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Artificial intelligence in healthcare: Public perception of robotic surgery

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Abstract. *Breakthrough after breakthrough, artificial intelligence has proven itself to be of support to the healthcare system. Public and private hospitals are improving their services through the adoption of different technologies, such as wearables, 3D printing, virtual reality or surgical robots, among others. This paper investigates the public opinion on one of the healthcare areas affected by the evolution of artificial intelligence, the robotic eye surgery (RES). The assessment is done from the safety, technology and pricing perspectives, considering the demographic distribution of the sample. The results reveal that RES is considered a safer alternative to traditional procedures performed by surgeons alone. The technology's influence over the medical field is seen as a significant contributor to public trust in RES. The price evolution for such procedures in the following years is seen with slight optimism. The demographic variables used in the paper have a weak or no relationship with public trust in RES, the opinion on its price evolution or the view over technology's impact on the medical field. Understanding the present view over robotic surgery is valuable for developing support measures, awareness campaigns and adjusting the healthcare providers' decisions.*

Keywords: Robotic surgery, Robot-assisted surgery, Eye surgery, Surgical robot, Medical technology, Artificial intelligence, Healthcare.

Introduction

Breakthrough after breakthrough, artificial intelligence has proven itself to be of support to the healthcare system. Public and private hospitals are improving their services through the adoption of different technologies, such as wearables, 3D printing, virtual reality (VR) or surgical robots, among others.

The first surgical robot was used for arthroplasty in 1983 in Canada (Rubin, 2017). Nowadays, some of the most famous surgery systems are: da Vinci (for various procedures), Ion (for biopsies of the lung), Mako (for hip and knee replacement surgery), NAVIO (for knee replacement surgery), and Monarch (for bronchoscopies), to name a few (Carfagno, 2019).

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While robotic surgery can be viewed as an autonomous system performing the surgery without human intervention, this is not the case for the majority of systems. Instead, most surgery robots today are assisting a certified surgeon during the procedure. This comes with advantages, such as: an increase in precision and stability, less trauma, 3D view with magnification, automation, multitasking etc. and disadvantages, such as: high implementation and maintenance costs, heterogeneous learning curves, the possibility of malfunction, difficulties in gaining patient trust etc. (Soomro et al., 2020; Pitcher et al., 2012; Nichols, 2019; Pandey & Sharma, 2019).

As technology is evolving and demand for robotic surgery is increasing, the spark in competition is driving improvements in quality while lowering implementation costs (Perez & Schwaitzberg, 2019). Still, the speed of development in robotic surgery might not coincide with a similar growth in public awareness and trust.

Context

With Artificial intelligence (AI), various technologies are brought together, allowing software robots to simulate human intelligence. It has a cross-disciplinary approach covering computer science, mathematics, neuroscience and other fields, enabling machines to perceive, learn, reason, take action and optimize their performance through feedback.

The estimated global market size for AI in healthcare in 2021 was USD 10.4 bn., being expected to reach USD 120.2 bn. by 2028, CAGR 41.8%, including software, hardware and services solutions (Grand View Research, 2021).

By application, in 2020, AI use in healthcare was the most present in clinical trials for trial designing, followed by robot assisted surgery, as surgical robot manufacturers started to develop strategic partnerships with AI technology providers and data analytics companies (Grand View Research, 2021). The "virtual assistants in healthcare" segment is expected to have significant growth by 2028, as a result of an increase in smartphone and AI use among patients and medical professionals (Grand View Research, 2021). The key players in AI for healthcare are IBM, NVIDIA, Nuance Communications, Microsoft, Intel and DeepMind (Grand View Research, 2021).

However, AI use in healthcare is seen through the fear that robots could completely replace doctors (Shuaib et al., 2020). Still, PwC (2018) estimates that the health sector will require a greater use of AI and robotics, alongside more human workers, healthcare being one of the industries with lower automation potential, at least for the following 20 years. Moreover, the same study has shown that people are willing to embrace the use of AI and robots in surgery and in other healthcare areas.

The traditional approaches in healthcare are transformed by the use of AI (Bellini & D'Ascenzo, 2020). For example, the use of predictive analytics for surgery lacks the depth and flexibility of AI (Loftus et al., 2020). Branches of AI, such as natural language processing (NLP), machine learning (ML) and deep learning (DL), used alongside big data have the potential to improve pre- and post-operative decision making (Loftus et al., 2020), especially since some studies have shown that physicians and residents have limitations in their statistical literacy when interpreting p-values, relative risks and odds ratios (Schmidt et al., 2021; Anderson et al., 2013; Petrova et al., 2019; Krouss et al., 2016).

The medical field benefits from AI in a number of ways, such as: reducing error in diagnosis (Ehteshami Bejnordi et al., 2017), aiding in medicine development (Fleming, 2018), improving hospital efficiency (Anagnoste et al., 2021; Sennaar, 2020), improving surgery precision and outcome (Edwards et al., 2018) etc.

In ophthalmology, ML can be used for more accurate diagnosis in certain pathologies and better screening for glaucoma, cataract, macular degeneration and diabetic retinopathy (Jayadev &

Shetty, 2020). AI predicts with >93% accuracy which patients would benefit from laser refractive surgery, such as laser-assisted subepithelial keratectomy (LASEK) or small incision lenticule extraction (SMILE) surgeries (Jayadev & Shetty, 2020). Furthermore, AI can predict the risk of surgical complications as a result of laser-assisted in-situ keratomileusis (LASIK), such as post-surgical ectasia (Ting et al., as cited in Jayadev & Shetty, 2020).

Eye surgical procedures benefit from AI assistive robots, which eliminate the surgeon's hand tremors, improve precision and adjust the instrument's speed. For instance, telemanipulation systems used in surgical procedures surrounding the retina allow for micrometric precision and speed control around this delicate area, which is especially useful as, under anesthesia, the eye still slightly moves with each heartbeat (Edwards and Hubschman, as cited in Cimberle, 2021).

However, the speed of development in robotic surgery might not coincide with a similar growth in public awareness and trust. For instance, a number of studies on public perception of robotic surgery concluded that there are misperceptions and limited understanding of the technology and benefits behind it, being imperative for healthcare providers to explain the AI procedures while being aware of the misinformation the patients could have come across (Stai et al., 2020; Boys et al., 2016; Buabbas et al., 2020). The public perception of AI in healthcare was also analyzed within a study based on social media data, showing that people tend to have positive attitudes toward AI use in the medical field, but they perceive it as unfriendly, advising medical practitioners to focus on meeting the patients' emotional needs (Gao et al., 2020).

Research aims and methods

The paper aims to assess the current public opinion on robotic eye surgery (RES), contributing to the literature studying public perception of robotic surgery. The investigation is focused on Romanian citizens and based on the research question: *How is RES perceived by the public, in terms of: (1) safety (compared with traditional procedures performed by surgeons alone), (2) price evolution in the following years, and (3) technology as an agent of change in the medical field; considering the demographic variables: gender, age, education level, income level, the existence of eyesight issues, and the intention of wearing glasses.*

A self-administered, online survey was distributed to random Romanian citizens in 2021, gathering 137 valid answers. The sample size meets the requirements for a 95% confidence level, 8.4% margin of error. The survey has two sections. The first section is aimed at gathering demographic data (i.e., gender, age, area, education, income, the existence of eyesight issues, and the intention of wearing glasses). The second section has 24 items, each item evaluated with a 6-point Likert scale, for assessing the public opinion on different aspects of RES (1 = "strongly disagree"; 2 = "disagree", 3 = "slightly disagree", 4 = "slightly agree", 5 = "agree", 6 = "strongly agree"). The survey was analyzed in SPSS through exploratory factor analysis (EFA) on the Likert items, a chi-square test to check the association between people who reported eyesight issues and their intention of wearing glasses, one-sample t-tests to check the public agreement with the statements, Spearman's and Pearson correlations. Index variables were created through arithmetic mean of the observed variables for each of the three identified factors. A stepwise regression model was constructed for measuring the impact of two of the index variables (i.e. the perceived level of technology's influence over the medical field, and the level of optimism regarding the price evolution of RES in the following years) over the third one (i.e. the level of trust in RES).

Findings

Sample structure

The 137 valid answers came from 43% men and 57% women. 91% of the respondents live in the urban area.

Most of the respondents were aged between 18-24 (56%) and 25-34 (27%), followed by 15% 35-44 year olds and 2% 45-54 year olds. No respondents were over 55 years old.

26% out of the 137 respondents said they have an income of over 5000 lei, the rest being evenly distributed between the under 1000 lei, 1000-1999 lei, 2000-2999 lei, 3000-3999 lei and 4000-4999 lei intervals. The income level has a moderate tendency to increase with age, $r_s = .592$, $p<.001$. The current national average net earnings per person is 3561 lei, the highest average earnings being in IT with 8671 lei (INSSE, 2021).

As for the education level, 27% of the respondents said their last form of completed education is high school, 34% have a bachelor's diploma, 34% have a master's diploma, and 5% have a PhD. The level of education has a strong tendency to increase with age, $r_s = .668$, $p<.001$, and a moderate tendency to be higher at higher income levels, $r_s = .595$, $p<.001$.

59% of the respondents reported eyesight issues, 85% of them saying they intend on wearing glasses. It might be the case that the 15% who are not interested in wearing glasses consider their eyesight problems as negligible or they intend on using alternatives to glasses. Out of the 41% respondents who said they do not have eyesight issues, 18% intend on wearing glasses, probably for protective purposes. More precisely, a strong association was found between people who reported eyesight issues and their intention of wearing glasses, $\chi^2(1, N=137) = 61.48$, $p<.001$, Phi =.670, $p<.001$. No significant association was found between age and eyesight issues for the age interval covered by the sample.

Factor analysis

Eight Likert items were removed as a result of EFA. After accounting for cross-loadings, the remaining 16 items were split into three constructs: (1) *safety*, representing the level of trust in RES, (2) *technology*, representing the perceived level of technology's influence over the medical field, and (3) *price*, representing the level of optimism regarding the price evolution of RES in the following years. The items constructing the *safety* factor were coded s1-s7, the ones for *technology* t1-t5, and the ones for *price* p1-p4. Table 1 presents each factor alongside its Cronbach's Alpha value.

Table 1. Factor analysis results

Factor	Item code	Item	Cronbach's Alpha (std.)
safety	s1	In ophthalmology, the use of robots and machines is particularly needed due to the advantages it provides: higher accuracy, reduced tremor, low risk of collateral damage.	.784
	s2	The fact that human involvement is reduced will determine a reduction in the risk of human error.	
	s3	The number of malpractice cases will decrease proportionally with the increase in the number of robotic eye surgeries.	
	s4	Since the human interaction between the doctor and the patient is minimal during the surgery, the risk of transmission of diseases and viruses is low.	
	s5	The fear of having a surgery performed by a less experienced or well-known doctor will be eliminated by the use of robots.	

Factor	Item code	Item	Cronbach's Alpha (std.)
	s6	The recovery time of the patient after these interventions will be diminished.	
	s7	Individuals will choose robotic eye surgery over traditional procedures for high-risk surgeries.	
technology	t1	Individuals who are familiar with the concept of artificial intelligence will be more open to the idea of robotic eye surgery.	.682
	t2	Doctors with additional knowledge regarding the use of artificial intelligence in eye surgery will have an advantage in finding a job.	
	t3	Concepts of artificial intelligence applied in medicine will become a mandatory subject in Medical School.	
	t4	Due to the high use of artificial intelligence in medicine, new niches will appear in the industry.	
	t5	The high prices of these procedures are justified by the high technological development, equipment and implementation costs.	
price	p1	In time, there will be lower prices for robotic eye surgery procedures than for traditional ones.	.702
	p2	Although, at first, prices for robotic eye surgery will be higher, in time, they will keep a steady state because they will become the standard procedures.	
	p3	In order to boost the use of artificial intelligence in medicine, the Government will subsidize these types of procedures.	
	p4	The prices will decrease due to the fact that the monthly expense with the depreciation of a robotic machine is lower than the expense generated by an employee.	

Source: Dataset analysis in SPSS

The latent variables have acceptable reliability values, KMO = .812 > .5, and adequate inter-item correlations to allow for factor analysis, $p < .001$. The three factors explain 64% of the variance.

The lowest item mean was observed for p3 (M = 3.69, SD = 1.353), which is not significantly higher than the Likert scale midpoint of 3.5, $t(136)=1.673$, $p=.097$, showing a level of skepticism regarding the Government's implication in supporting the use of AI within the medical field by offering subsidies.

All the other items had significantly higher means compared with the Likert scale midpoint, $p < .001$, showing a level of agreement with the statements.

Index variables were constructed through arithmetic mean of the observed variables for each of the factors, and will be referred to as: TECH (the perceived level of technology's influence over the medical field), PRICE (the level of optimism regarding the price evolution of RES for the following years), and SAFETY (the level of trust in RES).

RES is considered a safer alternative to traditional procedures performed by surgeons alone, SAFETY (M = 4.5, SD = .72) having a significantly higher mean compared with the Likert scale midpoint of 3.5, $t(136)=16.4$, $p<.001$.

Similarly, technology is seen as an agent of change in the medical field, as resulting from a one-sample t-test, $t(136)=23.97$, $p<.001$, applied on the TECH variable (M = 4.81, SD = .64).

Moreover, the price evolution of RES for the following years is seen with optimism, PRICE (M = 3.97, SD = .86) having a statistically significant difference between its mean and the Likert scale midpoint of 3.5, $t(136)=6.41$, $p<.001$, however, with a value of 3.97, the responses are only on the "slight agreement" range for the price optimism statements.

As available in Table 2, TECH, PRICE and SAFETY have moderate tendencies to vary in the same direction.

Table 2. Pearson correlations between the index variables

	SAFETY	TECH	PRICE
SAFETY	1		
TECH	.524**	1	
PRICE	.441**	.481**	1
Mean	4.5	4.81	3.97
Std. Deviation	.72	.64	.86

** p<.001
Source: Dataset analysis in SPSS

The income level has weak positive correlations with TECH and SAFETY, with $r_s = .239$, $p<.05$, and $r_s = .251$, $p<.05$ respectively. No significant correlation has been found between the level of income and PRICE, and no significant relationship has been found between any of the index variables: PRICE, TECH, SAFETY and the other demographic variables (i.e. gender, age, education, the existence of eyesight issues or the intention of wearing glasses).

A stepwise regression has been tested for TECH and PRICE as predictors of SAFETY. The model found that both TECH and PRICE make a statistically significant contribution to the prediction of SAFETY, $p<.05$. TECH makes the strongest contribution in explaining the outcome, with Beta = .406, $p<.001$, as presented in Table 3.

Table 3. Summary of stepwise regression for PRICE and TECH predicting SAFETY

Dep. var.	R Sq.	Adj. R Sq.	Std. Err.	F	Df1	Df2	VIF	Durbin-Watson	Intercept	95% conf. int. for intercept	Pred. var.	Beta	β	95% conf. int. for β
SAFETY	.321	.311	.594	31.72**	1	134	1.302	1.652	1.516	[.746, 2.287]	TECH.	.406**	.452	[.273, .631]
											PRICE	.246**	.204	[.071, .441]

**p<.001
Source: SPSS

There are no multicollinearity concerns, VIF=1.302 <10, Tolerance=.768 >.2. The regression residuals are uncorrelated, Durbin-Watson=1.652, $p<.05$ for N=137, k=2, and follow a normal distribution.

32.1% of the variance in the dependent variable is explained by the regression model. The model is a statistically significant predictor of the outcome, with $p<.001$ and defined by *Equation (1)*.

$$SAFETY_i = 1.516 + .452 * TECH_i + .204 * PRICE_i + \varepsilon_i \quad (1)$$

Conclusion

Understanding the present view over robotic surgery is valuable for developing support measures, awareness campaigns and adjusting healthcare providers' decisions.

The results show that RES is considered a safer alternative to traditional procedures performed by surgeons alone, and the price evolution of RES for the following years is seen with slight optimism. Technology is seen as an agent of change in the medical field. Moreover, the respondents recognize the benefits of RES, however, they are skeptical regarding the Government's implication in supporting the use of AI in medicine by offering subsidies.

The income level has no significant relationship with the level of optimism concerning the price evolution of RES for the following years. Still, it has a weak positive correlation with the perceived level of technology's influence over the medical field, and with the level of trust in RES. The gender, age, education level, the existence of eyesight issues and the intention of wearing glasses have no significant relationship with the perceived level of technology's influence over the medical field, the level of trust in RES, or the level of optimism regarding the price evolution of RES for the following years.

The output of regression analysis demonstrated that the perceived level of technology's influence over the medical field and the level of optimism regarding the price evolution of RES for the following years have a statistically significant contribution to the prediction of the level of trust in RES.

The paper can be seen in light of some limitations. Firstly, the survey did not include explanations on what is meant by robotic eye surgery or artificial intelligence use in the medical field, which could have led to measurement errors. Secondly, the survey focused on the general public perception and did not cover the respondents' own wishes in managing or treating their eyesight issues (if any), through RES or other options. Lastly, there were no participants over 55 years old, limiting the reach over the opinions of people predisposed to common age-related eye problems.

Further research could focus on specific medical issues and investigate patients' wishes concerning their treatment and management through AI technology, or take a qualitative approach, covering qualified professionals' perspectives over AI in healthcare, coming from both the medical field and the technology development field.

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