Digital healthcare: will the robot see you now?

Richard Harvey

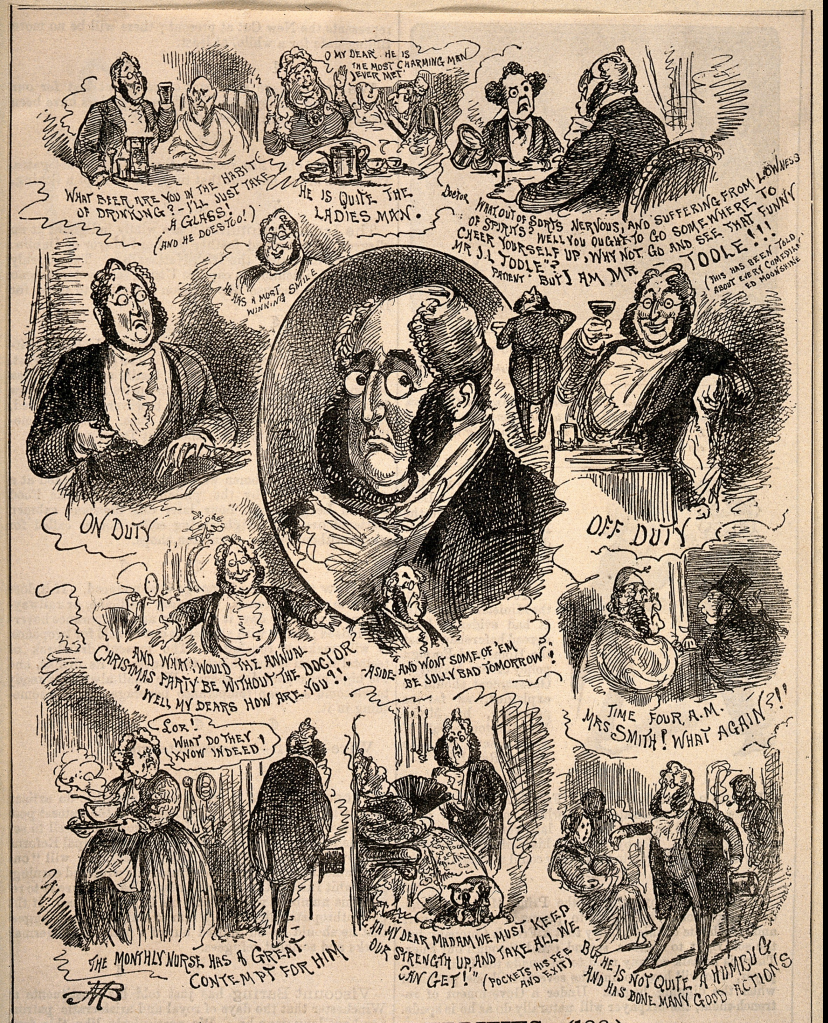
IT Livery Company Professor of Information Technology, Gresham College

Professor of Computer Science, School of Computing Sciences,

University of East Anglia

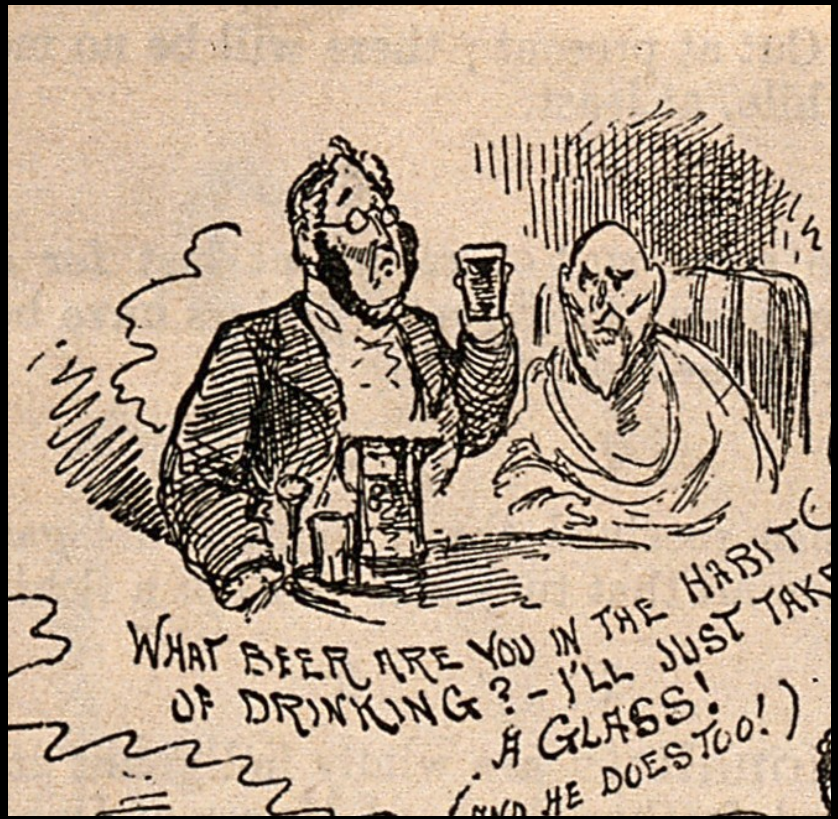
@richardwharvey

Royal Herbert Hospital Woolwich Ward in Main Building, 1920. The Qualis Photo Co, Wellcome collection, https://wellcomecollection.org/works/rp2df6e9

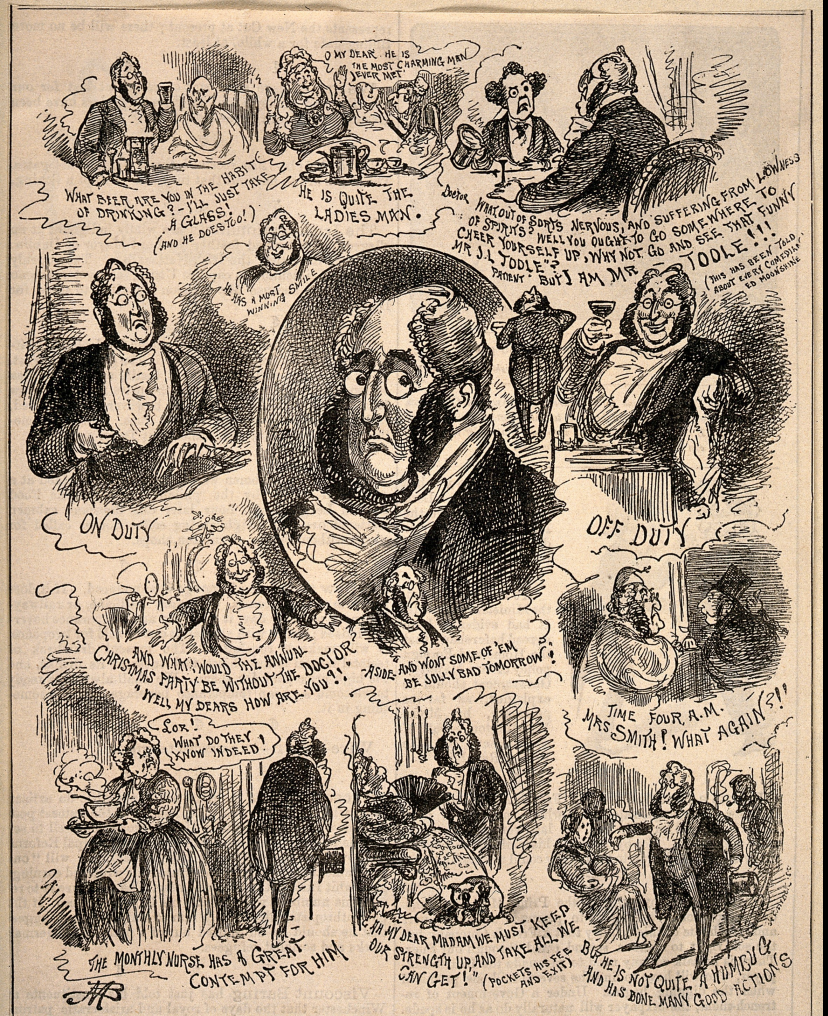


DAYS WITH CELEBRITIES. (126.)

THE FAMILY DOCTOR.



A dozen scenes presenting the manifold aspects of a family doctor's personality. Wood engraving by M.B.
Credit: Wellcome Collection.



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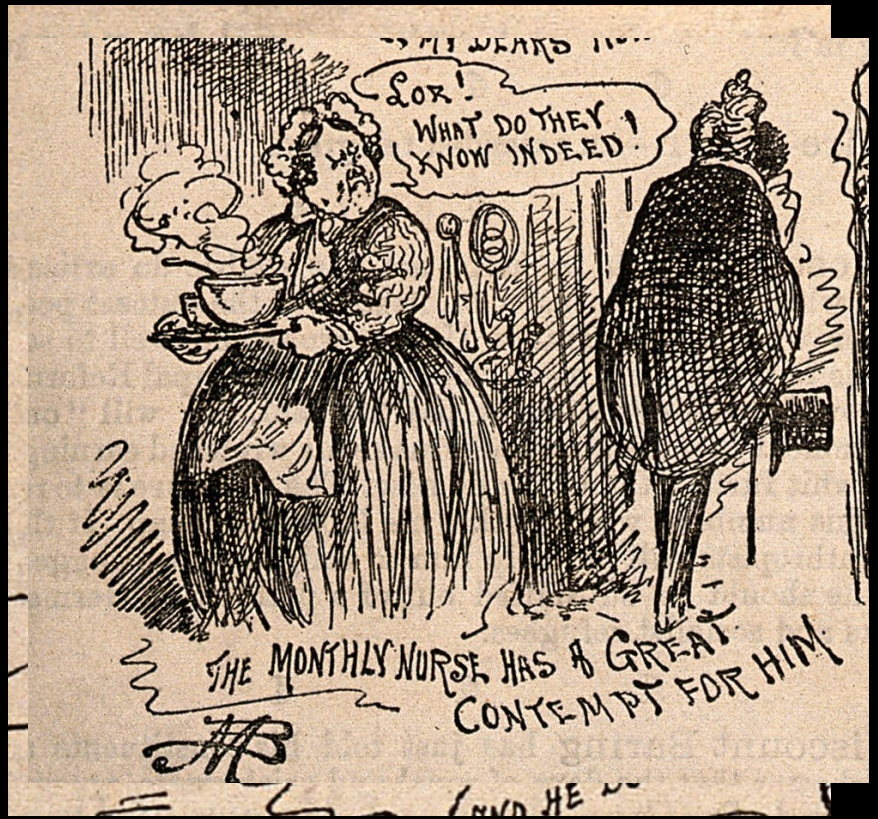
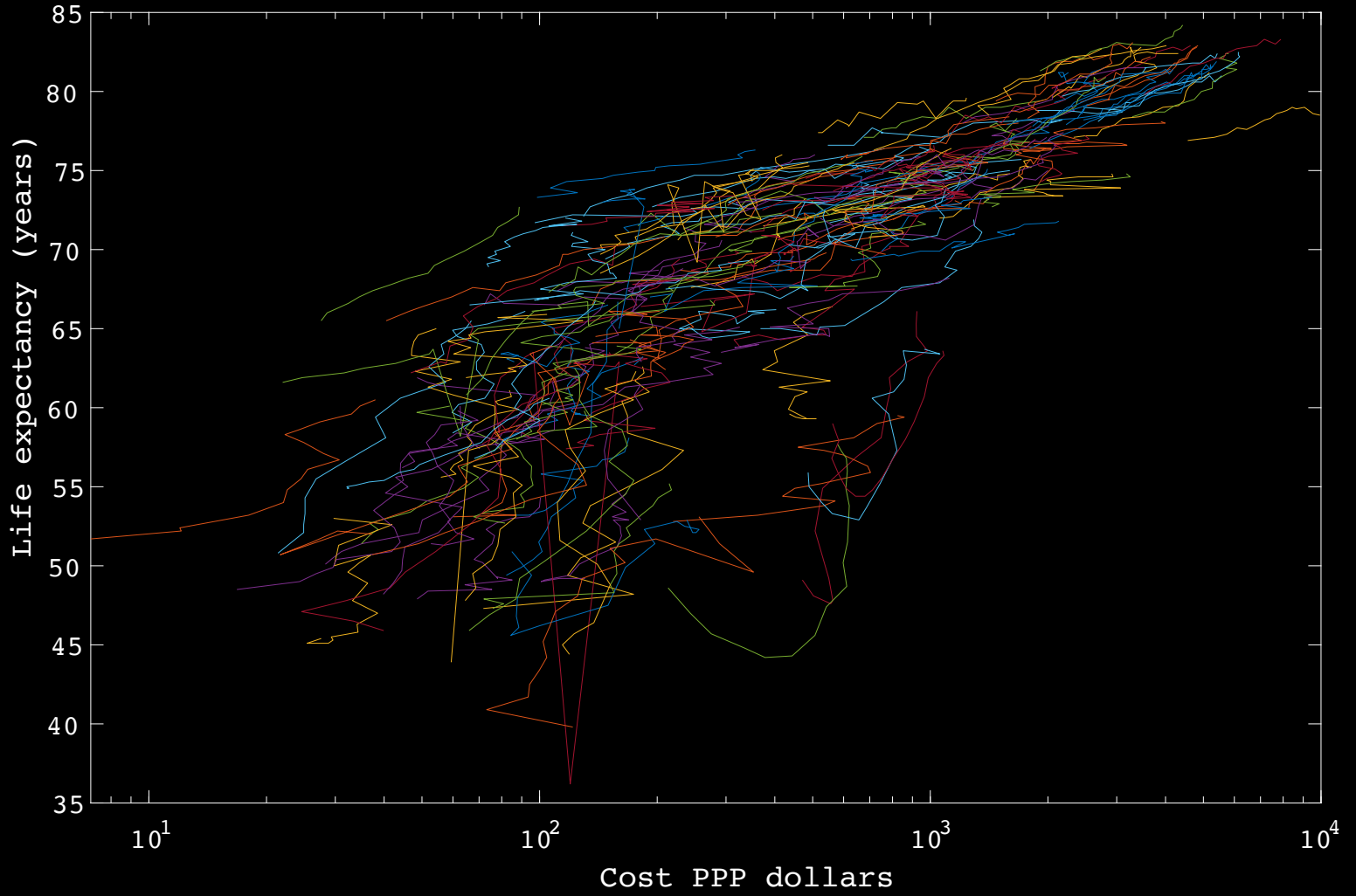
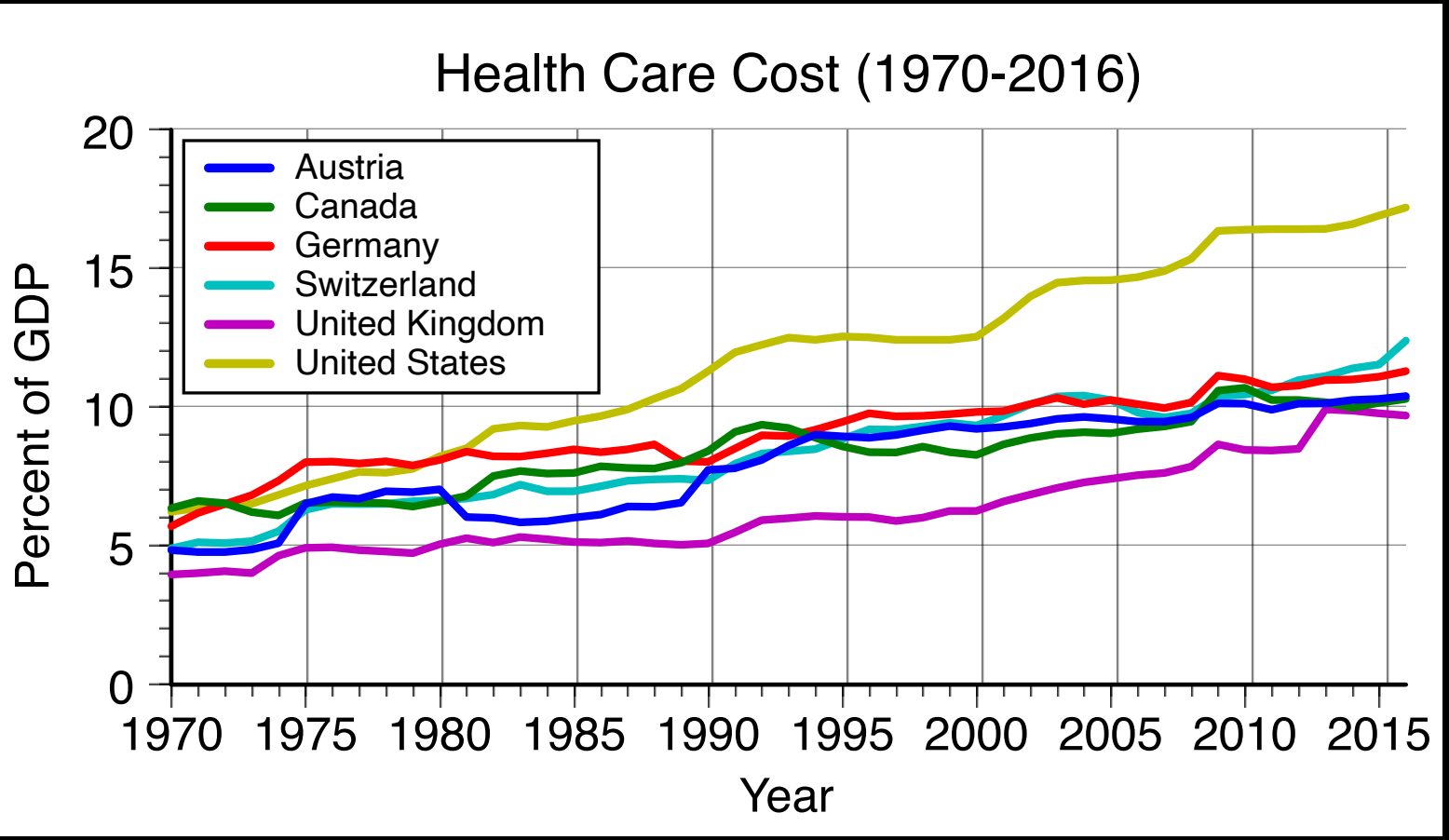


A dozen scenes presenting the manifold aspects of a family doctor's personality. Wood engraving by M.B.
Credit: Wellcome Collection.


Life expectancy (years)
85
80
75
70
65
60
55
50
45
40
35
10^1
10^2
10^3
10^4
Cost PPP dollars

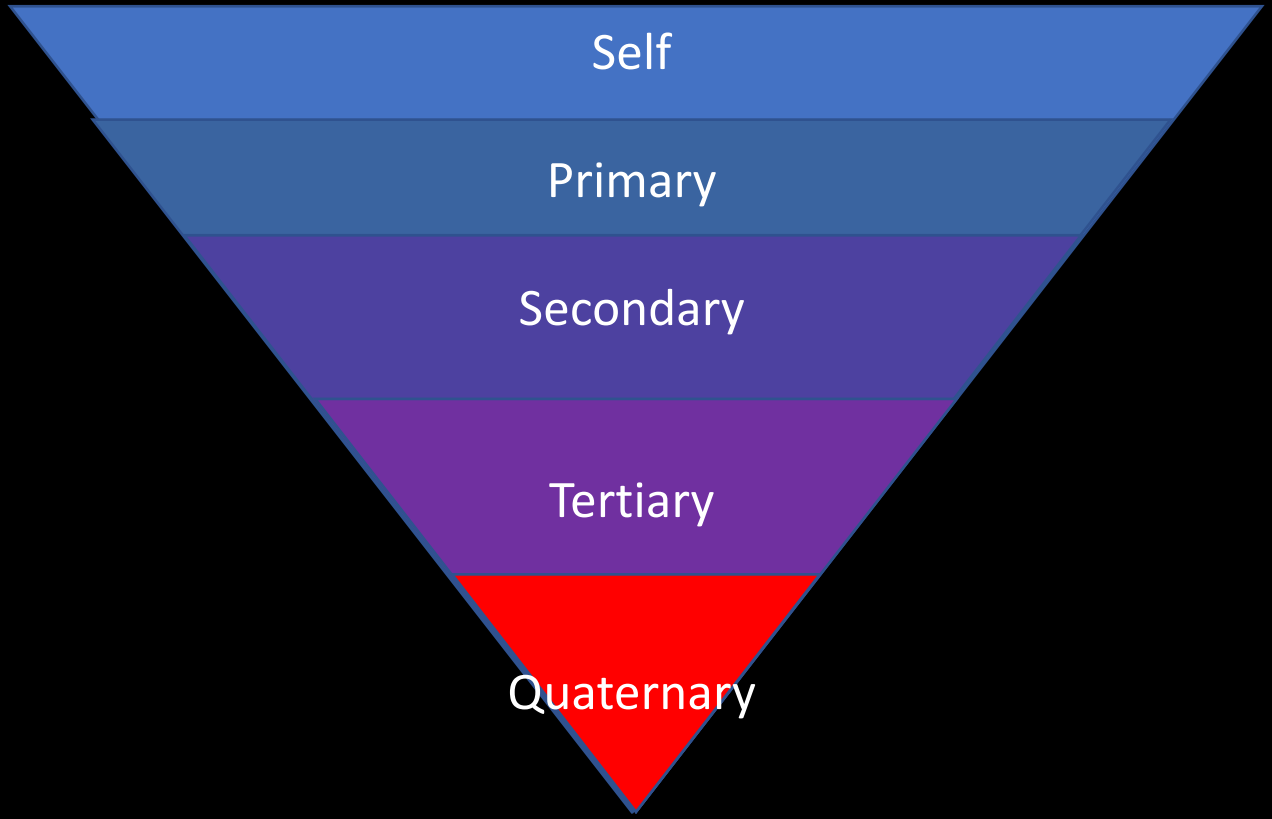


Wikipedia: List of countries by total health expenditure per capita

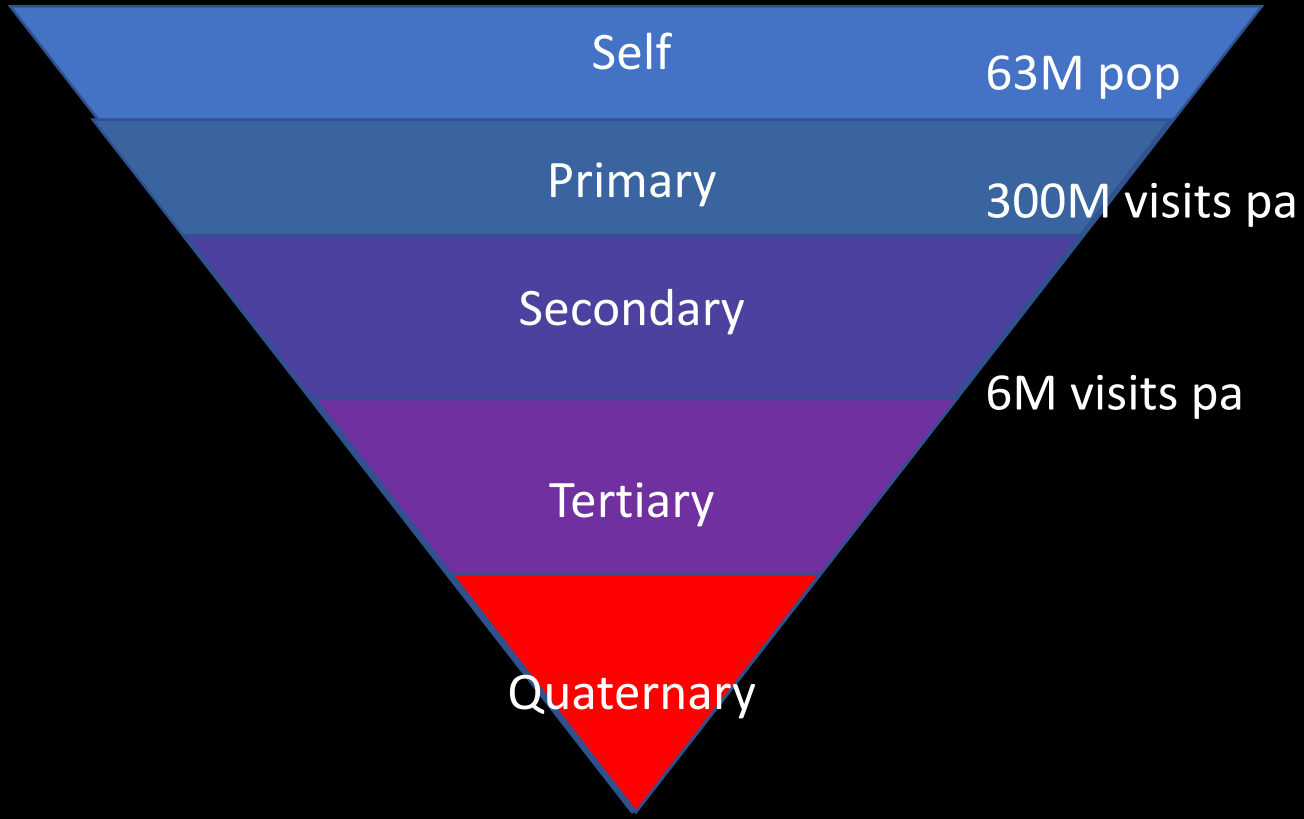
“Harnessing the power of digital technologies is essential for achieving the Sustainable Development Goals, including universal health coverage and the other “triple billion” targets in WHO’s 13th General Programme of Work. Such technologies are no longer a luxury; they are a necessity.”

Dr Tedros Adhanom Ghebreyesus
Director-General, World Health Organization

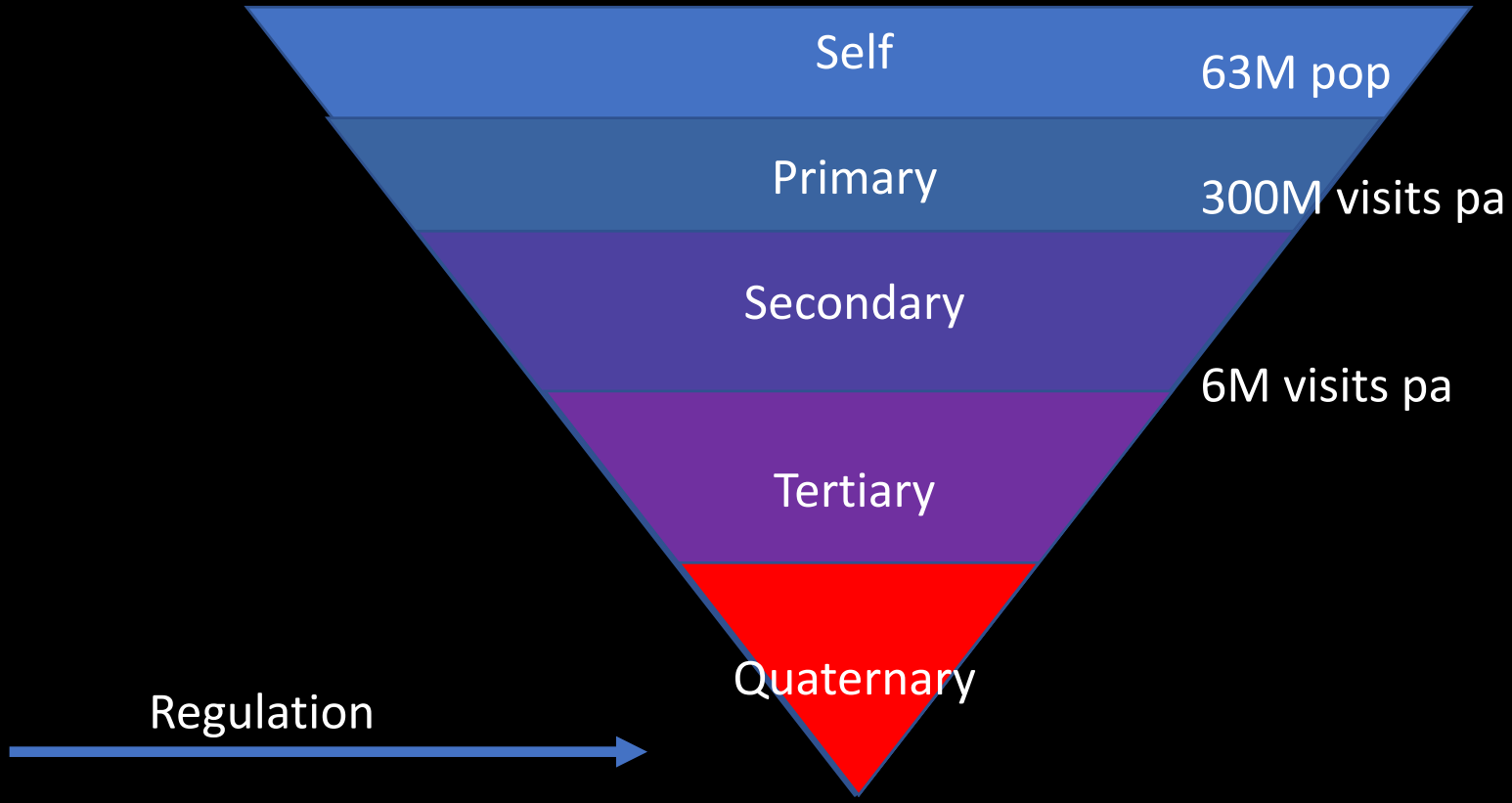
Taxonomy of medicine



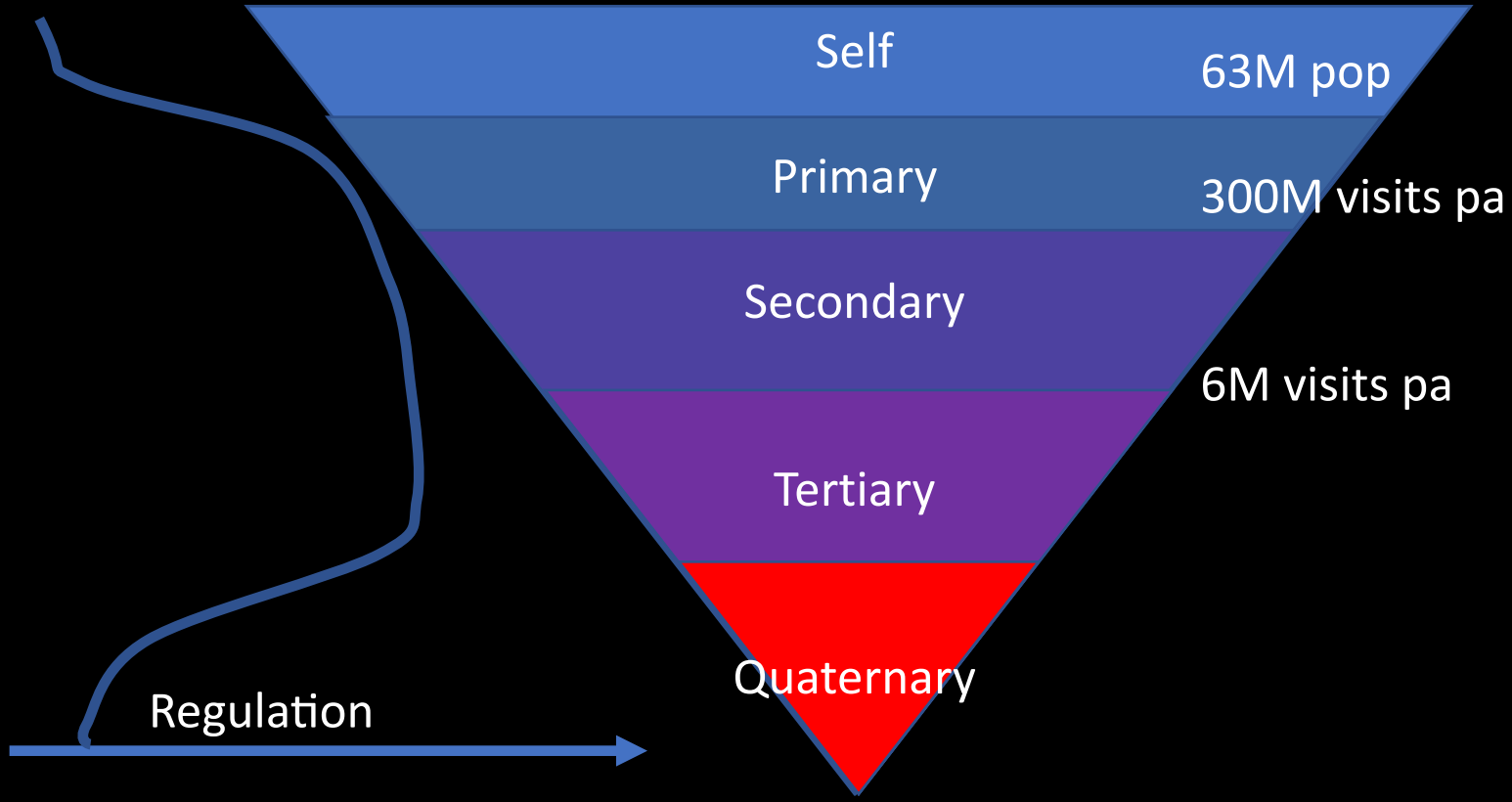
Taxonomy of medicine



Taxonomy of medicine



Taxonomy of medicine



Tertiary and Quaternary care

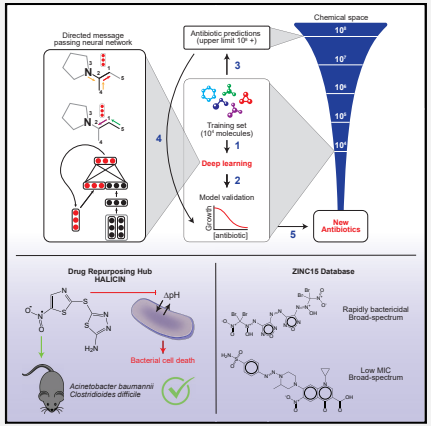
- Robot surgeons, neural nets and artificial hearts
- Very popular in the press
- Very small numbers of patients.

Article

Cell

A Deep Learning Approach to Antibiotic Discovery

Graphical Abstract



Highlights

- A deep learning model is trained to predict antibiotics based on structure
- Halicin is predicted as an antibacterial molecule from the Drug Repurposing Hub
- Halicin shows broad-spectrum antibiotic activities in mice
- More antibiotics with distinct structures are predicted from the ZINC15 database

Authors

Jonathan M. Stokes, Kevin Yang, Kyle Swanson, ..., Tommi S. Jaakkola, Regina Barzilay, James J. Collins

Correspondence

regina@csail.mit.edu (R.B.), jimjc@mit.edu (J.J.C.)

In Brief

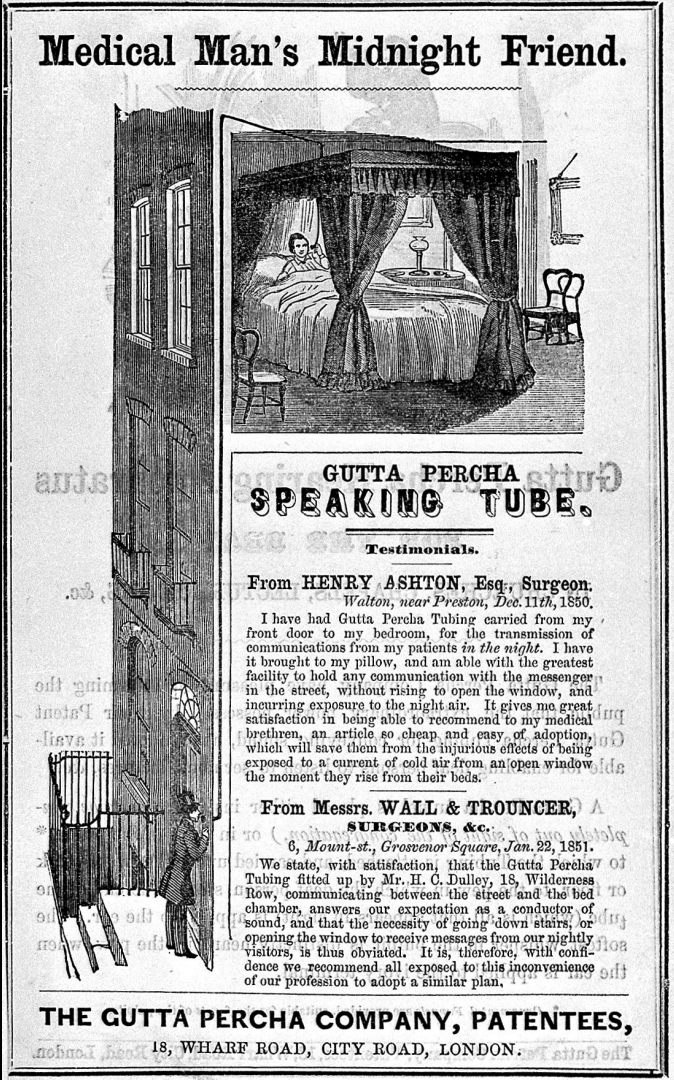
A trained deep neural network predicts antibiotic activity in molecules that are structurally different from known antibiotics, among which Halicin exhibits efficacy against broad-spectrum bacterial infections in mice.

Stokes et al., 2020, Cell *180*, 688–702
February 20, 2020 © 2020 Elsevier Inc.
https://doi.org/10.1016/j.cell.2020.01.021

CellPress

Primary care

Telemedicine



Advertisement for the Gutta Percha speaking tube..
Credit: Wellcome Collection.

Online consultations

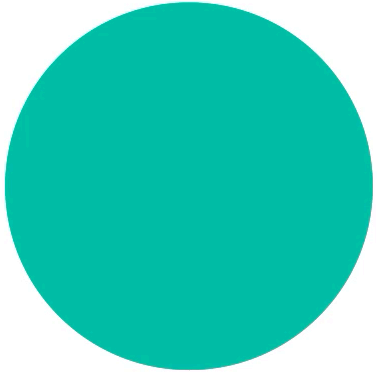
Healthcare-Focused Companies With Chatbot Services

Data is current through early December 2019.

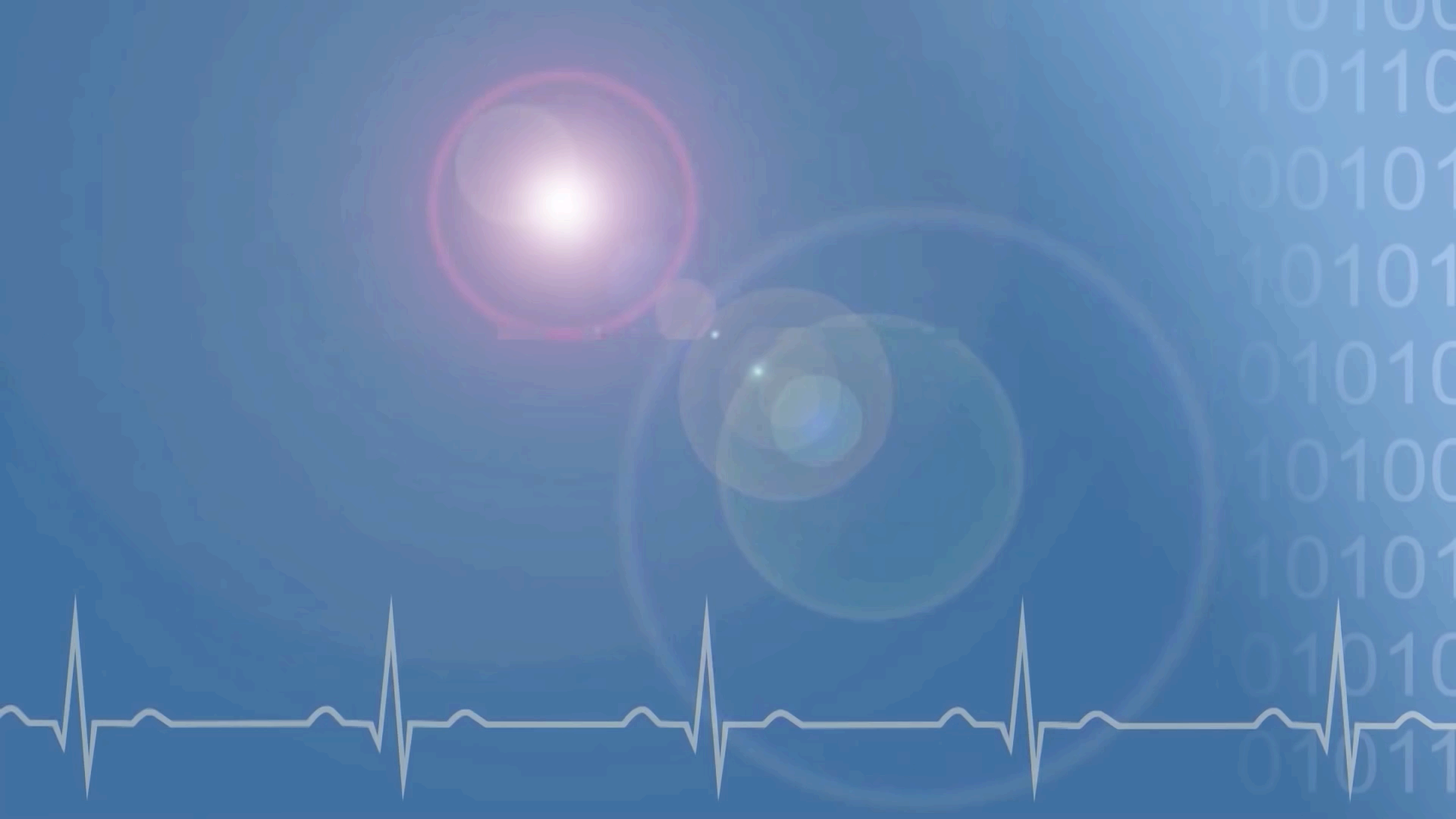
Company	Chatbot Name	Focus Area	Funding To Date
Babylon Health	Ask Babylon	General	$635M
Ada Health	Ada	General	$67M
Buoy Health	Buoy	General	$29M
Sensely	(Varies)	Connecting to insurance services and healthcare resources	$27M
Woebot Labs	Woebot	Mental health	$8M
Youper	Youper	Emotional health assistant	$3.5M
Clear Genetics	Gia	Genetics	Acquired

crunchbase news

Health Chatbots Are Proliferating, And VCs Love Them, Joanna Glasner
December 9, 2019



Secondary care




2

Google streams

ico.
Information Commissioner's Office

Upholding information rights

Wycliffe House, Water Lane, Wilmslow, Cheshire SK9 5AF
Tel. 0303 123 1113 Fax. 01625 524 510 www.ico.org.uk

Sir David Sloman, Chief Executive
Royal Free NHS Foundation Trust
Pond Street
Hampstead
London
NW3 2QC

3 July 2017

Dear Sir David,

RFA0627721 – provision of patient data to DeepMind

I write to confirm that I have concluded my investigation into the above.

In summary, my investigation has determined that the processing of approximately 1.6 million patients' personal data by DeepMind Technologies Limited ('DeepMind') for the purpose of the clinical safety testing of the Streams application did not fully comply with the requirements of the Data Protection Act 1998 (the 'Act').

This letter explains how my investigation has reached that conclusion and highlights my key areas of concern. It explains the steps that I expect The Royal Free London NHS Foundation Trust ("Royal Free") to take as a result. As the letter goes on to explain, this includes Royal Free London NHS Trust's agreement to the signing of an undertaking.

1.1 Our investigation

First and foremost, my office has made our support for the appropriate use of personal data for the purpose of research, development and clinical improvements clear. As you may be aware from my recent outreach work and public statements, I see the Data Protection Act, transparency for individuals, and sound data protection practices as fundamental to innovation. The ICO is committed to supporting technological advances in a way that locks in good data protection practice by default. We recognise that data analytics has huge and varied potential, but we also want to ensure that good data protection practice is seen as the positive force for good that we believe it to be.

In relation to health data, my office recognises the benefits that can be achieved by using patient data for wider public good and, where appropriate, we support

Some persistent problems

- Bugs in hospitals
- Computer-generated inefficiency
- Poor procurement
- Poor interoperability
- Poor systems design leading to
  - See above!

Are computer bugs worse than real bugs?

- Therac-25
  - injured or killed six people
  - A case study in poor software engineering practice
- Multidata Systems International RTP/2
  - killed five people (so far)
- Glucose monitoring software at Princess of Wales Hospital
  - 70 nurses disciplined and five sent to court
  - Database evidence thrown out of court

Computer Bugs in Hospitals: a new killer, Martyn Thomas and Harold Thimbleby, Gresham Lecture Feb 2018

Are computers really efficient?

RESULTS: Clinicians spent 355 minutes (5.9 hours) of an 11.4-hour workday in the EHR per weekday per 1.0 clinical full-time equivalent: 269 minutes (4.5 hours) during clinic hours and 86 minutes (1.4 hours) after clinic hours. Clerical and administrative tasks including documentation, order entry, billing and coding, and system security accounted for nearly one-half of the total EHR time (157 minutes, 44.2%). Inbox management accounted for another 85 minutes (23.7%).

Arndt, B. G., Beasley, J. W., Watkinson, M. D., Temte, J. L., Tuan, W. J., Sinsky, C. A., & Gilchrist, V. J. (2017). Tethered to the EHR: Primary Care Physician Workload Assessment Using EHR Event Log Data and Time-Motion Observations. *Annals of family medicine*, *15*(5), 419–426. https://doi.org/10.1370/afm.2121

Procurement disasters

NEWS

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Politics | Parliaments | Brexit

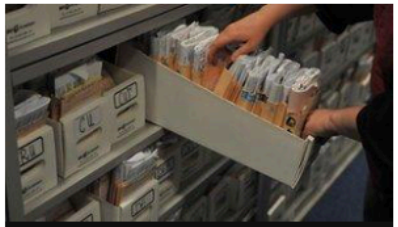
NHS IT system one of 'worst fiascos ever', say MPs

18 September 2013

Share

Taxpayers face a rising, multi-billion pound bill for a failed government IT project, MPs have said.

A report by the influential Public Accounts Committee (PAC) concluded an attempt to upgrade NHS computer systems in England



Ministers want to make the NHS paperless

Interoperability

Warren LR, Clarke J, Arora S, et al. Improving data sharing between acute hospitals in England: an overview of health record system distribution and retrospective observational analysis of inter-hospital transitions of care. BMJ Open 2019;**9**:e031637. doi:10.1136/bmjopen-2019-031637

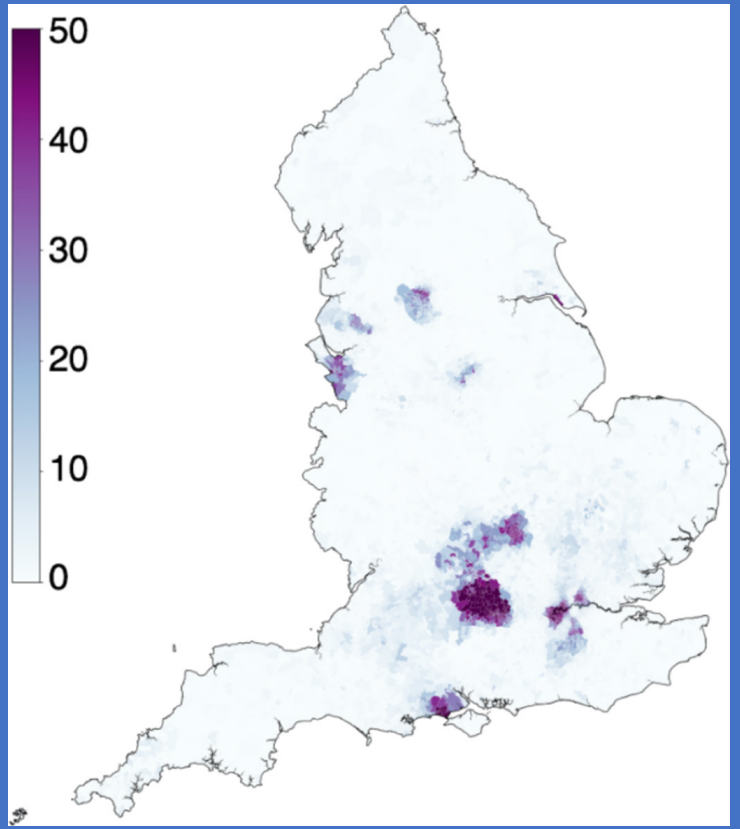


Figure 2 Map of England indicating the probability of patients in each Lower Layer Super Output Area having an encounter recorded on the same type of health record system, where consecutive encounters were at different trusts. Proportions range from zero (white) to high (dark purple) probability of attending a different trust using the same health record system.

Looking forwards

Given that

software cannot be trusted in life-threatening sitations

procurement is poor

IT infrastructure is poor…

Can we do anything at all?

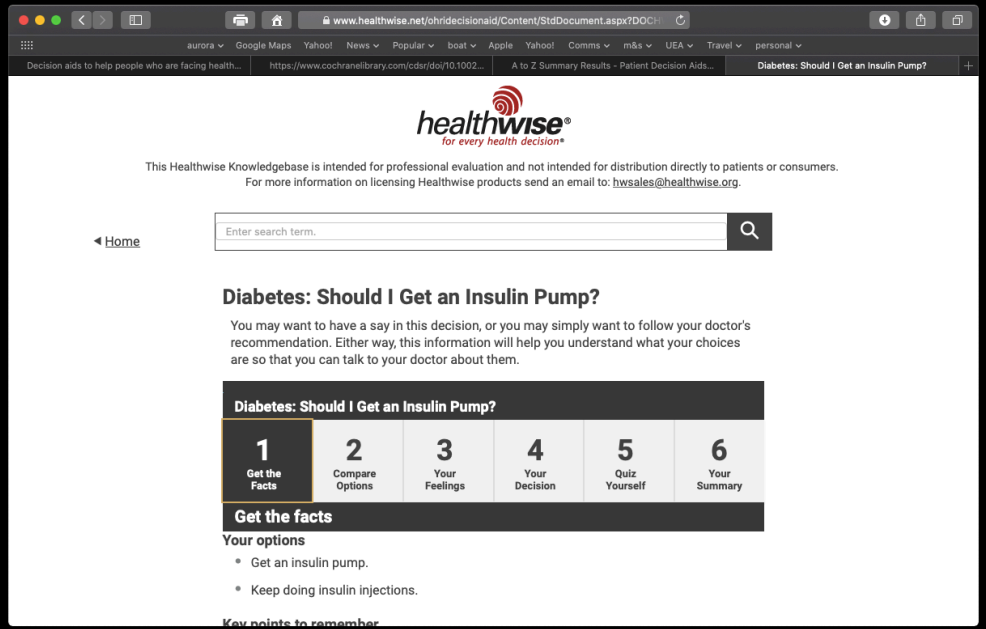
Simulation

Patient preferences

"Benign prostate disease. Patients typically seek treatment because of urinary symptoms. Surgery can ameliorate these symptoms, but there is a trade-off. Many patients suffer from a form of post-surgical sexual dysfunction. An observational study showed that **when patients were well informed about the trade-off**, 40 per cent fewer preferred surgery (Wagner *et al* 1995)"

Patients' preferences matter; stop the silent misdiagnosis, Al Mulley, Chris Trimble, Glyn Elwyn, The King's Fund 2012, ISBN 978 1 85717 637 7

Decision aids

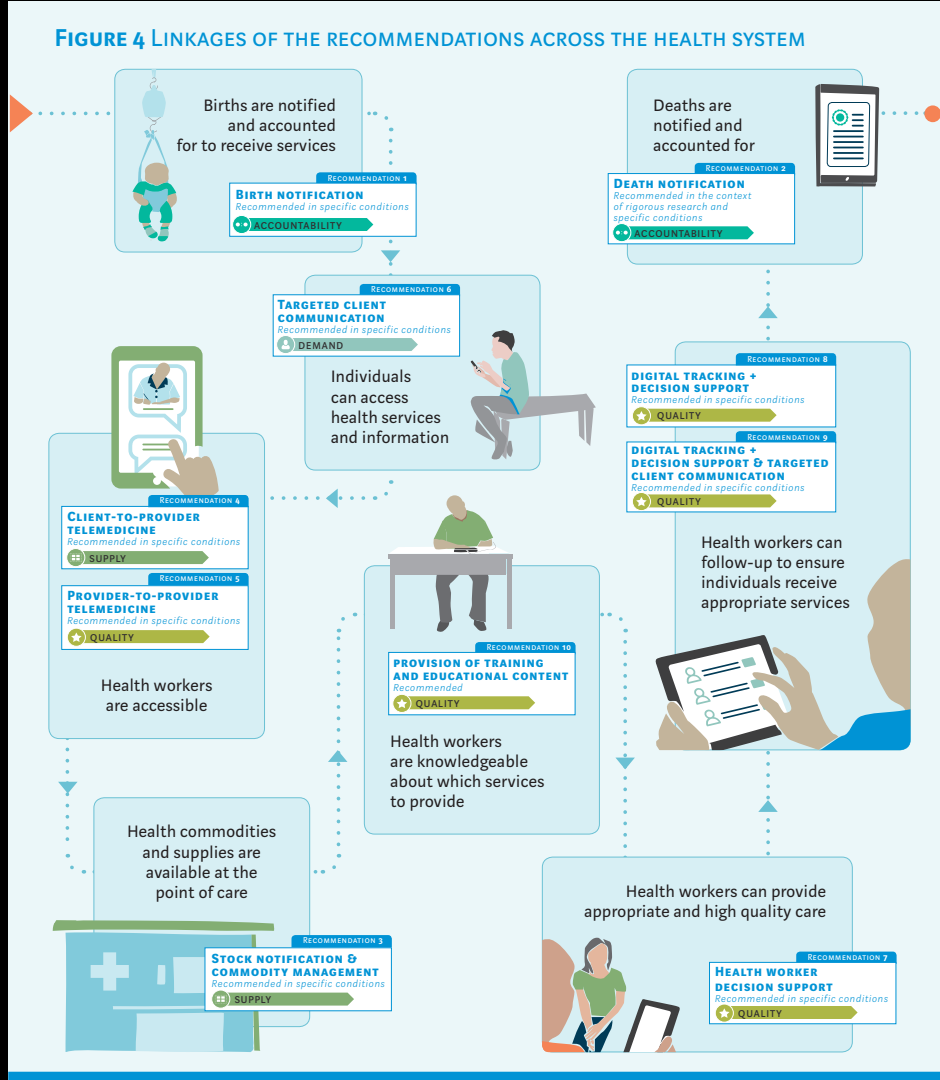


https://www.healthwise.net/ohridecisionaid/Content/StdDocument.aspx?DOCHWID=zx1815

Decision aids for people facing health treatment or screening decisions (Review); Stacey D, Légaré F, Lewis K, Barry MJ, Bennett CL, Eden KB, Holmes-Rovner M, Llewellyn- Thomas H, Lyddiatt A, Thomson R, Trevena L; *Cochrane Database of Systematic Reviews* 2017, Issue 4. Art. No.: CD001431.
DOI: 10.1002/14651858.CD001431.pub5.

WHO Guidelines

WHO guideline: recommendations on digital interventions for health system strengthening. Geneva: World Health Organization; 2019

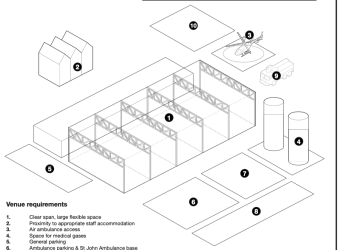



Now with added Covid
18
S9
© UK Ministry of Defence 2020

Now with added Covid

1. SCOPE OUT

Large barn type spaces with flat floor areas for the ICU wards and triage/entry, adjacent space for storage, pharmacy, staff break out and WCs (clean) and dirt/doff areas in between(clean/dirty)

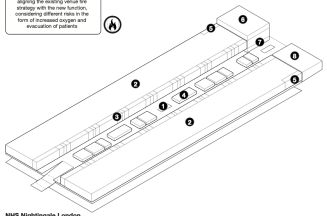


Venue requirements

1. Clear span, large flexible space
2. Proximity to appropriate staff accommodation
3. Air ambulance access
4. Space for medical gases
5. General parking
6. Space for Emergency & St John Ambulance base
7. Temporary generators
8. Space for staff changing and showers
9. Fire strategy consideration is key from the early stages
10. Additional space to accommodate CTs (at least two for resilience) and temporary mortuaries

2. LAY OUT

It is essential that an **NHS fire officer** is involved from early stage, aligning the existing venue fire strategy with the new function, considering different risks in the form of increased oxygen and evacuation of patients

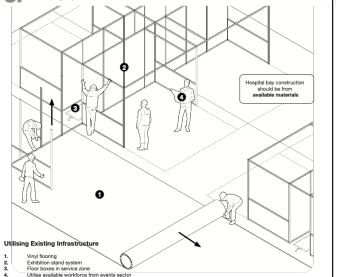


NHS Nightingale London

1. Central boulevard
2. Wards
3. DON/DOFF areas
4. Pharmacy (extends to top floor)
5. Triage
6. CT / Diagnostics
7. Mortuary
8. Staff canteen

Wayfinding and signage is key to assist staff in operation and make sure people stay in the allocated flow channel to avoid accidentally entering a dirty area

3. FIT OUT



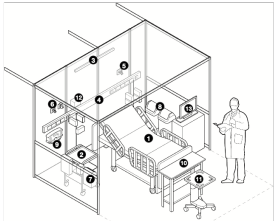
Hospital bay construction should be from **available materials**

Utilising Existing Infrastructure

1. Vinyl flooring
2. Exhibition stand system
3. Floor boxes in service zone
4. Utilise available workforce from events sector

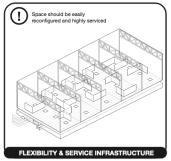
Note **Use what you have rather than trying to procure new and utilise large groups of available labour**

4. KIT OUT



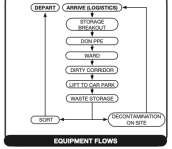
Typical Bed Bay Clinical Equipment

1. Bed bay [3930W x 4300L]
2. Consumaries trolley
3. LED overhead light [1200mm]
4. Bed trunking [3000W x 150H]
5. Curtain
6. 1x Oxygen & 1x Medical Gas
7. Dispensers and sharps bin
8. Clinical waste bins
9. Oxygen monitor
10. Chart table
11. Stool
12. Ventilator
13. Electronic patient records

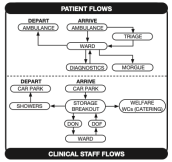


FLEXIBILITY & SERVICE INFRASTRUCTURE

Space should be easily reconfigured and highly serviced

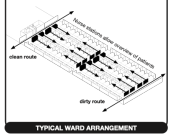


EQUIPMENT FLOWS

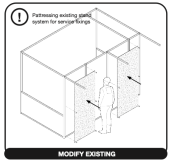


CLINICAL STAFF FLOWS

Primary consideration should be given to **infection control** separating clean and dirty areas.



TYPICAL WARD ARRANGEMENT

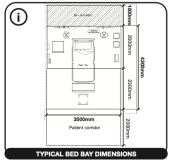


Pathressing existing ceiling system for service fixings

MODIFY EXISTING

Hospital grade, non slip vinyl can be installed quickly but the installation methodology needs to balance speed with robustness - ensuring appropriate bonding to avoid trip hazards

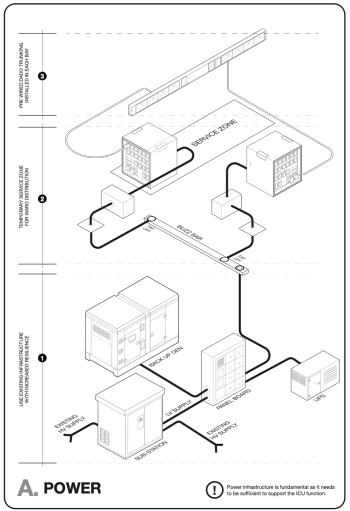
BALANCE SPEED WITH QUALITY



TYPICAL BED BAY DIMENSIONS

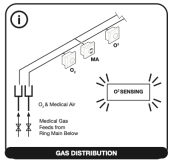
- **Bed bay row number**
- **Check for loose flooring around bed space and walkway**
- **Align the walls within the bay row**
- **Check for backing wall restraints**
- **Check for loose wall panels**
- **Check for wall pathressing are behind the medical gas**
- **Check for medical gas stability**
- **Check for electrical sign off certificate**
- **Check for nurse call sign off certificate**
- **Check for bed numbering signage**

TYPICAL BED BAY QA CHECKLIST

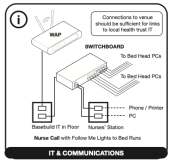


A. POWER

Power infrastructure is fundamental as it needs to be sufficient to support the ICU function.



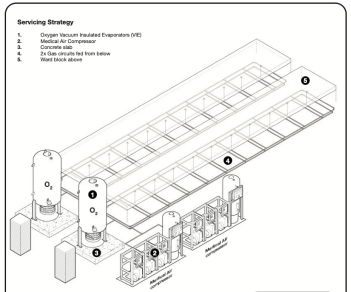
GAS DISTRIBUTION



IT & COMMUNICATIONS

Servicing Strategy

1. Oxygen Vacuum Insulated Evaporators (VIE)
2. Medical Air Compressor
3. Concrete slab
4. 2x Gas circuits fed from below
5. Ward block above

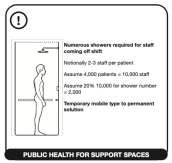


The provision of a **resilient oxygen infrastructure** is crucial to Nightingale hospitals.

B. MEDICAL GASES

Wash hand basin at nurse base. HOT WATER IF POSSIBLE

PUBLIC HEALTH FOR CLINICAL SPACES



Numerous showers required for staff coming off shift

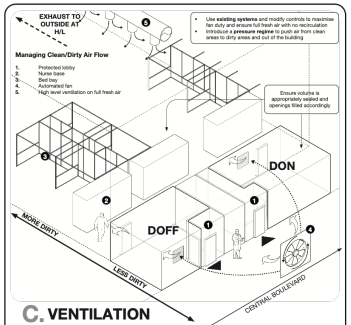
Notionally 2-3 staff per patient

Assume 4,000 patients = 10,000 staff

Assume 25% 10,000 for shower number = 2,500

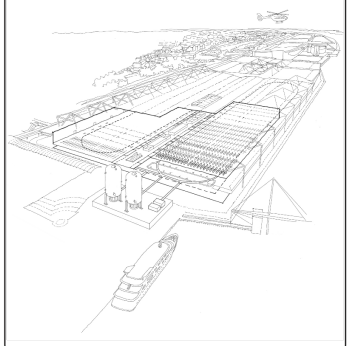
Temporary mobile type to permanent solution

PUBLIC HEALTH FOR SUPPORT SPACES



C. VENTILATION

NHS. NIGHTINGALE
INSTRUCTION MANUAL



BDP architects
www.bdp.com

AI for Pandemic prediction

JOURNAL of TRAVEL MEDICINE

International Society of Travel Medicine
Promoting healthy travel worldwide
Established 1991

Journal of Travel Medicine, 2020, 1–3
doi: 10.1093/jtm/taaa008
Rapid Communication

Rapid Communication

Pneumonia of unknown aetiology in Wuhan, China: potential for international spread via commercial air travel

Isaac I. Bogoch[1,2,*], Alexander Watts[3,4], Andrea Thomas-Bachli[3,4], Carmen Huber[3,4], Moritz U.G. Kraemer[5,6] and Kamran Khan[1,3,4]

[1]Department of Medicine, University of Toronto, Toronto, Canada, [2]Divisions of General Internal Medicine and Infectious Diseases, University Health Network, Toronto, Canada, [3]Li Ka Shing Knowledge Institute, St. Michael's Hospital, Toronto, Canada, [4]BlueDot, Toronto, Canada, [5]Department of Zoology, University of Oxford, Oxford, UK and [6]Centre for the Mathematical Modelling of Infectious Diseases, London School of Hygiene & Tropical Medicine, London, UK

*To whom correspondence should be addressed. Email: isaac.bogoch@uhn.ca

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Abstract

There is currently an outbreak of pneumonia of unknown aetiology in Wuhan, China. Although there are still several unanswered questions about this infection, we evaluate the potential for international dissemination of this disease via commercial air travel should the outbreak continue.

Key words: SARS, air travel, coronavirus, pneumonia, outbreak, zoonosis

On 30 December 2019, a report of a cluster of pneumonia of unknown aetiology was published on ProMED-mail, possibly related to contact with a seafood market in Wuhan, China.[1] Hospitals in the region held an emergency symposium, and that severe acute respiratory syndrome (SARS), the Middle East respiratory syndrome (MERS), avian influenza and several other common respiratory pathogens have been ruled out (http://news.hebei.com.cn/system/2020/01/05/100154729.shtml). On 8 Jan-

First scientific paper on COVID-19:

Bogoch II, Watts A, Thomas-Bachli A, Huber C, Kraemer MUG, Khan K. Pneumonia of unknown aetiology in Wuhan, China: potential for international spread via commercial air travel. *J Travel Med*. 2020;27(2):taaa008. doi:10.1093/jtm/taaa008

Produced by BlueDot AI

Uses and ML and NLP to scan reports
Adds travel tracking and hence predicts pandemics

Wearables and early warnings

WVU Rockefeller Neuroscience Institute and Oura Health unveil study to predict the outbreak of COVID-19 in healthcare professionals

Wednesday, April 08, 2020

Healthcare providers in the WVU Medicine J.W. Ruby Memorial Hospital Emergency Department receive their digital PPE from RNI team members. WVU Photo

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PLOS BIOLOGY

RESEARCH ARTICLE

Digital Health: Tracking Physiomes and Activity Using Wearable Biosensors Reveals Useful Health-Related Information

Xiao Li[1☯], Jessilyn Dunn[1,2☯], Denis Salins[1☯], Gao Zhou[1], Wenyu Zhou[1], Sophia Miryam Schüssler-Fiorenza Rose[3,4], Dalia Perelman[5], Elizabeth Colbert[3], Ryan Runge[1], Shannon Rego[3], Ria Sonecha[1], Somalee Datta[1], Tracey McLaughlin[5], Michael P. Snyder[1]*

1 Department of Genetics, Stanford University School of Medicine, Stanford, California, United States of America, **2** Mobilize Center, Stanford University, Palo Alto, California, United States of America, **3** Spinal Cord Injury Service, Veterans Affairs Palo Alto Health Care System, Palo Alto, California, United States of America, **4** Department of Neurosurgery, Stanford University School of Medicine, Stanford, California, United States of America, **5** Division of Endocrinology, Stanford University School of Medicine, Stanford, California, United States of America

☯ These authors contributed equally to this work.
* mpsnyder@stanford.edu

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Abstract

Contact tracing

Central versus distributed contact tracing

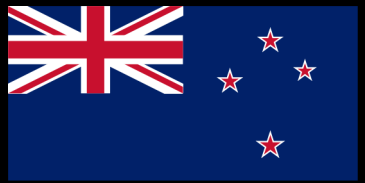
Bluetooth on mobiles
Infected person flags they are now ill
Messages sent to contacts
either via trusted intermediary
or via crypto-exchange

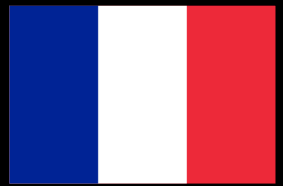
Government tracks all citizens
mobile signals
credit cards
Government contacts people and immobilises them

Decentralised, app

Centralised, app

Centralised, no app





Issues with contact tracing

- Bluetooth works through walls
- IoS turns off Bluetooth when its not used (StopCovid)
- Should you trust the government
- When will the data be destroyed?
- 80% adoption needed

Fowler on split infinitives

“The English-speaking world may be divided into (1) those who neither know nor care what a split infinitive is; (2) those who do not know, but care very much; (3) those who know and condemn; (4) those who know and approve; and (5) those who know and distinguish. Those who neither know nor care are the vast majority, and are a happy folk, to be envied by the minority classes”

The NHS

- One of the largest employers in the world: 1.4M people
- Relies on a national “spine” which processes around 6Bn transactions per year
- Spine was a legacy of a catastrophic project to digitise the NHS
- Obsessed with privacy and security
- Poor IT infrastructure
- Poor supply chains
- Madly fragmented management
- Long-term design-thinking is urgently needed
- Meanwhile…if you are in the UK…clap for your carers and hope!

Digital state - recap

- Digital identity, Social media, Digital universities, Crime and punishment, Money, Health
- Success or failure depends on “system thinking” at government and pan-government levels

- Governments, particularly in the older democracies need to decide what the over-arching principles of their systems should be … the techies can then design solutions to fit.
- “Bolt-on” legislation and orders are very dangerous to such designs