



Impact of the Internet of Things (IoT) to Curb AMR in Future Healthcare Settings

© J. P. Hays

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- One of the Largest University Medical Centres in Europe
- Faculty of Medicine + 3 University Hospitals
- Departments > 50
- Employees ~ 13,000
- In- / Out patients per year: ~ 40,000 / ~ 500,000

TEMPO test

TAILORED-Treatment

Point-of-Care Testing (POCT)

BRINGING THE LAB TO THE PATIENT

JPIAMR - AMRRDT

Working together to build the JPIAMR Virtual Research Institute

INTERNET OF THINGS

- IoT to curb AMR
- Medical Examples
- Implementation Issues

Estimates for the number of connected devices range from 25 to 50 billion by the year 2020 !

Lee & Lee, 2015; Weinberg, Milne, Andonova, & Hajjat, 2015

AMR Relevant IoT - What ?

- Medical Devices
 - Point-of-Care Disease Detection Devices
 - virus, bacteria, parasites, fungi, antibiotic resistances and MGE
 - immunological biomarkers
 - Patient Monitoring Devices - sensors on/in skin, gut, lungs
 - Drug sensors and packaging sensors
 - Environmental Devices
 - Water, soil, air sensors
 - Food packaging sensors
 - Behavioural Devices
 - Telephone Apps - Promoting healthy lifestyles
 - Wearables – Activity monitoring
- } Prevention is Better than Cure



AMR Relevant IoT – Uses ?

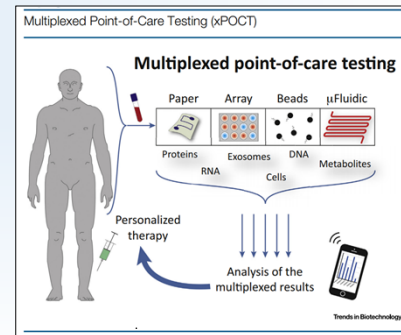
- Disease Detection
- Disease Monitoring
- Drug Prescribing Practices
- Contamination Prevention
- Cleaning Routines
- Quality Control / Quality Assurance
- Drug Inventories and Use-by-dates
- Antibiotic sales without prescription
- Behavioural / Compliance monitoring
- Surveillance
- Food Spoilage
- Environmental Contamination



<https://healthitanalytics.com/news/three-ways-the-internet-of-things-can-improve-patient-safety>

- In the ICU ?

- ICU mortality 18.6 %
- Predictive sensing of infection or patient relapse hours before visible physical signs or seen
- More accurate prediction of infection versus 'sterile' inflammation ?
- Better targeted antibiotic prescribing ('yes/no/wait' decision) ?



<https://www.vectorstock.com/royalty-free-vector/medical-health-care-human-virtual-body-hi-tech-vector-20386068>

<http://dx.doi.org/10.1016/j.tibtech.2017.03.013>

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• Hand Hygiene ?

- Hospital-acquired infections, are one of the top killers of patients.
- Less than half of surveyed organizations adhere to infection prevention guidelines recommended by the World Health Organization and the CDC.
- In 2014, OhioHealth partnered with IBM to deploy wireless RFID sensors
- Linked to a staff member's ID badge
- Don't have to recruit somebody to follow people around
- Not intrusive in the patient care
- Compliance increased 70 % to 90 %

Please wash your hands !



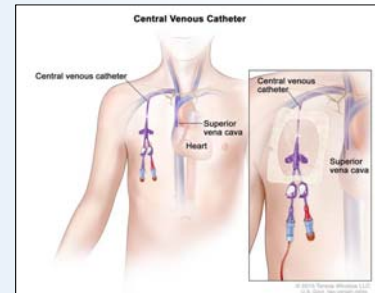
Doctor #4578 didn't wash her hands !



www.infectioncontroltoday.com

• Catheter-Related Bloodstream Infections - CRBSI

- A central venous catheter (CVC) is used to inject parenteral nutrition, blood products or fluids e.g. chemotherapy.
- Additional cost of CRBSI (\$20,000 - \$50,000 dollars per ICU per year)
- Biofilms caused by e.g.

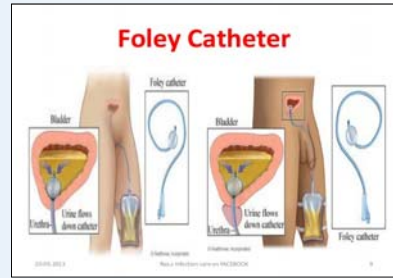


coagulase-negative Staphylococci, *Staphylococcus aureus*, enteric Gram-negative bacilli and *Candida* spp.

- IoT sensors built into catheters to inform clinicians of :
 - 1) Excess biofilm formation
 - 2) Guide early catheter replacement / disinfection
 - 3) Choice of antibiotic (Gram positive/Gram Negative/Antifungal).

- Catheter Associated Urinary Tract Infections - CAUTI

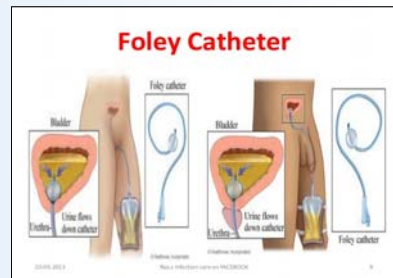
- CAUTI are among the most commonly reported hospital acquired infections.



Doi: 10.1038/s41598-018-26342-3

- Catheter Associated Urinary Tract Infections - CAUTI

- CAUTI are among the most commonly reported hospital acquired infections.



No more unnecessary bladder infections or antibiotic treatments

Using my intelligent IoT Catheter Monitor

I know exactly when to clean or replace my urinary catheter

.... and more convenient



- Compliance Monitoring ?

ABILIFY MYCITE

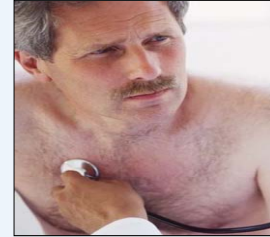
- Ingestible Event Marker (IEM) 1 mm² pill
- The pill gets electrical charge from a patient's stomach.
- Each pill has a unique identification number.
- It transmits a signal to a small, battery-powered patch, which the patient must wear on his or her body.
- A notification that it has been ingested is sent via Bluetooth.



<https://www.forbes.com/sites/nextavenue/2013/04/16/the-newest-high-tech-pill-will-text-when-swallowed/>

Implementation Issues (!)

How do we maximize the benefit of IoT knowing that many varied technologies, environments and hurdles exist ?



- IoT Planning or just random implementation ?
- 'sit back and hope' philosophy

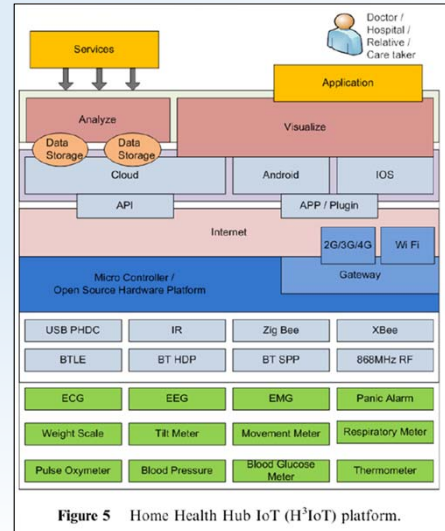
Sr. #	Challenges In Medical Domain
	<i>Challenges</i>
1	Managing device diversity Scale, data volume and performance Flexibility and evolution of applications Data privacy Need for medical expertise CPU capacity
2	Memory of the system Constrained over network performance like bandwidth
3	Data exchange Availability of resources Privacy
4	Hardware implementation and design optimization issues
5	Security challenges
6	Interoperability
7	Technical challenges: Modeling relationship between acquired measurement and diseases. Software implementation of medical analytic schemes.
8	Intelligence in Medical Care.
9	Real time processing System predictability Low power consumption
10	Data integration
11	Unstructured, growing and diverse data at exponential rate



Only technological issues here !

Who is making the implementation decisions and who to convince ?

- Clinician (non-microbiologist)
- General Practitioner
- Financial Manager
- Insurers
- Heads of Department
- General Public at Home
- QC/QA Specialists
- IT Specialists
- Software Writers
- Electrical Engineers
- Regulation Compliance Monitors



<https://doi.org/10.1016/j.jksuci.2016.10.003>



'Old Habits Die Hard'

I always prescribe.
Just in case.



- Healthcare professionals may disagree

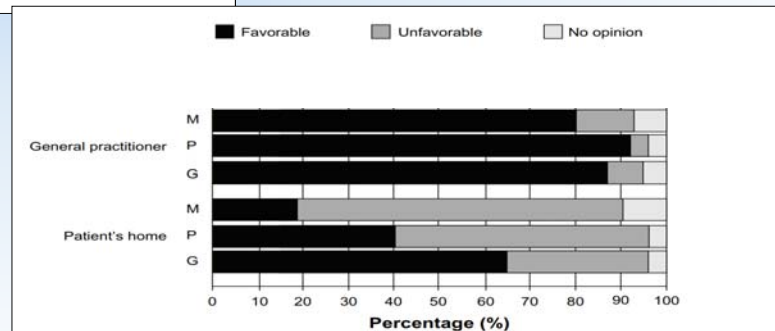
Patient Preference and Adherence

Dovepress

Open Access Full Text Article

ORIGINAL RESEARCH

Perceptions of point-of-care infectious disease testing among European medical personnel, point-of-care test kit manufacturers, and the general public



<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3693915/pdf/ppa-7-559.pdf>

Decentralisation of Healthcare ?

Sore Throat Test and Treat service, which has been trialed in 35 Boots pharmacies



- The skills of clinicians and pharmacists are likely to differ
- People self-presenting to a pharmacy are different from those seen in clinical settings; they are likely to be healthier, so fewer need antibiotics, limiting the potential for antibiotic reduction.
- The service may actually increase antibiotic usage (!)

<https://www.bbc.com/news/health-37961366>

- Technology for technology's sake

“The celebrated startup attracted a flattering New York Times profile and funding from high-profile firms, including Kleiner Perkins Caufield & Byers and Google Ventures.”

Squeezed out: widely mocked startup Juicero is shutting down

The company, which offered pre-sold packets of diced fruits and vegetables that users plugged into its \$400 machines, launched only 16 months ago



▲ Juicero's \$400 machine. Photograph: PR company handout

<https://www.theguardian.com>

- One size fits all ?

- We designed a small, wireless photoplethysmographic device capable of continuously assessing pulse, respiratory frequency and oxygen saturation on the sternum.

Glasin et al. 2014

- Internet of Thing

I
am all you need !



- Smartphone-based devices and smart applications (SBDA)s are Problematic

- Of 94 microbiology-themed apps only 34% had stated medical professional involvement
- Contamination
 - 9 – 25% of mobile devices used by physicians contaminated with pathogenic bacteria
 - Keypads significantly more contamination than touch screens
 - Regular disinfection protocols or throw-away covers ?



doi.org/10.1111/j.1469-0691.2012.03892.x

doi.org/10.1177/1757177413475903

doi.org/10.1016/j.jhin.2008.12.009

Added Value ?

- How do we convince stakeholders of the financial value of IoT in combatting AMR ?
- Note - **In house** versus **society** costs !

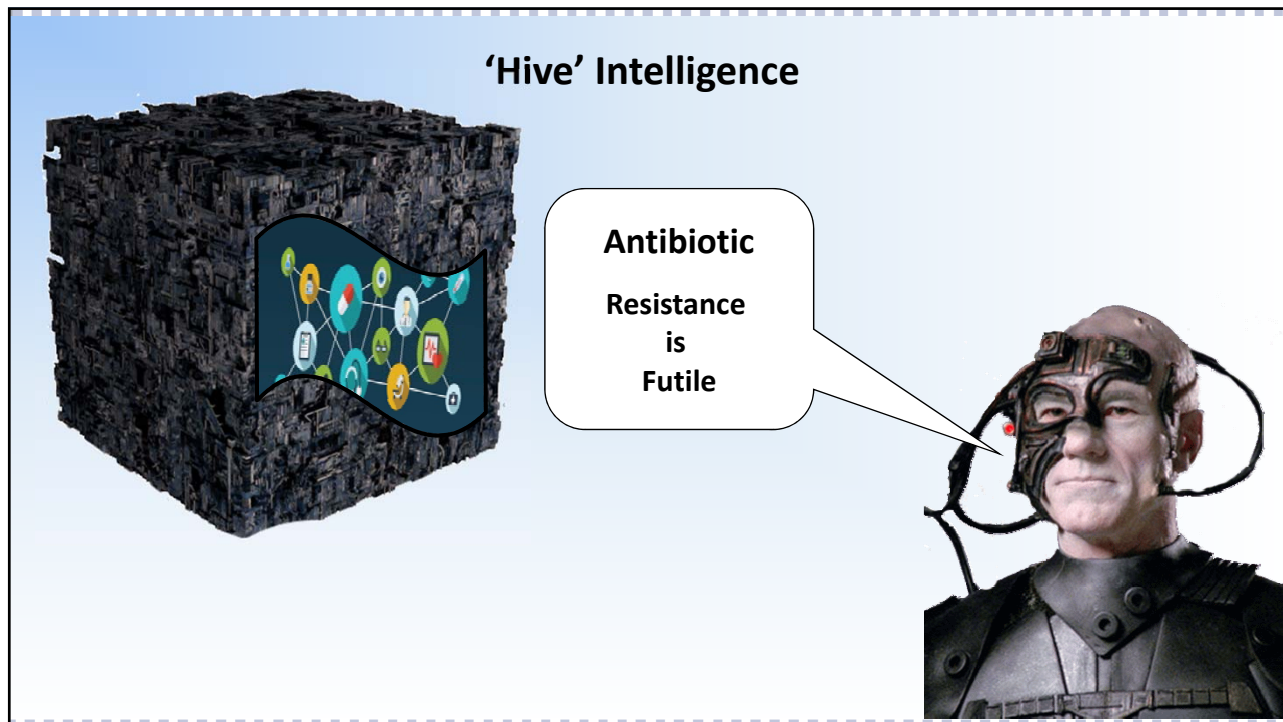


- Big Brother House



- Big Brother House ~~X~~ Hospital ?





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