Abstract

Background: Artificial Intelligence (AI) may favorably support surgeons but may result in concern among patients and their relatives.

Objective: To evaluate attitudes of patients and their relatives towards the use of AI in neurosurgery.

Methods: In this two-stage cross-sectional survey, a qualitative survey was administered to a focus group of former patients to investigate their perception of AI and its role in neurosurgery. Five themes were identified and used to generate a case-based quantitative survey administered to inpatients and their relatives over a two-week period. Presented AI platforms were rated appropriate and acceptable using 5-point Likert scales. Demographic data was collected. A Chi Square test was performed to determine whether demographics influenced participants' attitudes.

Results: In the first stage, 20 participants responded. Five themes were identified: interpretation of imaging (4/20; 20%), operative planning (5/20; 25%), real-time alert of potential complications (10/20; 50%), partially autonomous surgery (6/20; 30%), fully autonomous surgery (3/20; 15%). In the second stage, 107 participants responded. The majority felt appropriate and acceptable to use AI for imaging interpretation (76.7%; 66.3%), operative planning (76.7%; 75.8%), real-time alert of potential complications (82.2%; 72.9%), and partially autonomous surgery (58%; 47.7%). Conversely, most did not feel that fully autonomous surgery was appropriate (27.1%) or acceptable (17.7%). Demographics did not have a significant influence on perception.

Conclusions: The majority of patients and their relatives believed that AI has a role in neurosurgery and found it acceptable. Notable exceptions remain fully autonomous systems, with most wanting the neurosurgeon ultimately to remain in control.

Introduction

Artificial Intelligence (AI) is the ability for a machine to think and learn. Machine Learning (ML) is a subset of AI where algorithms are trained with variable levels of human direction or supervision to learn patterns by studying large amounts of data and to perform specific tasks without external programming[1]. In the last decade, advances in computational power and data storage, and the increasing availability of big digital data sets have contributed to an exponential increase in AI research. AI platforms have the capability to boost productivity and disrupt workflows.

Healthcare is a major sector promoting AI development with the prospect to augment healthcare providers in decision-making, predicting patients' outcomes and enhancing efficency[2,3]. To date, several AI platforms have been described within surgery where they may augment decision-making across all phases of care[4], including: pre-operative diagnosis and surgical planning[5,6]; intra-operative surgical workflow[7,8]; providing post-operative reporting[9] and predicting post-operative outcome[10]. Similar assistance has been reported in neurosurgery, especially within the subspecialties of oncology, spinal, and vascular surgery, by using platforms for image interpretation[9–11], pre- and intra-operative planning[12–15] and outcome prediction[16–20]. Except for early attempts described on animal models[21], the development of autonomous AI-guided robotic surgery still requires the development of an appropriate regulatory framework, supported by ethical guidelines and scientific evidence[22]. Barriers to the adoption of such AI platforms in surgery are probably related to the interactions between patients, surgeons and intelligent computers[4,23].

A greater understanding of the attitudes towards AI of healthcare providers and patients may provide valuable insights and ultimately overcome some of these barriers to adoption. Pinto dos Santos et al.[24] found that undergraduate medical students, despite limited understanding of AI, had a clear awareness of its future relevant impact in medicine, particularly in radiology. This is likely to grown as AI systems mature to be usable by non-AI experts[15]. Similar findings were encountered in recently performed surveys of clinicians[25,26]. The attitudes of patients towards AI in medicine have also been explored which has shown a reluctance in being treated solely by AI systems[27]. Longoni et al.[28] identified that "*uniqueness neglect"* was the public's greatest concern. By operating only in standardized processes, AI platforms were incapable of adapting to the specific condition of each individual, divergent from the rest of the population. When a treatment tailored to one's unique characteristics was proposed, the respondents showed a reduced resistance to medical AI platforms.

In view of the proposed applications of AI in surgery, and their position as key stakeholders, patient perception should be considered to guide future research, and inform future patient and public engagement. To the best of our knowledge, there are no previous studies in the literature that investigate patient perception of AI in the different surgical specialties. To this end, the aim of this study was to evaluate patient attitudes towards AI applied in neurosurgical procedures.

71 We further appraised to what extent educating patients about AI and its application in surgery
72 influenced their perspectives.

Methods

A cross-sectional two-stage mixed-method quantitative and qualitative survey was performed: (1) to comprehensively appraise people's knowledge about AI and its current applications in healthcare, and to examine their attitudes about AI applied in neurosurgery (qualitative survey), and, (2) to further explore attitudes identified in the first study with a case-based survey with participants including both patients and patients' relatives (quantitative survey). In this study, patients that had undergone surgery for brain tumors were chosen as an exemplar, both because it has been suggested that patients undergoing such high-risk surgery may be particularly concerned about the introduction of new technologies, and because these patients are managed by the senior author.

Both surveys were administered following good practice in conducting and reporting of survey research[29]. Results for both surveys were reported according to the AAPOR standard definitions[30]: (1) questionnaires with 50%-80% of all applicable questions answered were considered partial responses; (2) questionnaires with more than 80% of all applicable questions answered were considered complete responses. Since the purpose of this study was to recruit patients and their relatives for planning and advising on future research, ethical approval was not required[31].

Qualitative Survey:

The qualitative survey was conducted in September 2019 among patients from UK, who underwent surgical interventions for brain tumors, and had previously expressed an interest in participating in focus group. The questionnaire was designed with accredited qualitative research methods[29,32] on Qualtrics Survey Platform (Qualtrics, LLC, SAP American Inc. company). The form was sent to the participants, with an invitation link, via email. Two email attempts at contact were made, and the survey was closed after two weeks from its initial distribution. Participants were presented with four open ended questions to ascertain their knowledge of and attitudes towards AI (**Table 1**). Responders likely feelings on undergoing brain surgery with the application of AI platforms were appraised before and after a brief description of AI platforms operated in clinical care.

Quantitative Survey:

The quantitative survey was designed to further explore the major themes that emerged from the qualitative survey. Guidelines of good practice in conduct and reporting of survey research had been observed[29]. The survey was carried out from the 1st October 2019 to the 16th October 2019 at the Department of Neurosurgery of our institution. The questionnaire was devised on Qualtrics Survey Platform (Qualtrics, LLC, SAP American Inc. company), and was administered in person using a tablet computer (iPad). Participants were recruited from inpatients and their relatives. For inpatients, the following inclusion criteria were used: (1) undergone brain surgery; (2) adequate capacity to understand and complete the survey; (3) willingness to participate. Relatives of the participating inpatients were invited to complete the survey, and only the ones inclined to be involved were enrolled. A case-based design was adopted. Five cases were illustrated, representing the different roles of AI in neurosurgery, and different levels of involvement and

autonomy (**Table 2**). Participants were asked to identify themselves as the patient, and to rate, using 5-point Likert-scales, how *appropriate* – how much they "agree" – with the role of AI platforms described, and how *acceptable* – how "comfortable" they would be – to personally undergo that treatment. Following the last case, an optional comment box was provided to allow participants the opportunity to report any further remarks. Demographic data was collected with an anonymized 7-part multiple-choice questionnaire (**Table 3**) submitted to the participants at the end of the survey. The obtained responses were applied to categorize participants into different groups based on age, gender, ethnicity, religion, education and profession.

Data Analysis:

The first survey responses were analyzed qualitatively looking for major themes in participants answers. Participants' knowledge about AI was evaluated with the first question (**Table 1** – **Q1**). Participants' responses to the second question (**Table 1** – **Q2**) were reviewed to identify major themes proposed to apply AI systems in neurosurgery. Responses obtained before and after the brief description of AI (**Table 1** – **Q3** and **Q4**) were compared to perceive if appropriate information influenced patients' acceptance of AI in neurosurgery. The second survey responses were analyzed quantitatively by calculating the proportions of responders finding the use of AI appropriate and acceptable for each case. Following this, statistical correlation was examined between participants' perception on appropriateness and acceptance of AI in neurosurgery and demographics. Demographic data was dichotomized into: gender ('male' and 'female'); age ('age 45 or less' and 'age 46 or greater'); ethnicity ('white' and 'non-white)'; religion ('religious' and 'non-religious'); educational level ('A-levels or less' and 'Degree or more'); specialization ('Specific field of specialization'). Statistical analysis was performed on Vassarstats (Vassar College, Poughkeepsie, NY, USA) using Chi-square 2x5 contingency tables. Tests were run between dichotomized pairs, comparing, separately, the appropriateness and acceptability rates, reported by responders for each presented case, with respect of demographics. A value of $p < 0.001$ was considered statistically significant, accounting for the Bonferroni correction ($n = 30$)[33].

Results

Qualitative Survey

A total of 20 complete responses were gathered in the first stage survey. Over half of the participants (11/20; 55%) confirmed their knowledge about AI, describing it as a "computer program", "system", or "software", competent in supporting humans in "decision-making". Four participants (20%) asserted that AI consisted of "robots" and that they were "responsible for replacing the human workers" or "capable of performing the surgery". The remaining responders (5/20; 25%) declared their absolute lack of knowledge about AI. The twenty responses to the second question (**Table 1** – **Q2**) were analyzed to identify major themes for the role of AI in neurosurgery. In some of the responses, more than one role was mentioned. A total of five AI functions in neurosurgery were highlighted (**Table 4**): (1) pre-operative interpretation of imaging (4/20; 20%), (2) operative planning (5/20; 25%), (3) real-time alert of potential complications (10/20; 50%), (4) partially autonomous surgery (6/20; 30%), and (5) fully autonomous surgery (3/20; 15%).

Overall, participants were willing to undergo brain surgery supported by AI platforms – 35% of them (7/20) reported to be "happy" to do so (**Table 1** – **Q3**). Nine of the responders (45%) stated that the following criteria had to be met for them to be operated on with an AI-assisted neurosurgeon: (1) receiving clear and exhaustive information by the neurosurgeon about the exact application of the adopted AI system and its involvement in the surgery itself (4/20, 20%); (2) AI systems used only to support the neurosurgeons and not to replace them (4/20; 20%); (3) further research before their application (2/20; 10%). Four participants (20%) expressed their fear in undergoing AI-assisted brain surgery.

Responses to the fourth question (**Table 1** – **Q4**) displayed a definite change in perception in seven participants (35%). These participants were more comfortable undergoing AI-assisted brain surgery when better informed about the role of AI as supporting, rather than replacing, neurosurgeons (3/20; 15%), and the valuable information AI can provide to neurosurgeons (4/20; 20%). Suggestions to comprehensively educate the patients before surgery were reported (2/20; 10%). Two participants (2/20; 10%) were somewhat more comfortable undergoing AI-assisted brain surgery, but still had concerns over the potential improper use of clinical information, especially for financial purposes. The remaining eleven participants (55%) reported no differences in their attitudes as they were already inclined in receiving the abovementioned surgery (8/20; 40%) or because of their strong apprehension towards new technologies in surgery (3/20; 15%).

Quantitative Survey:

In total, 107 complete responses were collected within the two-week study period. Most participants were female (62/107; 57.9%), white (87/107; 81.3%), with most responders being 46 years old or older (56/107; 52.3%). The majority identified themselves as religious (64/107; 59.8%) and had completed GCSEs or A-levels (59/107; 55.1%). Participants' attitudes toward

the appropriateness of the presented AI platforms are demonstrated in **Figure 1**. The largest number of responders (88/107; 82.2%) found appropriate – to some degree (35/107; 32.7%) or entirely (53/107; 49.5%) – the application of AI for real-time alert of potential complications (**Table 2** – **Case 3**). Similar numbers of participants (82/107; 76.7%) believed that it was appropriate to use AI for pre-operative interpretation of imaging (**Table 2** – **Case 1**) and operative planning (**Table 2** – **Case 2**). AI systems capable of performing parts of the surgery autonomously (**Table 2** – **Case 4**) was considered appropriate by over half of the participants (62/107; 58%). On the other hand, few responders (29/107; 27.1%) felt it would be appropriate for an AI system to perform the surgery entirely autonomously (**Table 2** – **Case 5**).

For each AI system, participants' acceptability rates partially diverged with the reported rates of perceived appropriateness (**Figure 2**). The majority of participants reported they would feel comfortable – both "extremely" and "somewhat" – in the event of being treated with the systems presented, when used for operative planning (80/107; 75.8%), intraoperative real-time alert of potential complications (78/107; 72.9%), and pre-operative interpretation of imaging (71/107; 66.3%). Less than half of the responders would accept AI system performing autonomously parts of the surgery (53/107; 47.7%), and few (19/107; 17.7%) would personally accept being operated on by an AI platform performing autonomously the entire operation.

There was no significant difference in the perception of different demographic groups towards the presented cases. In addition, three major themes emerged among the open-ended comments (**Table 5**): (1) acceptance of AI systems applied as support rather than substitute the neurosurgeon (8/20; 40%); (2) predilection in interacting with a human doctor capable of sympathizing with patient's feelings (4/20; 20%); (3) importance of performing further research on AI, especially regarding the accuracy of data used for its development (3/20; 15%)**.**

Discussion

In healthcare, the introduction of innovative technologies is intended to facilitate healthcare providers' jobs and improve patients' management and outcomes[34]. AI has the capacity to disrupt a wide range of surgical workflows from intelligent diagnostic tools, image analysis algorithms, operative planning and scheduling and intra-operative support with robotic systems. In neurosurgery, image analysis algorithms have been developed to rapidly detect and categorize vertebral compression fractures[10], cerebral aneurysms[11] and brain tumors[9]. A number of machine learning algorithms have also been used to prognosticate in neurosurgical patients including risk assessment of vasospasm following subarachnoid hemorrhage[20], survival prediction in traumatic brain injury[19], and in patients with glioblastoma receiving bevacizumab treatment[16]. Such pervasive disruption from a single technology is unprecedented and there is an urgent need to ascertain patient attitudes towards the implication of the introduction of AI systems into surgery, particularly in neurosurgery.

In this two-stage survey, we present one of the most comprehensive assessments of the attitudes of neurosurgical patients and their relatives towards AI in neurosurgery. In the first stage of the survey, we found that more than half of the responders (55%) provided a partially accurate definition of AI, with the 25% of participants totally unaware of it. Coupled to this, there was evidence that people's understanding of AI applied in medicine somewhat differed from the actual state of the technology. This phenomenon is likely due to the way AI has been reported in the media with exaggerated claims on the technology capabilities and implications[35].

Initial resistance towards innovative technologies may interfere with the implementation of systems advantageous for care providers and patients. Several studies focused on the importance to establishing trust between people and AI presented in different areas of interest[36-38]. The recommendations from these studies, include: (1) introducing new AI applications in gradual phases to the public, highlighting their principal role of assistant rather than autonomous systems; (2) engaging in clear and transparent dialogue with the public, detailing the specific functions and benefits related to AI; (3) providing statistical data from previous testing to support the safety of AI. Responses obtained in our qualitative survey displayed similar findings. The brief information on current AI systems applied in medicine generated evident changes in participants attitudes and perceptions. In spite of the difficulty in relieving people from their concerns, seven responders (35%) said they felt more comfortable towards AI when aware of its role in supporting the neurosurgeons. Furthermore, one of the responders, previously unwilling to undergo AI-assisted brain surgery, accepted the described AI systems when aware of their application as supportive tools rather than autonomous robots. These results, along with comments from two participants (10%), suggested that patient education will increase their trust in AI and their willingness in being operated on by AI-assisted neurosurgeons.

Our survey highlighted clear concerns from respondents about being operated on by a fully autonomous surgical robot system. These findings are analogous to studies on the public attitudes towards autonomous vehicles in aviation and car transport[37,38]. These studies reported

people's resistance to autonomous systems but acceptance in technologies assisting the conductor. Such studies have identified fears within the public that they will be replaced by superior technologies, anxiety that systems will lose control, and difficulties in identifying concrete benefits and prospected risks[34,37,38]. Public lack of awareness distorts their perception of AI, giving the impression of autonomous systems rather than supportive tools[39]. These misconceptions result in greater skepticism and distrust toward the application of AI in healthcare, due to the false belief of AI providing standardized medical care, unable to administer treatments tailored to patients' unique characteristics and symptoms - *"uniqueness neglect"*[28]. Conversely, in accordance with similar findings in different fields, less resistance was reported for AI systems providing assistance to healthcare providers[24,37,39].

Overall, participants found appropriate AI platforms designed to act as support for the neurosurgeon, with the purpose of improving the surgical outcome and reducing the risks of complications. At the same time, responders largely disagreed with AI systems performing surgery entirely autonomously. Of interest, respondents appeared to be comfortable with the concept of partially autonomous surgery, but less so when they were asked if they happy as the patient to undergo partially autonomous surgery. These results were consistent with similar findings reported in literature, underlining the importance, for the patients, to relate with human doctors, to receive a unique treatment according to their decision, and their resistance towards autonomous systems[4,24,27,28,37].

The present study has several limitations. The qualitative methodology selected for the first phase of the study was aimed at examining patients' general knowledge and main concerns regarding AI with the purpose of creating the quantitative survey. Despite the small sample size, and the selection of patients who expressed their interest in being part of a focus group, the *a priori* aim of identification of major themes was accomplished, suggesting a likely external validation of the collected findings. The quantitative survey sample size was small and a convenience sample of patients which may limit the ability to generalize the findings. Patients with brain tumors may perceive their illnesses as more severe, which may bias their responses away from AI given the grave impact of complications. However, although neurosurgical patients may be more reluctant to the use of AI in neurosurgery, the perceived attitudes were mostly positive, supporting the principle findings that most patients would find AI appropriate and acceptable also in other surgical specialties. Definitions and clarifications of the presented cases were meant to improve participants' understanding of the displayed AI platforms; however, due to the self-completion of the survey, it was impossible to probe whether they fully comprehended the cases. Nonetheless, current evidence suggests that self-completed surveys are more accurate as responders do not attempt to please the interviewer[40].

Future research should include patients undergoing other procedures such as elective spinal surgery, to obtain a greater understanding of attitudes towards AI within a wider and more heterogeneous neurosurgical population.

Conclusions

Our survey highlighted patient awareness of AI but demonstrated a limitation of their understanding of the current state of the technology. Importantly, the survey showed clear concerns from patients and their relatives about the use of fully autonomous surgical robotic systems in their care despite this level of technology currently being a thing of science fiction. Respondents were much more comfortable with the use of AI systems to augment their care and support the surgeon. This highlights the value patients place on maintaining human interaction in their treatment and should be used as a basis for guiding the disruption these technologies are likely to have on the way surgery is practiced in the future.

Funding:

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

1. Senders JT, Arnaout O, Karhade A V., et al. Natural and Artificial Intelligence in Neurosurgery: A Systematic Review. *Neurosurgery*. 2018;83(2):181-192. doi:10.1093/neuros/nyx384

2. Obermeyer Z, Emanuel EJ. Predicting the Future — Big Data, Machine Learning, and Clinical Medicine. *N Engl J Med*. 2016;375(13):1216-1219. doi:10.1056/NEJMp1606181

3. He J, Baxter SL, Xu J, Xu J, Zhou X, Zhang K. The practical implementation of artificial intelligence technologies in medicine. *Nat Med*. 2019;25(1):30-36. doi:10.1038/s41591-018-0307-0

4. Hashimoto DA, Rosman G, Rus D, Meireles OR. Artificial Intelligence in Surgery. *Ann Surg*. 2018;268(1):70-76. doi:10.1097/SLA.0000000000002693

5. Titano JJ, Badgeley M, Schefflein J, et al. Automated deep-neural-network surveillance of cranial images for acute neurologic events. *Nat Med*. 2018;24(9):1337-1341. doi:10.1038/s41591-018-0147-y

6. Bennett CC, Hauser K. Artificial intelligence framework for simulating clinical decision-making: A Markov decision process approach. *Artif Intell Med*. 2013;57(1):9-19. doi:10.1016/j.artmed.2012.12.003

7. Volkov M, Hashimoto DA, Rosman G, Meireles OR, Rus D. Machine learning and coresets for automated real-time video segmentation of laparoscopic and robot-assisted surgery. In: *2017 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE; 2017:754-759. doi:10.1109/ICRA.2017.7989093

8. Stauder R, Okur A, Peter L, et al. Random Forests for Phase Detection in Surgical Workflow Analysis. In: *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Vol 8498 LNCS. ; 2014:148-157. doi:10.1007/978-3-319-07521-1_16

9. Choi KS, Choi SH, Jeong B. Prediction of IDH genotype in gliomas with dynamic susceptibility contrast perfusion MR imaging using an explainable recurrent neural network. *Neuro Oncol*. 2019;21(9):1197-1209. doi:10.1093/neuonc/noz095

10. Burns JE, Yao J, Summers RM. Vertebral Body Compression Fractures and Bone Density: Automated Detection and Classification on CT Images. *Radiology*. 2017;284(3):788-797. doi:10.1148/radiol.2017162100

11. Ueda D, Yamamoto A, Nishimori M, et al. Deep Learning for MR Angiography: Automated Detection of Cerebral Aneurysms. *Radiology*. 2019;290(1):187-194. doi:10.1148/radiol.2018180901

12. Chang K, Beers AL, Bai HX, et al. Automatic assessment of glioma burden: a deep learning algorithm for fully automated volumetric and bidimensional measurement. *Neuro Oncol*. 2019;21(11):1412-1422. doi:10.1093/neuonc/noz106

13. Hollon TC, Pandian B, Adapa AR, et al. Near real-time intraoperative brain tumor diagnosis using stimulated Raman histology and deep neural networks. *Nat Med*.

2020;26(1):52-58. doi:10.1038/s41591-019-0715-9

14. Durand WM, DePasse JM, Daniels AH. Predictive Modeling for Blood Transfusion Following Adult Spinal Deformity Surgery. *Spine (Phila Pa 1976)*. 2018;43(15):1. doi:10.1097/BRS.0000000000002515

15. Nielsen A, Hansen MB, Tietze A, Mouridsen K. Prediction of Tissue Outcome and Assessment of Treatment Effect in Acute Ischemic Stroke Using Deep Learning. *Stroke*. 2018;49(6):1394-1401. doi:10.1161/STROKEAHA.117.019740

16. Chang K, Zhang B, Guo X, et al. Multimodal imaging patterns predict survival in recurrent glioblastoma patients treated with bevacizumab. *Neuro Oncol*. 2016;18(12):1680-1687. doi:10.1093/neuonc/now086

17. Kim JS, Merrill RK, Arvind V, et al. Examining the Ability of Artificial Neural Networks Machine Learning Models to Accurately Predict Complications Following Posterior Lumbar Spine Fusion. *Spine (Phila Pa 1976)*. 2018;43(12):853-860. doi:10.1097/BRS.0000000000002442

18. Scheer JK, Smith JS, Schwab F, et al. Development of a preoperative predictive model for major complications following adult spinal deformity surgery. *J Neurosurg Spine*. 2017;26(6):736-743. doi:10.3171/2016.10.SPINE16197

19. Rughani AI, Dumont TM, Lu Z, et al. Use of an artificial neural network to predict head injury outcome. *J Neurosurg*. 2010;113(3):585-590. doi:10.3171/2009.11.JNS09857

20. Dumont TM, Rughani AI, Tranmer BI. Prediction of Symptomatic Cerebral Vasospasm after Aneurysmal Subarachnoid Hemorrhage with an Artificial Neural Network: Feasibility and Comparison with Logistic Regression Models. *World Neurosurg*. 2011;75(1):57-63. doi:10.1016/j.wneu.2010.07.007

21. Shademan A, Decker RS, Opfermann JD, Leonard S, Krieger A, Kim PCW. Supervised autonomous robotic soft tissue surgery. *Sci Transl Med*. 2016;8(337):337ra64-337ra64. doi:10.1126/scitranslmed.aad9398

22. Yang G-Z, Bellingham J, Dupont PE, et al. The grand challenges of Science Robotics. *Sci Robot*. 2018;3(14):eaar7650. doi:10.1126/scirobotics.aar7650

23. Mirnezami R, Ahmed A. Surgery 3.0, artificial intelligence and the next-generation surgeon. *Br J Surg*. 2018;105(5):463-465. doi:10.1002/bjs.10860

24. Pinto dos Santos D, Giese D, Brodehl S, et al. Medical students' attitude towards artificial intelligence: a multicentre survey. *Eur Radiol*. 2019;29(4):1640-1646. doi:10.1007/s00330-018-5601-1

25. Oh S, Kim JH, Choi S-W, Lee HJ, Hong J, Kwon SH. Physician Confidence in Artificial Intelligence: An Online Mobile Survey. *J Med Internet Res*. 2019;21(3):e12422. doi:10.2196/12422

26. Liyanage H, Liaw S-T, Jonnagaddala J, et al. Artificial Intelligence in Primary Health Care: Perceptions, Issues, and Challenges. *Yearb Med Inform*. 2019;28(01):041-046. doi:10.1055/s-0039-1677901

27. Tran V-T, Riveros C, Ravaud P. Patients' views of wearable devices and AI in healthcare: findings from the ComPaRe e-cohort. *npj Digit Med*. 2019;2(1):53. doi:10.1038/s41746-019-0132-y

28. Longoni C, Bonezzi A, Morewedge CK. Resistance to Medical Artificial Intelligence. Inman JJ, Schmitt BH, eds. *J Consum Res*. 2019;0:1-22. doi:10.1093/jcr/ucz013

29. Kelley K, Clark B, Brown V, Sitzia J. Good practice in the conduct and reporting of survey research. *Int J Qual Heal Care*. 2003;15(3):261-266. doi:10.1093/intqhc/mzg031

30. The American Association for Public Opinion Research. Standard Definitions: Final Dispositions of Case Codes and Outcome Rates for Surveys. 9th edition, AAPOR. https://www.aapor.org/AAPOR_Main/media/publications/Standard-Definitions20169theditionfinal.pdf; 2016 Accessed September 25, 2019.

31. Health Research Authority (HRA) / INVOLVE. Patient and public involvement in research and research ethics committee review. http://invo.org.uk/wp-content/uploads/2016/05/HRA-INVOLVE-updated-statement-2016.pdf; 2016 Accessed October 15, 2019.

32. Pope C, Ziebkand S, Mays N. Qualitative research in health care: Analysing qualitative data. *BMJ*. 2000;320(7227):114-116. https//doi.org/10.1136/bmj.320.7227.114

33. Dunn OJ. Multiple Comparisons Among Means. *J Am Stat Assoc*. 1961;56(293):52. https//doi.org/10.1080/01621459.1961.10482090

34. Sanson-Fisher RW. Diffusion of innovation theory for clinical change. *Med J Aust*. 2004;180(S6):55-56. https//doi.org/10.5694/j.1326-5377.2004.tb05947.x

35. Brennen AJS, Howard PN, Nielsen RK. An Industry-Led Debate: How UK Media Cover Artificial Intelligence. *Reuters Inst Study Journal Fact Sheet.* 2018;(December):1-10.

36. Siau K, Wang W. Building trust in artificial intelligence, machine learning, and robotics. *Cut Bus Technol J*. 2018;31(2):47-53.

37. Hengstler M, Enkel E, Duelli S. Applied artificial intelligence and trust—The case of autonomous vehicles and medical assistance devices. *Technol Forecast Soc Change*. 2016;105:105-120. https//doi.org/10.1016/j.techfore.2015.12.014

38. MacSween S. A Public Opinion Survey- Unmanned Aerial Vehicles for Cargo, Commercial, and Passenger Transportation. Paper presented at: 2nd American Institute of Aeronautics and Astronautics "Unmanned Unlimited" Conf. and Workshop & Exhibit; September 15-18, 2003; Reston, VA. https//doi.org/10.2514/6.2003-6519

39. Fast E, Horvitz E. Long-Term Trends in the Public Perception of Artificial Intelligence. Paper presented at: 31st AAAI Conference on Artificial Intelligence; February 4-10, 2017; San Francisco, CA.

40. Del Giudice A, Plaum J, Maloney E, Kasner SE, Le Roux PD, Baren JM. Who Will Consent to Emergency Treatment Trials for Subarachnoid Hemorrhage? *Acad Emerg Med*. 2009;16(4):309-315. https//doi.org/10.1111/j.1553-2712.2009.00367