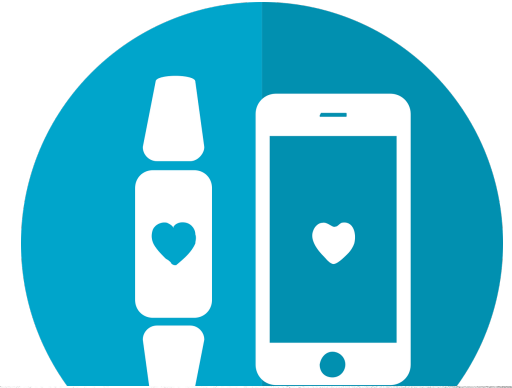
2. New data from closely outside our bodies

- New and more data can complicate the causal picture:
  - Evidence of effectiveness
  - Real-world evidence
  - Trade-offs between real-world and representative evidence

2. New data from closely outside our bodies

- Limitations to the empiricist stance:
  - Case of new data from close outside our bodies
  - More and new data and causal gaps
  - Can more and new data really help here?

3. A new empiricism for causality in medicine?

- Work so far:
  - Trace current and expansive movements at the level of health data, from deep within our bodies to close outside our bodies
  - Key promises for causal inference and its gaps for epidemiology and medicine
  - Limitations to these promises and central philosophical categories and tools
- What should we make of all this then?

3. A new empiricism for causality in medicine?

- Empiricism at the background:
  - Causal inferences in contemporary sciences, epidemiology and medicine in particular
  - Ways of thinking about causality in philosophy of science and medicine
  - Calls for new and more data
- Empiricist stance as implicit assumption
  - (Causal) knowledge on a specific topic is and should be based by experience (Markie & Folescu, 2023)
  - Experimentalist paradigm (Reiss, 2015)

Quackery Unmask'd Or, Empiricism display'd

3. A new empiricism for causality in medicine?

- Limitations of the empiricist stance applied to causal inference:
    - Collecting more molecular data might not give us the mechanistic information we think we need
    - New digital data might not expand our understanding of the causality of health and disease in daily lives and in the real world
    - Causal categories seem to slip as we collect more data
    - Evidence as fragile clues (Caniglia & Russo, 2024)

3. A new empiricism for causality in medicine?

- Moreover, collecting more data can lead to other issues:
  - Problematic forms of reification (Dupré and Leonelli, 2022)
  - Criticised from the point of view of reductionism and determinism (Merlin & Giroux, forthcoming)

3. A new empiricism for causality in medicine?

- Empiricist stance on casual inference as scientific datafication:
  - Conversion of various aspects of human life and its environment into digital data for quantified analysis and decision making
  - Beneficial in epistemic as well as ethical and social terms

Quackery Unmask'd. Or, Empiricism display'd.
Dedicated to Doctor Chiron riding Master to Achilles, and Æsculapius physician extraordinary to the Dead

3. A new empiricism for causality in medicine?

- But also tensions with scientific datafication:
    - Necessary means for achieving social recognition or legitimisation
    - E.g. New evidential basis for women's health
    - Also problematic forms of medicalisation
    - E.g. Seeing PMS as biomedical issue (Canali & Hesselbein, 2023)

3. A new empiricism for causality in medicine?

- Where does all this leave us then?
- More specific and limited empiricist and experimentalist approach to causal inference in epidemiology and medicine.

3. A new empiricism for causality in medicine?

- Moderate form of empiricism:
  - Data as not the the definitive answer to all our causal issues
  - Critically unpacking the justifications for expanding or for limiting datafication in health
  - Pragmatist and contextualist approach for coherence as well as empirical anchoring of causal knowledge (Reiss, 2009; 2015; Caniglia & Russo, 2024; Canali & Lohse, 2024)
  - Empiricism inspired by specific values starting from science itself (Ratti & Russo, 2024)

Thanks for the attention!

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