Public acceptability of computer-controlled antibiotic management: an exploration of automated dosing and opportunities for implementation

Timothy M Rawson , Damien Ming , Sally AN Gowers , David ME Freeman , Pau Herrero , Pantelis Georgiou , Anthony E Cass , Danny O'Hare , Alison H Holmes

PII: S0163-4453(18)30250-0
DOI: https://doi.org/10.1016/j.jinf.2018.08.005
Reference: YJINF 4148

To appear in: *Journal of Infection*

Received date: 5 August 2018
Accepted date: 6 August 2018

Please cite this article as: Timothy M Rawson , Damien Ming , Sally AN Gowers , David ME Freeman , Pau Herrero , Pantelis Georgiou , Anthony E Cass , Danny O'Hare , Alison H Holmes , Public acceptability of computer-controlled antibiotic management: an exploration of automated dosing and opportunities for implementation, *Journal of Infection* (2018), doi: https://doi.org/10.1016/j.jinf.2018.08.005

Letter to the Editor

Running Title: Citizen perceptions on biosensor technology

Public acceptability of computer-controlled antibiotic management: an exploration of automated dosing and opportunities for implementation

Timothy M Rawson[1,*] timothy.rawson07@imperial.ac.uk, Damien Ming[1], Sally AN Gowers[2], David ME Freeman[3], Pau Herrero[4], Pantelis Georgiou[4], Anthony E Cass[3], Danny O'Hare[2], Alison H Holmes[1]

[1]National Institute for Health Research Health Protection Research Unit in Healthcare Associated Infections and Antimicrobial Resistance, Imperial College London, Hammersmith Campus, Du Cane Road, London. W12 0NN. United Kingdom.

[2]Department of Bioengineering, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom

[3]Department of Chemistry, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom

[4]Department of Electrical and Electronic Engineering, Imperial College London, South Kensington Campus, London, SW7 2AZ, United Kingdom

***Corresponding author.** Health Protection Research Unit in Healthcare Associated Infections & Antimicrobial Resistance, Hammersmith Hospital, Du Cane Road, London.W12 0NN. United Kingdom.

Letter to the Editor

Abstract

A paucity of data describing citizen perceptions of novel technologies, including those containing unsupervised computer-controlled systems is currently available. We explored citizen perceptions of using a microneedle biosensor and automated dose control system at a university public festival. Groups of citizens (from 2-6 people per group) attended a short demonstration of a microneedle biosensor and automated dosing system versus a traditional phlebotomy approach over a two-day public festival. Individual groups discussed and reached consensus on a number of short questions regarding their perceptions on the acceptability of such technology. Over the two days, 100 groups participated (56/100 day 1 and 44/100 day 2). The majority of individuals reported high acceptability of microneedle technology (median Likert score 9/10), but the majority believed that doctors should decide what dose of antibiotic is delivered (75/100; 75%). Groups concurred with the acceptability of microneedles to reduce blood tests and pain associated with them. However, concerns were reported over unsupervised computer-controlled programmes making decision about antibiotic dosing. This was driven by concerns over computer error and the inability of systems to contextualise decision making to the human and social context. Future work must consider the greater role of citizen engagement in the development of such technologies, to ensure their acceptability upon implementation in clinical practice.

Main text

Letter to the Editor

Dear Editor,

We read with interest the article by Pan and colleagues on the role of aptamers in infectious diseases.[1] As well as diagnostic and drug delivery, aptamers have a potential role for facilitating the real-time monitoring of antimicrobial therapy. Within healthcare there is a strong emphasis on the development and introduction of novel technologies, including those that make automated, computer-controlled decisions.[2] These technologies offer the potential to enhance the precision with which we practice medicine. However, there are also concerns surrounding the safety of such devices, especially when human decision making is removed from their context.[3] Whilst there is now a healthy debate on the subject of automated, intelligent technologies in the literature and media, there remains a paucity of work exploring citizen views on the acceptability of such intervention.[4,5]

Public festivals offer the opportunity to rapidly collect and explore citizen views on focused subjects, having successfully been used by our group to explore a number of infection related topics.[6,7] Within this study, we explored citizen perceptions of using microneedle-based biosensors and computer-controlled dose optimisation software for the delivery of precision antibiotic dosing. Microneedle-based technology is rapidly expanding, with *in-vivo* clinical studies of these devices underway for monitoring a range of molecules, including antibiotics.[8]

This study was performed across two days (28th and 29th April 2018) at a London university public festival. The festival is open to the public and is visited by over 15,000 people annually. A stand was set up in the "infection zone" (which is visited by >3,000) of the festival (**Figure 1)**. Two phlebotomy arms were set up to demonstrate traditional phlebotomy versus the use of microneedle technology for continuous antibiotic monitoring.[9,10] Over the festival, two researchers (TMR and DM) manned the scenario which was visited by groups of 2-6 people for 10-minute periods. During visits, the group had a 1-minute demonstration of traditional drug monitoring versus the use of microneedle technology on the phlebotomy arms. A simulation of a closed-loop control system for computerised

antibiotic dose optimisation using the microneedle technology was then demonstrated. The groups then had the remaining time to attempt phlebotomy and use the microneedles on the demonstration arms and complete a short survey (**Appendix 1**) providing one set of answers (agreed as a consensus). This methodology was the same on both days except for the questions asked. On day two, individual groups were asked to undertake an additional task to facilitate triangulation of findings from day one. Groups undertook discussion to agree or disagree with the answers obtained from day one and provided comments. For speed and anonymity, group demographics were not collected. All data were collected electronically, using a free data entry interface (typeform.com) and a tablet device. All quantitative responses were analysed in R. Qualitative responses were analysed using line-by-line coding undertaken independently by two researchers (TMR and DM) to group responses into common categories and then themes. This project was reviewed by the regional ethics committee, who deemed that given the anonymous nature of data collection, ethical approval was not required. Participants providing anonymous votes and written justifications at the festival were not required to provide written consent.

In total, the stall was visited by 100 groups (56 /100 day one and 44/100 day two). Median (range) group size was 4 (2-6) people. Groups spent a mean (SD) of 7 (3) minutes discussing and responding to the questionnaire after the short demonstration. Overall, the groups demonstrated good knowledge regarding the importance of antibiotic dose optimisation. On day one, 47/57 (82%) of groups identified that individuals need differing doses of antibiotics to treat their infections. The majority believed that antibiotic monitoring was beneficial for improving treatment of infections, stopping the development of drug resistance, and preventing side effects (36/57; 64%). The majority of individuals believed that their doctor should be the individual who decides what dose of antibiotic is delivered (35/57; 63%), followed by a decision from a computer-controlled programme (15/57; 27%). This was corroborated by participating groups on day two (34/44; 77%) with a high level of agreement for the use of microneedles for antibiotic monitoring (40/44; 93%).

Figure 1 summarises the groups reported agreement with the use of microneedle-based technology to monitor antibiotic concentrations and automated computer-controlled dosing, respectively. These responses used a Likert scale from 1 to 10, where 10 was strong agreement with the statement. These results demonstrated high agreement with use of microneedle technology scoring a median (IQR) of 9/10 (5-10) with the groups having less confidence in automated dosing systems, scoring a median (IQR) of 6/10 (4-8).

Qualitative analysis of the group responses demonstrated common themes driving the agreement with the use of microneedles. These were that the microneedles would be less intrusive and less painful than blood testing. Furthermore, the groups felt that microneedles may also improve the accuracy and therefore effectiveness of antibiotic treatment. However, concerns were also noted about potential errors in the sensor technology and its impact on day-to-day activities, such as showering, if worn for prolonged periods of time. In contrast to sensors, there was a broader range of opinions reported with regards to automated dosing systems. On one hand, citizens believed that computers may be safer and less prone to mistakes compared to humans. However, citizens also reported concerns over the use of unsupervised systems, stating that they would prefer trained humans to be the final decision makers. This was because they believe that humans can contextualise the decisions being made, helping to guide more individualised and humanised decisions on dosing.

Although this study was limited by its small sample size, lack of demographic data, and potential for citizens attending to have a favouring view of science; it demonstrates that citizens are willing to accept the use of novel technologies, including those using computer-controlled decisions. However, there are concerns over the unsupervised nature of such systems, with the need for recommendations to be contextualised by a human still favoured. Future work must consider the greater role of citizen engagement in the development of such technologies, to ensure their acceptability upon implementation in clinical practice.

Contribution statement

TMR developed the idea for this study. All authors contributed significantly towards the development of the methodology and demonstration performed during the study. TMR and DM undertook data collection and primary analysis. All authors contributed to the analysis and finalisation of data. TMR drafted the initial draft of the manuscript with all authors significantly contributing to the development and finalisation of the final iteration for submission.

Search terms

Patient and Public Engagement, biosensors, machine learning

Funding

This report was supported by grants from (i) This report is independent research funded by the National Institute for Health Research Invention for Innovation Grant (i4i), Enhanced, Personalized and Integrated Care for Infection Management at Point of Care (EPIC IMPOC), II-LA-0214-20008. (ii) Imperial College Biomedical Research Centre (BRC).

Transparency declarations

The authors have no conflicts of interest to declare.

Acknowledgements

The authors would like to acknowledge the National Institute of Health Research Imperial Biomedical Research Centre and the National Institute for Health Research Health Protection Research Unit (NIHR HPRU) in Healthcare Associated Infection and Antimicrobial Resistance at Imperial College London in partnership with Public Health England and the NIHR Imperial Patient Safety Translational Research Centre. They would also like to acknowledge Imperial Biomedical Research Centre (BRC). The views expressed in this publication are those of the authors and not necessarily those of the NHS, the National Institute for Health Research or the UK Department of Health.

References

1 Pan Qin, Luo Fengling, Liu Min, Zhang Xiao-Lian. Oligonucleotide aptamers: promising and powerful diagnostic and therapeutic tools for infectious diseases. *J Infect* 2018;**77**(2):83–98. Doi: 10.1016/j.jinf.2018.04.007.

2 Absalom Anthony R, Sutcliffe Nicholas, Kenny Gavin N. Closed-loop Control of Anesthesia Using Bispectral Index. *Anesthesiology* 2002;**96**(1):67–73. Doi: 10.1097/00000542-200201000-00017.

3 Verghese Abraham, Shah Nigam H, Harrington Robert A. What This Computer Needs Is a Physician. *JAMA* 2018;**319**(1):19. Doi: 10.1001/jama.2017.19198.

4 Birnbaum Faith, Lewis Dana M, Rosen Rochelle, Ranney Megan L. Patient engagement and the design of digital health HHS Public Access. *Acad Emerg Med* 2015;**22**(6):754–6. Doi: 10.1111/acem.12692.

5 Money Arthur G, Barnett Julie, Kuljis Jasna, Craven Michael P, Martin Jennifer L, Young Terry. The role of the user within the medical device design and development process: medical device manufacturers' perspectives. *BMC Med Inform Decis Mak* 2011;**11**:15. Doi: 10.1186/1472-6947-11-15.

6 Rawson Timothy M, Castro-Sánchez Enrique, Charani Esmita, Husson Fran, Moore Luke SP, Holmes Alison H, et al. Involving citizens in priority setting for public health research: Implementation in infection research. *Heal Expect* 2017;(June):1–8. Doi: 10.1111/hex.12604.

7 Castro-Sánchez Enrique, Moore Luke SP, Husson Fran, Holmes Alison H. What are the factors driving antimicrobial resistance? Perspectives from a public event in London, England. *BMC Infect Dis* 2016;**16**(1):465. Doi: 10.1186/s12879-016-1810-x.

8 Sharma Sanjiv, El-Laboudi Ahmed, Reddy Monika, Jugnee Narvada, Sivasubramaniyam Sujan, El Sharkawy Mohamed, et al. A pilot study in humans of microneedle sensor arrays for continuous glucose monitoring. *Anal Methods* 2018;**10**(18):2088–95. Doi: 10.1039/c8ay00264a.

9 Rawson Timothy Miles, Sharma Sanjiv, Georgiou Pantelis, Holmes Alison, Cass Anthony, O'Hare Danny. Towards a minimally invasive device for beta-lactam monitoring in humans. *Electrochem Commun* 2017;**82**:1–5. Doi: 10.1016/j.elecom.2017.07.011.

10 Rawson TM, O'Hare D, Herrero P, Sharma S, Moore LSP, de Barra E, et al. Delivering precision

antimicrobial therapy through closed-loop control systems. *J Antimicrob Chemother* 2018;**73**(4):835–43. Doi: 10.1093/jac/dkx458.

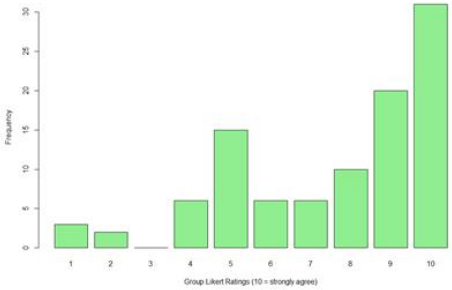
Letter to the Editor

Figure 1. Example of demonstration and Likert score summaries of group acceptance of demonstrated technologies at a public festival

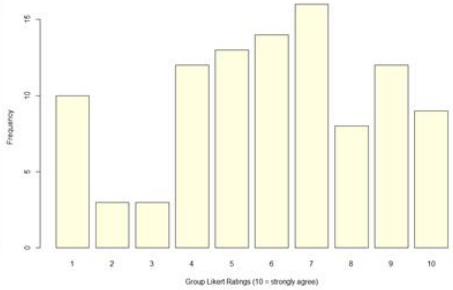
Example of demonstration provided during the open day event

Legend: Phlebotomy arms were set up to allow demonstration of the phlebotomy versus microneedle based drug monitoring and dose optimisation. Researchers presented a short 2 minute demonstration to groups attending the station followed by allowing 5 minutes to try blood taking and microneedle sensing for themselves. Groups then complete a short survey and qualitative evaluation of the session on ipads, which were provided by the team.

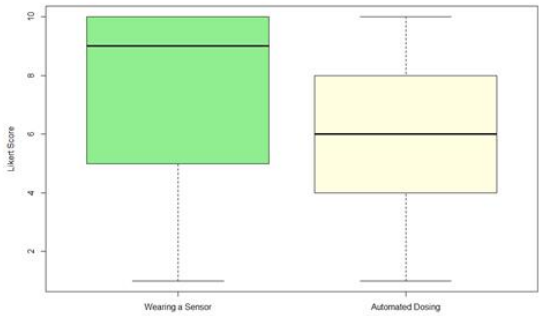
Likert score distribution for agreement with wearing microneedle biosensor device



Likert score distribution for agreement with automated computer dosing systems



Comparison of Likert score distributions for group responses



Supplementary document 1. Questionnaire questions provided to groups at the public festival.

Day 1.

1. True or false: Jim and John need the same amount of antibiotic to treat their infection (picture provided of two people with very different body size)
2. We can monitor antibiotic concentrations to (select one):
    a. Improve the treatment of infections
    b. Stop drug-resistant infections
    c. Prevent side effects
    d. All of the above
3. Antibiotic dosing should be decided by (select one):
    a. My doctor
    b. A computer programme
    c. My pharmacist
    d. The drug company
4. I would wear a microneedle sensor to improve how much antibiotic I receive (Likert score. 1 = strongly disagree, 10 = strongly agree)
5. I would trust a computer to make decisions about my treatment (Likert score. 1 = strongly disagree, 10 = strongly agree)
6. If I had an infection, to improve the dose of antibiotics I receive I would prefer to use (select one):
    a. A biosensor on the skin and a doctor to decide the dose of antibiotic
    b. A biosensor on the skin and a computer to decide the dose of antibiotic
    c. Blood tests and a doctor to decide the dose
    d. I would prefer to take the “normal” dose of antibiotic

Day 2.

1. Yesterday most people (62.5%) told us that the dose of an antibiotic should be decided by a doctor. Do you agree? (Yes/No)
2. Please explain your groups answer (free text)
3. How happy would you be letting a computer decide the dose of antibiotic for you? (Likert score. 1 = strongly disagree, 10 = strongly agree)

4. Please explain your groups answer (free text)
5. Yesterday, most people said that they would be happy to wear a biosensor patch (microneedle) to help monitor their treatment. Do you agree? (Yes/No)
6. I would wear a microneedle sensor to improve how much antibiotic I receive (Likert score. 1 = strongly disagree, 10 = strongly agree)
7. Please explain your groups answer (free text)
8. Which of the following statements do you agree most with? (select one)
    a. We should allow computers to support doctors to make decisions about our treatment
    b. We should allow computers to make decisions about our treatment as the do not make mistakes
    c. We should stick with our current approach to decision making, as it seems to be working okay