Persuading from the Start: Participatory Development of Sustainable Persuasive Data-Driven Technologies in Healthcare

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Abstract. Data-driven technologies can persuade humans to optimize their behavior and context based on objective data. However, current data-driven technologies have limited persuasive powers, because of a misfit between technology, end-users and context. Neglecting end-users in the development process contributes to this misfit and to limited engagement with the to-be-developed technology. This threatens sustainable (long-term) implementation. Therefore, this paper demonstrates how a bottom-up participatory development approach can improve the persuasive design of data-driven technologies and simultaneously increase engagement of end-users to foster sustainable implementation. This is done by describing part of the development of an Audit & Feedback system for healthcare workers at a Dutch regional general hospital. The system intends to contribute to reducing antimicrobial resistance. The rationale for, questions asked at and results of a questionnaire and two focus groups are described.

Keywords: Participatory development · Bottom-up · Data · Antimicrobial resistance (AMR)

1 Introduction

Society faces wicked problems that threaten the quality and safety of healthcare and harm public and individual health [1]. Humans (unintentionally) contribute to these problems by behaving suboptimal (e.g. not complying with guidelines) or creating suboptimal contexts (e.g. creating a messy work environment) [2]. At the same time, there is no doubt that humans and their behavior are vital in developing and implementing successful solutions [3]. However, to cope with the complexity of modern-day challenges, humans require substantial support. Persuasive technologies that take advantage of the potentials that (big) data offer are promising for efficient and sustainable solutions. Data-driven

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technologies can persuade people to optimize their behavior (i.e. individual actions) and context (e.g. working routines) based on objective data [4].

From previous studies in hospitals, we know that (big) data are routinely collected for each individual patient to make diagnostic and treatment decisions and to monitor the patient's status (e.g. result of diagnostic tests) [4]. However, these data are not optimally used for improvement strategies [5]. This relinquishes the opportunities of reflecting on one's work and work processes, disallowing healthcare workers (HCW) to learn from mistakes and to identify good-practices [6]. Especially this reflective form of reusing routinely collected data promises to be a feasible, cost-effective way to support humans: the (big) data are already available, yet not smartly combined, translated and communicated to persuade HCW to improve their behavior and context [4]. This principle is not new. Audit and feedback (AF) has been widely used in healthcare [7]. By summarizing data about aspects of care (i.e. audit) and reporting the findings back (i.e. feedback) to HCW, AF encourages behavior and practice changes. This makes AF an interesting case to study data-driven persuasive technologies.

Although AF is widely used in healthcare, it yields variable and modest effects in practice [7]. AF is mostly organized in a top-down (e.g. audits by healthcare inspectorate [8]) and expert-driven (e.g. indicators created by quality-experts [9]) way. Thereby, feedback, often provided at hospital-level, is hardly useful for HCW to improve their behavior and working routines [4]. Because of this misfit between the datadriven technology, the end-users and their context, current AF have little persuasive powers. The limited persuasiveness and thus added value of AF might be caused by neglecting end-users (in this case HCW) in the AF development process [10]. Making AF persuasive requires extensively studying users and their context throughout the development process. Therefore, the first aim of this paper is to demonstrate **how a bottom-up participatory development approach can improve the persuasive design of data-driven technologies** for their end-user (i.e. HCW), and within their context.

However, this is not enough for sustainable solutions that are used and have an effect in the long-term. Persuasively designed technologies do not guarantee adoption and acceptance in practice. Often, factors that determine successful implementation are studied after the design of the technology. But, implementation is not a post-design step; extensively discussing success factors for implementation from the start of the development process with relevant stakeholders is crucial [11]. As mentioned before, they are the ones responsible for implementing successful solutions in practice. Therefore, the second aim of this paper is to demonstrate **how bottom-up participatory development is a necessary precondition for the development of persuasive datadriven technologies that foster sustainable implementation**. We do this, by showing how our bottom-up participatory approach persuaded end-users (i.e. HCW) from the start to get engaged by and take ownership of the persuasive technology.

Our studies have focused on the application of persuasive data-driven technologies for a striking modern-day example of behavior-inflicted wicked problems: antimicrobial resistance (AMR) [4, 12, 13]. AMR is a threat to global health(care). It is largely caused by humans and relies on human actions to be solved [14]. Persuasive data-driven technologies can inform, support and persuade HCW to optimize their diagnostic, antibiotic (AB) prescription and infection control behavior to limit AMR [15].

We used the CeHRes-roadmap, which guides the holistic development (from problem definition to evaluation) of persuasive technology [11]. Drawing from participatory development, persuasive design and business modelling, it assumes that people, technologies and their contexts are always interrelated. By using this multidisciplinary, socio-technical behavioral approach, we gained deep understanding of the relevant stakeholders, their think- and work-processes and their context, including success factors for future implementation. By studying these, we aim to better match HCW' and other stakeholders' perspectives to optimally benefit from the vast amount of routinely collected data, to improve the quality and safety of healthcare. Incorporating these findings into future AF strategies ensures that they match HCW' needs and their context, thereby increasing the likelihood of uptake and integration in practice [16]. Simultaneously, it builds towards a methodological and conceptual guide for good-practice bottom-up participatory development and implementation processes of persuasive technologies.

2 Methods

A participatory development approach requires multiple complementary methods to grasp the breadth of wicked problems. Therefore, this study used a mixed-methods sequential explanatory design [17]. Quantitative results from a questionnaire provided input for two consecutive (qualitative) focus groups. Since the persuasiveness of a technology largely depends on the **content**, **functionalities** and **design**, this research focused mostly on these aspects. Additionally, attention was paid to implementation factors (e.g. what is the **added value**, how it be **used in practice** and what are **preconditions** for uptake and sustainable use?). In a second focus group, specific attention was paid to the bottom-up participatory research approach in relation to fostering implementation (see Table 1 for rationales and the respective goals of the sub-studies).

Table 1. Elucidating the mixed-methods sequential explanatory design

Method	Method rationale	Sub-study goal
Questionnaire	Specify topics for the focus groups, while integrating AMR-expert views	Prioritize *what* topics for AF, derived from national AMR guidelines, are most relevant to the end-users/HCW
Focus group 1	Realize in-depth discussions (no consensus needed)	Gain insight in *what* audit & feedback topics would be of added value and *why*
Focus group 2	Realize in-depth discussions (no consensus needed)	(1) Gain insight in *how* AF would be used in practice, identify *technology requirements*. (2) Discuss *experiences* via the bottom-up participatory research approach

The study was performed in a Dutch regional general hospital (687 beds) by a research team of three health sciences/psychology researchers, a clinical microbiologist and a pharmacist. End-users (i.e. urologists, residents and co-assistants) from a high-risk AMR department (urology) were included. The University's ethical committee approved the study (190008), all respondents signed an informed consent prior to participating in this study.

2.1 Step 1: Questionnaire (Prioritizing Topics for AF Content)

To prioritize what topics for AF were deemed most relevant, "top-down" content from national AB stewardship guideline [18], infection control audits of the national healthcare inspectorate [19] and key publications on AMR [20–25] were translated into 27 AMR quality-indicators (e.g. "Were cultures taken before the start of empirical treatment?"). To end up with a feasible number of AF topics to be discussed within the hour time-frame of the focus groups, HCW answered the following questions about each predetermined indicator: "Would you like to have in-sight in this indicator? ("No/Yes") and "How relevant would insight in this indicator be for the treatment of individual patients/for limiting AMR?" (5-point Likert items: "Limited – High relevance").

A pilot-test was held with two AMR-experts and a urologist to ensure comprehension and clarity of the questions. All attendees of a regular weekly educational session ($n = 7$, ± 50% of department) filled in the questionnaire after a short presentation about the research. Descriptive analyses were performed in Microsoft Excel (v2016). Responses were summarized in means and standard deviations and the research team discussed the quality-indicators for which more than 75% of respondents saw relevance to avoid individual preferences in the small number of respondents. Through discussion, four AF topics were selected for the consecutive focus groups.

2.2 Step 2: Focus Group 1 (*Content & Added Value*)

The second step was to determine *why* HCW would want to use audit and feedback and *what* (kind of) AF they need for it to be relevant and meaningful. Therefore, the first semi-structured focus group used the results of the questionnaire to discuss the following questions for each topic: (1) "*Why* would you want to have this insight?", (2) "Currently, *what* insight do you use to determine quality of X?", (3) "Which *additional insight* would you need to determine quality of X?". Probing questions were used to gain deeper insight in perceived relevance of and to find preconditions for successful AF.

2.3 Step 3: Focus Group 2 (*Practical Use & Requirements*)

The third step within this study was to determine how HCW would want to use AF in practice and to identify technology requirements (e.g. functionalities and design) for AF, using three examples in the form of low-fidelity prototypes. The first example was the prototype based on focus group 1. For the second and third example, screenshots of existing AMR-tools were requested and attained from the first authors of published papers. The second example was an interactive open-source software app for infection management and antimicrobial stewardship: Rapid Analysis of Diagnostic and Antimicrobial Patterns in R (RadaR), developed to support AMR-experts in analyzing AMRdata [26].

The third example was an existing tool to measure the quality of infection control and antimicrobial use: the Infection Risk Scan (IRIS), developed to easily and transparently communicate risks and improvement areas to HCW and managers [27].

The following three questions (and subsequent probing questions) were asked for each example: (1) "What is your first impression?", (2) "How would you use this in your work?", (3) "How would you like the AF system to support you in doing so?". Furthermore, experiences with the bottom-up participatory research approach and expectations of how this approach might influence the persuasiveness, usefulness and effectivity of the to-be-developed technology, its development and implementation were discussed.

For both focus groups pilot-tests were held with a urologist to ensure clarity and comprehension of the questions. All urologists and urology-residents who work at the studied Dutch regional general hospital were invited for the meetings. One hour of each meeting was dedicated to audit and feedback (April & October 2019). Participants were specifically asked not to think in limitations by data/IT-systems. The focus groups were audio-recorded and transcribed verbatim. Transcripts were coded in Excel by researcher JK. The first round of coding was deductive based on the focus group schemes and was succeeded by open and axial coding to establish sub-codes and variations. Analyst triangulation was applied (independent coding of 25% by another researcher (BB)) [28] and kappa statistic were used to test interrater reliability [29].

3 Results

Sociodemographic characteristics of the questionnaire (QNR) respondents and focus group participants are shown in Table 2. Completing the questionnaire took 20 min on average, and both focus groups took one hour. Interrater reliability was found to be substantial for focus group 1 (Kappa = 0.685, $p < 0.001$) and moderate for focus group 2 (Kappa = 0.479, p 0.017). Participants were unfamiliar with qualitative research in the form of focus groups and with participating in a participatory research project.

Table 2. Respondents'/Participants' characteristics

	n	Age mean (SD)	Gender n		Function n (%)		Experience mean (SD)	
			F	M	Physician	Resident	Function	Hospital
Questionnaire	7*	34.1 (12.4)	4	3	2	2	4.7 (8.3)	4.7 (8.5)
Focus group 1	5	42.0 (10.8)	3	2	3	2	8.8 (8.4)	8.2 (8.8)
Focus group 2	5	41.8 (11.0)	3	2	3	2	8.6 (8.5)	8.0 (9.0)

*Co-assistants (n = 2) were excluded from the focus groups due to their limited experience in urology. Note. Four out of five participants of focus groups 1 and 2 were the same individuals.

The results section of this paper focuses on **content, functionalities and design,** which are all relevant to the persuasive design of data-driven technologies [30]. Results are structured in ***HCW needs*** and ***contextual considerations*** (e.g. perceived added value, anticipated use in practice and preconditions), both relevant to the persuasive design of data-driven technologies and for fostering implementation through persuasive development. Main findings are shown in bold and illustrative quotes in italic.

3.1 Content

The Sequential Explanatory Design Enabled Prioritizing HCW' Content Needs

Questionnaire. Table 3 shows five quality-indicators that were rated as being most relevant. They were discussed in the research team to select the final four AF topics. Indicators three and four were combined into "Updating the (empirical) AB treatment plan once new information (e.g. culture results or advice from colleague) is available".

Table 3. Questionnaire results (most relevant quality indicators)

Most relevant quality-indicators (k = 27)	Relevance patient (n = 5)		Relevance AMR (n = 5)	
	Mean	SD	Mean	SD
Taking cultures before the start of (empirical) AB	4.43	0.79	4.43	0.79
Adequate AB use (e.g. quantity and duration of AB treatment)	3.86	0.69	4.57	0.53
Following advices from other health care professionals	4.00	0.58	4.29	0.49
Adapting the (empirical) AB treatment based on culture results	4.14	0.90	4.43	0.98
Resistance patterns (e.g. surveillance of micro-organisms)	4.29	0.95	4.86	0.38
AB = Antibiotic				

Focus Group 1. In focus group 1, participants expressed their need to have insight in process indicators, such as the **quantity and quality of their diagnostics and AB treatment**. Participants would like insight in outcomes relevant to their patients:

"*Whether you used an AB that allows patients to go home sooner." (R3).* Both positive (how often do we do it right?) and negative insight are relevant. Also, participants were interested in **resistance patterns for specific sub-groups** to tailor their (empirical) AB treatment to individual patients. These insights would have to be **benchmarked** against some standard, such as local policies, guidelines or comparisons to other hospitals. Lastly, participants expressed the need for information **tailored to function groups**.

HCW Could Easily Envision the Added Value of and Preconditions for AF

Focus Group 1. Respondents saw clear added value of AF **to evaluate and improve the status quo** and consequently **proactively change current policies and practices**. Furthermore, AF can **facilitate objective discussions** about performance. Lastly, it creates **room for discussions on innovations** (e.g. phage therapy). For AF to be useful in practice, respondents warned that some content was more relevant for inpatients than for outpatients (e.g. changing empirical treatments after receiving culture results). In consultation with the pharmacist and the hospital data-manager, the decision was made to focus on inpatients in the rest of the studies, because there would be many missing data for the outpatient population that are crucial for meaningful audits (e.g. GP cultures). Furthermore, participants urged the need to, **from the early development phases, start thinking about practical issues and consequences for policies and working routines that insights could convey**: "*What if the patient is on your OR table, you are doing the time-out and your culture results are not known yet. Do you cancel the operation? … Then we have to be honest: if the results are not in yet, you willingly and knowingly take a risk, how small that risk may be." (R1).* Therefore, participants wanted to extensively discuss goals to make them realistic and relevant for their patients and for limiting AMR. Also, participants mentioned data management, including their own registration behavior, and ICT-support as a crucial precondition for successful AF. Lastly, participants require an open culture, in which quality of their work can be discussed safely.

HCW Required Examples to Envision and Verbalize Technological Needs

Creating The Prototype. Results of focus group 1 were translated into a lo-fi prototype together with a creative company specialized in developing serious games (see Fig. 1 for detailed description). The prototype consisted of screenshots and was not interactive. The prototype was merely used to show what an AF technology could entail to help participants to envision and verbalize their needs.

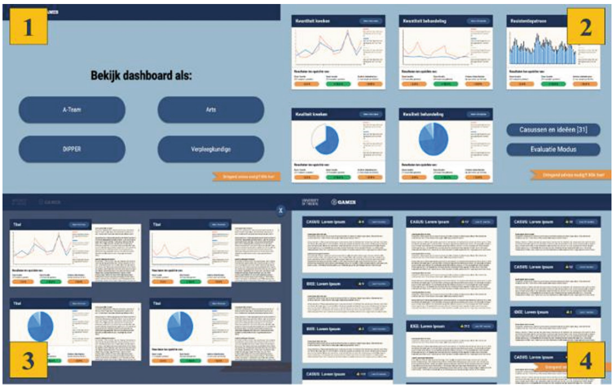

Fig. 1. Prototype quality dashboard based on findings of focus group 1.

Screen 1: specific user-roles (e.g. physician, AMR-expert). Screen 2: overview of the five topics that were deemed important (i.e. quality & quantity of cultures/AB treatment, *resistance patterns). Trends over time are shown in graphs and coloured scores below (e.g. results relative to the past 12 months). A benchmark with other regional hospitals is shown below the graphs in coloured scores. When clicking on a graph, screen 3 opens: more details and background information (e.g. justification of score calculations). Screen 4: discussion mode, HCW can upload interesting cases, improvement plans or innovations to discuss.*

Could Easily Envision the Anticipated Use in Practice

Focus Group 2. To realize the potential added value as envisioned in the first focus group, participants indicated that elaborate AF, such as the examples provided, would be interesting to use in practice. However, participants envisioned that the examples would **not be used in daily practice**, but could be used in three "modes":

(1) In **(half) yearly meetings dedicated to AMR** aiming to evaluate status quo, discuss improvement strategies and strive for innovation. More frequent meetings were not deemed relevant, since resistance patterns and working routines (incl. individual behaviors) do not change fast, nor feasible, because of time-constraints.
(2) In **ongoing educational meetings of residents** (e.g. monthly) aiming to create AMR awareness and to reflect upon one's individual impact on quality and safety of care through their own diagnostic and AB treatment behaviors.
(3) As a **decision-support system** to make more proactive decisions both on individual patient level (e.g. choosing the right AB given the culture results) and on policy level (e.g. regularly changing empirical treatment policy).

The three modes could coexist in practice with different target groups, for whom the technological functionalities should differ.

3.2 Functionalities

HCW Could Clearly Verbalize Functionality Needs for Each AF Mode

Focus Group 2. Consequently, HCW expressed needs with regards to AF content within the before mentioned modes:

(1) Quality management: participants required an **overview** to quickly see what does (not) go well and improvement suggestions. The task force, AMR-experts and other interested HCW should be able to dive into the data **in-depth** (e.g. filtering and zooming in on subgroups/-topics). Both trends over time and benchmarks with other regional hospitals were required.
(2) Education: additional needs for educational purposes were the possibility to **zoom in to individual cases** that can be reflected upon. AF should support reconstructing and improving the reasoning underlying decisions (i.e. declarative information).
(3) Decision-support: participants required **timely advice** to optimize diagnostic and AB treatments for individual patients (i.e. personalized medicine) and warnings to proactively change empirical treatment.

HCW Could Clearly Envision Preconditions to Foster Implementation

Focus Group 2. Participants thought that AF alone would not improve outcomes. Additional activities are required **to engage HCW** in accepting and using AF in one or various modes such as creating a **task force**, having a **consensus meeting** and **training** on how to use AF. Participants did not want responsibility for collecting, analyzing and interpreting data, due to time constraints, insufficient data management skills and AMR knowledge: *"I think it can be dangerous for us to look at this ourselves… it is difficult to assess quality." (R3).* To come to **substantiated improvement strategies** that fit AF data and HCW working routines, and that contribute to improved individual patient care and limiting AMR, participants required **help from data-, quality-, and AMR-experts**.

3.3 Design

HCW Could Clearly Verbalize Design Needs

Focus Group 2. Participants appreciated a **clear and structured overview**, with **easily interpretable graphs** and an easy-to-use **navigation structure** (e.g. using workbook tabs per topic): *"Yes, I find it nicely structured. You still have to be careful not to present too much information on one tab, but it works nice with the tabs." (R4).* Participants preferred **graphs over numbers**, especially for scores that were too complicated to be represented with a single score. Furthermore, there must be **coherence between visuals and scores** (e.g. use green for positive). One participant indicated that choices on for example colors and lay-out should be based on generic design rules for dashboards.

3.4 Participatory Research

Participants were **enthusiastic** about the participatory research, because it incorporates their perspective from the start of development: *"You start from the user groups that you want to reach. From the whole process you learn if and how they are open for that and how they want to be persuaded." (R5).* At first, participants had some doubts about the qualitative and open nature of the focus groups. Along the way, participants realized its added value, because the abstracted findings and **prototype matched their needs and context**. However, concerns remained regarding **generalizability** of the findings: *"It could well be that it does not work in other hospitals … We cannot just translate our findings to the rest of the country." (R3).* Finally, planning focus groups with as many HCW as possible was difficult, reflecting the **time- and resource-intensive** characteristics of focus groups.

4 Discussion

This paper demonstrated how participatory, bottom-up development can serve as the foundation for persuasive design and simultaneously increase engagement of end-users to foster sustainable implementation. The approach allowed for continuous formative evaluations to iteratively elicit and sharpen HCW' needs, contextual considerations and their interdependencies to design persuasive technology. The participatory bottom-up development persuaded end-users to remain engaged throughout the development process. By paying attention to needs and contextual considerations from the start of the persuasive development process, a fostering implementation context was provoked.

4.1 Persuasive Data-Driven Technologies

From the discussions on HCW' needs and contextual considerations, persuasiveness of AF technology mostly relied on content, functionalities and design. These are also of importance to the Persuasive System Design (PSD) Model [31]. Our bottom-up participatory approach revealed an additional layer to the PSD's design principles, thereby supporting the PSD postulates. By matching "top-down"-context requirements with bottom-up HCW' needs from the start of the development process, credibility support elements (e.g. expertise) are incrementally and transparently integrated in the content of the technology ánd in the end-users' perceptions. Primary task support elements (e.g. personalization) should be adaptable to the anticipated mode of use (e.g. quality management or training), while preconditions for successful AF use required changes in current working and training schemes. Users and their context thus shape the process of persuasive development and implementation, while reversely, the process shapes its users and context. For each wicked behavior-inflected problem, the users and context vary, requiring iteratively adaptable persuasive features and implementation strategies. Thus, the PSD should be complemented with models and strategies from the early development phases to increase persuasiveness and foster sustainable implementation, such as via actionable AF [32] and the multidimensional benefit framework [33].

4.2 Bottom-Up Participatory Approach to Foster Engagement/Ownership

To optimize the fit between humans, their context and the persuasive technology, an agile development process is required [34]. In this paper, we demonstrated why iterative phases are crucial for successful development: both HCW and the research team needed and used several sessions to clearly envision and verbalize their needs and the direction of the project. Additionally, we believe that the iterative nature of the bottomup participatory approach persuaded end-users (i.e. HCW) to engage with and take ownership of the development of the persuasive technology. Engagement needs to grow, especially for subjects that are not within the primary tasks of HCW, such as AMR [35]. We saw increased engagement with the subject (i.e. AMR), but also with reflecting on one's work (i.e. embracing quality management). The focus groups provided time to discuss matters that otherwise would have not been discussed. Also, the participatory approach created enthusiasm among the participants for the research topic and a stronger working relationship with the researchers. With that, it created more willingness to facilitate other research activities, such as data collection. Effect on implementation has yet to be determined, but participatory research has persuaded HCW to be closely engaged with this research. We are convinced that this is a crucial precondition to realize ownership and nurture local champions, which are highly recommended for successful sustainable implementation [36]. This study concretized ownership by showing that

HCW still require top-down support from data-, quality-, and AMR-experts to come to substantiated and sustainable improvement strategies. Rethinking ownership in terms of shared-ownership is thus required to embrace the true multidisciplinary nature of the complex wicked problems that the world faces today.

4.3 Professionalizing Persuasive Design

The bottom-up participatory approach allowed us to continuously adapt the persuasive design of the technology to HCW' needs and contextual considerations. In the persuasive design field, the need to match user, context and technology is not new [11]. However, few studies explicitly report on how this match can be realized. This study adds to this knowledge base by demonstrating the dependencies between HCW' needs and contextual considerations, and how the persuasive design can incorporate them. Furthermore, it showed how a bottom-up participatory approach can help in iteratively optimizing the user, context, technology fit. Crystallizing values and requirements from mixed-methods and transparently reporting on the taken steps are required to further professionalize the field of persuasive technology. First steps in that direction have already been taken by Kip et al. [37] and Van Velsen et al. [30].

4.4 Strengths and Limitations

A limitation to this bottom-up approach is that top-down considerations were mostly ignored. For example, only minimal efforts were taken to match Inspectorate audits that are a legal obligation. Matching new to existing initiatives is one of the key-factors of implementation and we did take actions to avoid 'discovering the wheel all over again'. We included top-down content by basing the discussions on existing quality-indicators from AMR-experts. Also, top-down considerations were incorporated in the questionnaire and focus group schemes by including AMR-experts in our research team. Including the top-down perspective indirectly thus was an explicit choice within our development project, because we were interested in studying the bottom-up approach (i.e. letting the HCW' needs and context guide the development process). Starting with a small and homogeneous target-group allowed us to gain in-depth insights at the cost of generalizability. This reflects a methodological issue apparent in all (pilot-) development processes and urges the need for local adaptations to the to-be-developed technology.

5 Conclusion

A bottom-up participatory development approach has the potential to improve the persuasive design of data-driven technologies and simultaneously increase engagement of end-users. This is a necessary precondition for the development of persuasive datadriven technologies that foster sustainable implementation.

References

1. World Health Organization [WHO]: World health statistics 2018: monitoring health for the SDGs, sustainable development goals. WHO, Geneva, p. 47

2. Holden, R.J., et al.: SEIPS 2.0: a human factors framework for studying and improving the work of healthcare professionals and patients. Ergonomics **56**(11), 1669–1686 (2013)
3. Lorencatto, F., et al.: Driving sustainable change in antimicrobial prescribing practice: how can social and behavioural sciences help? J. Antimicr. Chemother. **73**(10), 2613–2624 (2018)
4. Keizer, J., et al.: Finding the match between user and expert for optimal audit and feedback: sense-making of routinely collected antimicrobial data Journal of Antimicrobial Resistance and Infection Control (2019). p. Manuscript submitted for publication (copy with author)
5. Micallef, C., et al.: Secondary use of data from hospital electronic prescribing and pharmacy systems to support the quality and safety of antimicrobial use: a systematic review. J. Antimicrob. Chemother. **72**(7), 1880–1885 (2017). https://doi.org/10.1093/jac/dkx082
6. Van Mourik, M.S.M., et al.: Designing surveillance of healthcare-associated infections in the era of automation and reporting mandates. Clin. Infect. Dis. **66**(6), 970–976 (2018)
7. Ivers, N., et al.: Audit and feedback: effects on professional practice and healthcare outcomes. Cochrane Database Syst. Rev. **13**(6), CD000259 (2012)
8. Mitchell, B.G., et al.: Time spent by infection control professionals undertaking healthcare associated infection surveillance: a multi-centred cross sectional study. Infect. Dis. Health **21**(1), 36–40 (2016). https://doi.org/10.1016/j.idh.2016.03.003
9. Bal, A.M., Gould, I.M.: Antibiotic stewardship: overcoming implementation barriers. Curr. Opin. Infect. Dis. **24**(4), 357–362 (2011). https://doi.org/10.1097/QCO.0b013e3283483262
10. Colquhoun, H.L., et al.: Advancing the literature on designing audit and feedback interventions: identifying theory-informed hypotheses. Implement Sci. **12**(1), 117 (2017)
11. Van Gemert-Pijnen, J.E.W.C., et al.: eHealth Research, Theory and Development: A Multidisciplinary Approach. Routledge, London (2018)
12. Keizer, J., et al.: Antimicrobial Resistance Safety Stewardship (AMSS): empowering healthcare workers through quality management. In: International Forum on Quality & Safety in Healthcare: People Make Change (2019)
13. Keizer, J., et al.: Cross-border comparison of antimicrobial resistance (AMR) and AMR prevention measures: the healthcare workers' perspective. Antimicrob. Resist. Infect. Control **8**(1), 123 (2019). https://doi.org/10.1186/s13756-019-0577-4
14. World Health Organization [WHO]: Global Action Plan on Antimicrobial Resistance. WHO, Geneva (2015)
15. Kullar, R., et al.: The "epic" challenge of optimizing antimicrobial stewardship: the role of electronic medical records and technology. Clin. Infect. Dis. **57**(7), 1005–1013 (2013)
16. Baysari, M.T., et al.: The effectiveness of information technology to improve antimicrobial prescribing in hospitals: a systematic review and meta-analysis. Int. J. Med. Inform. **92**, 15–34 (2016). https://doi.org/10.1016/j.ijmedinf.2016.04.008
17. Creswell, J.W., et al.: Advanced mixed methods research designs. In: Tashakkori, A., Teddlie, C. (eds.) Handbook on Mixed Methods in the Behavioral and Social Sciences. Sage, Thousand Oaks (2003)
18. Stichting Werkgroep Antibioticabeleid [SWAB]: SWAB Guidelines for Antimicrobial Stewardship. SWAB, Bergen (2017)
19. Inspectorate, H.a.Y.C.: Toetsingskader TIP3. Ministry of Health, Welfare and Sports (2016)
20. World Health Organization [WHO]: Diagnostic stewardship: A guide to implementation in antimicrobial resistance surveillance sites. WHO (2016)
21. Filice, G., et al.: Antimicrobial Stewardship Programs in Inpatient Settings: A Systematic Review (2013)
22. Dellit, T.H., et al.: Infectious diseases society of America and the society for healthcare epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. Clin. Infect. Dis. **44**(2), 159–177 (2007)
23. Centers for Disease Control and Prevention [CDC]: Core Elements of Hospital Antibiotic Stewardship Programs. US Department of Health and Human Services, Atlanta, GA (2014)

24. Storr, J., et al.: Core components for effective infection prevention and control programmes: new WHO evidence-based recommendations. Antimicr. Resist. Infect. Control **6**, 6 (2017)
25. Zingg, W., et al.: Hospital organisation, management, and structure for prevention of healthcare-associated infection: a systematic review and expert consensus. Lancet Infect. Dis. **15**(2), 212–224 (2015). https://doi.org/10.1016/s1473-3099(14)70854-0
26. Luz, C.F., et al.: Rapid analysis of diagnostic and antimicrobial patterns in R (RadaR): interactive open-source software app for infection management and antimicrobial stewardship. J. Med. Internet Res. **21**(6), e12843 (2019). https://doi.org/10.2196/12843
27. Willemsen, I., Kluytmans, J.: The infection risk scan (IRIS): standardization and transparency in infection control and antimicrobial use. Antimicr. Resist. Infect. Control **7**, 38 (2018)
28. Patton, M.Q.: Enhancing the quality and credibility of qualitative analysis. Health Serv. Res. **34**(5 Pt 2), 1189–1208 (1999)
29. Landis, J.R., Koch, G.G.: The measurement of observer agreement for categorical data. Biometrics **33**(1), 159–174 (1977). https://doi.org/10.2307/2529310
30. Van Velsen, L., et al.: Designing eHealth that matters via a multidisciplinary requirements development approach. JMIR Res. Protoc. **2**(1), e21 (2013). https://doi.org/10.2196/resprot.2547
31. Oinas-Kukkonen, H., Harjumaa, M.: Persuasive systems design: key issues, process model, and system features. Commun. Ass Inf. Syst. **24**, 28 (2009)
32. Hysong, S.J., et al.: Audit and feedback and clinical practice guideline adherence: making feedback actionable. Implement Sci. **1**, 9 (2006). https://doi.org/10.1186/1748-5908-1-9
33. Wang, Y., et al.: Big data analytics: understanding its capabilities and potential benefits for healthcare organizations. Technol. Forecast. Soc. Change **126**, 3–13 (2018)
34. Hekler, E.B., et al.: Agile science: creating useful products for behavior change in the real world. Transl. Behav. Med. **6**(2), 317–328 (2016). https://doi.org/10.1007/s13142-016-0395-7
35. Charani, E., Holmes, A.H.: Antimicrobial stewardship programmes: the need for wider engagement. BMJ Qual. Saf. **22**, 885–887 (2013). https://doi.org/10.1136/bmjqs-2013-002444
36. Zimmerman, B., et al.: Front-line ownership: generating a cure mindset for patient safety. Healthcare Pap. **13**(1), 6–22 (2013)
37. Kip, H., et al.: Putting the value in VR how to systematically and iteratively develop a value-based VR application with a complex target group. In: CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), Glasgow, Scotland (2019)