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Surgeons' perspectives on artificial intelligence to support clinical decision-making in trauma and emergency contexts: results from an international survey

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Abstract

Background: Artificial intelligence (AI) is gaining traction in medicine and surgery. AI-based applications can offer tools to examine high-volume data to inform predictive analytics that supports complex decision-making processes. Time-sensitive trauma and emergency contexts are often challenging. The study aims to investigate trauma and emergency surgeons' knowledge and perception of using AI-based tools in clinical decision-making processes.

Methods: An online survey grounded on literature regarding AI-enabled surgical decision-making aids was created by a multidisciplinary committee and endorsed by the World Society of Emergency Surgery (WSES). The survey was advertised to 917 WSES members through the society's website and Twitter profile.

Results: 650 surgeons from 71 countries in five continents participated in the survey. Results depict the presence of technology enthusiasts and skeptics and surgeons' preference toward more classical decision-making aids like clinical guidelines, traditional training, and the support of their multidisciplinary colleagues. A lack of knowledge about several AI-related aspects emerges and is associated with mistrust.

Discussion: The trauma and emergency surgical community is divided into those who firmly believe in the potential of AI and those who do not understand or trust AI-enabled surgical decision-making aids. Academic societies and surgical training programs should promote a foundational, working knowledge of clinical AI.

Keywords: Artificial intelligence, Clinical decision-making, Decision aids, Trauma and emergency surgery, Survey

Background

Artificial intelligence (AI) is defined as the development of algorithms that give machines the ability to act with human-like rationality in complex tasks, such as problem-solving and decision-making, and is poised to reshape medicine and surgery broadly [1].

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Diagnostic and judgment errors are the second leading cause of preventable harm [2]. Decision-making is one of the most challenging and crucial tasks performed by trauma and emergency surgeons, where time constraints and high cognitive loads from high volumes of information demand reliance on cognitive shortcuts, leading to mistakes and preventable patient harm [3].

In recent years, decision support systems based on AI algorithms are receiving considerable attention in the literature [4–6]. In contrast to human cognitive capacities, AI can be used to examine high-complexity and high-volume data for predictive analytics to augment the precision of complex decision-making processes. Nonetheless, deploying medical AI systems in routine trauma and emergency surgery care presents a critical yet largely unfulfilled opportunity as the medical AI community steers the complex ethical, technical, and human-centered challenges required for safe and adequate translation [7–10]. Experienced surgeons are appropriately cautious of enthusiastic, novel solutions that are unsubstantiated by academic rigor and evidence of performance advantages in clinical settings [8]. Even when AI accurately predicts clinical outcomes hours or days in advance, its application in trauma and emergency surgery will remain marginal until the deployment proves trust in the accuracy and the lack of bias of the model, addresses target risk-sensitive decisions, and integrates with clinical workflows [11, 12].

The recently published artificial intelligence in Emergency and Trauma Surgery (ARIES) survey, endorsed by the World Society of Emergency Surgery (WSES) evaluated the knowledge, attitude, and practices in the application of AI in the emergency setting among international acute care and emergency surgeons. The investigation revealed how the implementation of AI in the emergency and trauma setting is highly anticipated but still in an early phase, with trauma and emergency surgeons enthusiastic about being involved [13].

Starting from these premises and research gaps, this article aims to assess surgeons' understanding and knowledge about the role of new technologies like AI in clinical decision-making by employing an international survey endorsed by the WSES.

Methods

Design and setting

The exploratory study of the international trauma and emergency surgeons' community used a population-based online questionnaire to gather demographic, knowledge, and practice-based information regarding the adoption of new technological tools to support clinical decision-making. The online questionnaire was generated in English through Google Forms [14, 15], and followed the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [16].

A steering committee within the WSES was appointed, involving a multidisciplinary panel of academics and practitioners in the fields of trauma and emergency surgery, healthcare management and policies, innovation, business and medical ethics, information technology, law, and organization science. No Institutional Review Board (IRB) approval was required. Starting from a review of the literature, a research protocol was conceived and shared by the principal investigators (LC and FDM) with the steering committee. The protocol was peer-reviewed and published [17]. The leading references to create the protocol and the survey structure were gathered from Dal Mas et al. [18], Loftus et al. [19, 20], Cobianchi et al. [21], Venkatesh et al. [22], and Bashshur, Shannon and Sapci [23]. Before the initiative's official launch, the research protocol and the online survey were reviewed by the steering committee and filled in by a sample of surgeons to avoid mistakes.

The poll was made available at the end of November 2021 and was open until the middle of August 2022. All 917 WSES members received an e-mail invitation to participate in the survey. The initiative was also shared on the society's website and Twitter account. Additionally, the members of the Team Dynamics Study Group [14, 15] were also invited via e-mail. Four e-mail reminders were sent. WSES membership was not required to answer the survey. Still, it may be assumed that the vast majority of the participants come from the 917 WSES members to whom the research initiative was publicized, yielding an approximate 70% response rate.

The invitation e-mail included comprehensive details on the initiative's goals and rationale, the anticipated time frame (about 10 min), and the option to join the Team Dynamics Study Group to carry out additional research and disseminate the results. The identities of the participants were kept secret. Additionally, the identity of the investigators and the research protocol were kept private.

Survey

The first group of questions aimed at understanding the participants' features. The questions' structure and list were derived from the previous Team Dynamics investigation [14, 15]. Surgeons were asked to disclose their gender, years of experience in trauma/emergency surgery, type of institution (academic versus non-academic), the country in which they work, role, eventual participation within a trauma team (institutionalized or not, and of which type), the kind of trauma leader, the educational training attended, and the eventual presence of diverse team members.

Table 1 Descriptive statistics about surgeons and institutions participating in the investigation

Item	Number of responses	% of total responses
Participants	**650**	**100.00%**
Males	531	81.69%
Females	118	18.15%
Prefer not to answer	1	0.15%
	Mean	**SD**
Years of experience	12.32	8.42
Minimum	1	
Maximum	36	
Kind of institution	**Number**	**%**
	650	**100.00%**
Academic	499	76.77%
Non-academic	151	23.23%
Role/position	**650**	**100.00%**
Senior Consultant	233	35.85%
Board-certified surgeon	179	27.54%
Resident	124	19.08%
Division chief or head	114	17.54%
Part of an emergency surgery team	**650**	**100.00%**
Yes	540	83.08%
No	110	16.92%

The second group of questions investigated the decision aids as reported by the surgical literature [18–20], by assessing the surgeons' perception of 11 items using a 5-point Likert scale.

The third group of questions concerned the perceived challenges that surgeons need to face when making clinical decisions, assessing 13 items gathered from Loftus and colleagues [20] using a 5-point Likert scale.

The fourth section of the questionnaire aimed at assessing the surgeons' feelings about AI by asking them if they were familiar with the term AI, their understanding of it through an open question, and the perceived importance of AI in surgery at the present time and in a five-year horizon. One last question aimed to assess the perceived benefits [21, 22] of the application of AI in surgery.

The survey's questions related to clinical decision-making through new technological aids are reported in Appendix 1.

Statistical analysis

The statistical analysis was conducted using the software R (RStudio 2022.07.0 + 548 "Spotted Wakerobin" Release) [24].

Manual coding was also employed concerning the qualitative questions. Surgeons were required to express their understanding of AI through an open question. Results were manually coded by two researchers (LC and FDM), who rated each statement as concordant, discordant, or inconclusive, following the analysis of Woltz et al. [25] and Cobianchi et al. [14].

Results

Participants

650 surgeons responded to the questionnaire. Located on five continents, participants hailed from 71 different nations. The sample, however, was not evenly dispersed, with the majority of surgeons coming from Europe (477, or 73%), particularly Italy (251, or 39%). 465 responders (72%) were from the 10 nations with the most participants overall.

118 female surgeons (18%), 531 male surgeons (82%), and one person who would rather remain anonymous made up the sample. Surgeons' years of experience in the field ranged from 1 to 35, with a mean of 12. The majority of participants (499, or 77% of the sample) were from academic institutions, and 540 of them declared to be part of a formally-established emergency surgery team (83%). Although there were a variety of roles indicated, senior consultants made up the bulk of surgeons (233, or 36%). Department heads made up 114 (18%) of the sample.

Table 1 presents descriptive statistics about the individuals and institutions that participated in the study, whereas Table 2 reports some information about the number of respondents according to their locations.

Clinical decision-making facilitators

Surgeons were given a list of 11 items referred to clinical decision-making facilitators to be rated on a 5-point Likert scale according to their perceived importance. Clinicians underlined the importance of training, clinical guidelines, and multidisciplinary committees and meetings, with a mean of over 4 out of 5. Interestingly, the most modern tools (namely, risk stratification by additive scores using static variable thresholds, machine learning and artificial intelligence, regression modeling and calculations—with 3.87, 3.56, and 3.49, respectively) received the lowest scores, with machine learning and artificial intelligence recording the highest standard deviation (1.07). The following Table 3 reports the results.

Table 3 Decision aids and facilitators

	Item	Mean	SD
1	Training	4.40	0.78
2	Clinical guidelines and cases	4.25	0.82
3	Multidisciplinary committees and meetings	4.19	0.85
4	Time spent to engage patients	4.10	0.89
5	Networking and international experiences	4.10	0.88
6	Non-technical skills	3.98	1.02
7	Mobile electronic medical records and online tools, including telemedicine	3.96	1.02
8	Publications	3.95	0.94
9	Risk stratification by additive scores using static variable thresholds	3.87	0.91
10	Machine Learning and Artificial Intelligence	3.56	1.07
11	Regression modeling and calculations	3.49	1.01

The responses given to the item "Machine Learning and Artificial Intelligence" were analyzed by dividing the sample by institution, position held, and country. Interestingly, the institution (academic or non-academic) and the role did not show any significant difference. Major differences emerged when analyzing countries, with some of them (like Argentina) showing a high mean (4.5) and a low standard deviation (0.548), and others (like Switzerland) a very low mean (2.6) and a high standard deviation (0.89). Such results are reported in the following Table 4.

Moreover, the same responses were analyzed by considering the institution, position, and country simultaneously. Although numbers become smaller, some interesting findings emerge. For instance, all senior consultants belonging to Malaysian academic institutions firmly believed in AI, with all of them giving a rate of 5/5,

Table 2 Number of respondents according to their location

Total participants	**650**	**100%**
Number of countries	*71*	
Continents	*5*	*100%*
Europe	477	73%
Asia	85	13%
America	62	10%
Africa	22	3%
Oceania	4	1%
Ten most present countries	**465**	**72%**
Italy	251	39%
Greece	45	7%
Spain	37	6%
United Kingdom	37	6%
United States	26	4%
Turkey	16	2%
Malaysia	15	2%
France	14	2%
Brazil	13	2%
Ukraine	11	2%

Table 4 Item 10 "Machine Learning and Artificial Intelligence" responses per country

id	Country	# responses	Mean	SD
1	Argentina	6	4.5	0.548
2	Saudi Arabia	7	4.43	1.13
3	Brazil	13	4.38	0.768
4	Malaysia	15	4.13	1.30
5	India	8	4.12	0.835
6	France	15	4.07	0.884
7	United States	24	3.92	1.21
8	Ukraine	11	3.91	0.944
9	Bulgaria	9	3.89	0.928
10	Belarus	6	3.83	0.753
11	Russia	5	3.8	1.64
12	Spain	37	3.68	1.03
13	Netherlands	10	3.6	0.843
14	Germany	7	3.57	0.535
15	Romania	9	3.56	1.13
16	Turkey	16	3.5	0.966
17	Greece	45	3.42	1.14
18	Japan	5	3.4	0.548
19	Portugal	5	3.4	0.548
20	Italy	251	3.38	1.10
21	United Kingdom	37	3.35	1.09
22	Israel	6	3.17	0.408
23	Thailand	6	2.67	0.816
24	Canada	5	2.6	0.548
25	Switzerland	5	2.6	0.894

compared to division chiefs working in the USA, who scored the item 2.5 with a standard deviation of 1.05. Despite being digital natives, residents do not appear in the top positions. Results are depicted in the following Table 5.

Challenges in clinical decision-making

Surgeons were asked to rate 13 items regarding the challenges that could arise when engaging in clinical decision-making. The items were adapted from Loftus et al. [20].

Results underline a perceived misalignment between the actual clinical scenario and the independent assessment, the lack of complete data availability, the risk of expecting specific outcomes grounded on inaccurate data, the presence of bias derived from the most recent experiences, and the possibility of making mistakes all along the clinical journey. Interestingly, surgeons rated the potential support granted by new technologies like AI as the lowest item (with a mean of 3.10 and the highest standard deviation of 1.14).

Findings are reported in the following Table 6.

Knowledge and understanding of AI

Surgeons were asked if they were familiar with the term AI. 451 out of 650 participants (69% of the sample) declared they were familiar with the term, while 199 (31%) admitted they were not.

The following question required surgeons to write their understanding of AI applied to surgery. Each given statement was rated by the two principal investigators (LC and FDM) as concordant, discordant, or inconclusive.

To be rated as concordant, definitions needed to somehow stress the capability of the machine to mimic human intelligence or, at least, to express the aims and potential of AI applied to surgical practice or its technological functioning. Only 112 surgeons (17% of the sample) provided a statement that fitted the criterion. 178 participants (27% of the sample) gave responses that were incomplete, showing only a partial view of the phenomenon, being so rated as inconclusive. The remaining 360 surgeons (55% of the participants) gave answers that were not fitting the concept of AI, its aims, and its potential. Most of these participants declared they had no idea about what AI could entail in surgical practice.

The following Table 7 reports some examples of answers that were rated as concordant, inconclusive, and discordant [14, 25].

The statements were also analyzed according to different keys, namely, the fact that they recalled the idea of AI supporting clinical decision-making and of learning/training, and the eventual other technologies linked to AI. Most surgeons (409, 63% of the sample) mentioned the impact on clinical decision-making, and 57 (9%) recalled the potential of AI for surgical training. Among the most cited technologies that may be linked with AI, there are Big Data (mentioned by 130 participants – 20% of the sample) and new technologies in general terms (107, 16%).

Table 8 highlights such results.

The potential of AI today and tomorrow

Surgeons were asked to express their opinion about the importance of AI-based applications to support clinical

Table 5 Item 10 "Machine Learning and Artificial Intelligence" responses per institution, position, and country

id	Institution	Position	Country	#	Mean	SD
1	Academic	Senior-consultant	Malaysia	5	5	0
2	Academic	Division-chief	Brazil	7	4.57	0.535
3	Academic	Board-certified-surgeon	United-States	6	4.5	0.837
4	Academic	Senior-consultant	United-States	5	4.2	0.447
5	Academic	Board-certified-surgeon	France	6	4.17	0.753
6	Academic	Board-certified-surgeon	Greece	12	4	1.28
7	Academic	Division-chief	Ukraine	6	4	0.894
8	Academic	Resident	United-Kingdom	6	4	0.894
9	Academic	Senior-consultant	Bulgaria	5	4	1
10	Non-academic	Resident	United-Kingdom	8	3.88	1.13
11	Academic	Division-chief	Turkey	6	3.83	0.983
12	Academic	Resident	Greece	13	3.69	0.947
13	Academic	Senior-consultant	Romania	8	3.62	1.19
14	Academic	Board-certified-surgeon	Italy	45	3.6	1.18
15	Academic	Senior-consultant	Spain	20	3.6	0.995
16	Academic	Board-certified-surgeon	Malaysia	6	3.5	1.05
17	Non-academic	Senior-consultant	Italy	39	3.46	1.14
18	Academic	Board-certified-surgeon	Spain	11	3.46	1.13
19	Non-academic	Division-chief	Italy	14	3.43	0.756
20	Non-academic	Resident	Italy	5	3.4	0.548
21	Academic	Senior-consultant	Italy	46	3.35	1.06
22	Academic	Resident	Italy	56	3.34	1.16
23	Academic	Senior-consultant	Turkey	7	3.29	0.951
24	Non-academic	Senior-consultant	Greece	7	3.29	0.951
25	Academic	Senior-consultant	United-Kingdom	9	3.22	1.09
26	Academic	Division-chief	Israel	5	3.2	0.447
27	Non-academic	Board-certified-surgeon	Italy	29	3.17	1.04
28	Academic	Board-certified-surgeon	United-Kingdom	6	3.17	1.17
29	Academic	Division-chief	Italy	17	3.12	1.27
30	Academic	Senior-consultant	Greece	5	2.8	1.1
31	Academic	Division-chief	United-Kingdom	6	2.67	0.816
32	Non-academic	Board-certified-surgeon	Greece	5	2.6	0.548
33	Academic	Division-chief	United-States	6	2.5	1.05

decision-making at the current time and on a five-year horizon, using a 5-point Likert scale.

Participants rated the importance today with a mean of 3.06 out of 5 and a standard deviation of 1.1. In the future, the sample rated the importance as 3.88 as an average with a standard deviation of 0.97.

The goals of AI

One last question referred to the perceived goals and benefits of AI-based in supporting clinical decision-making. Five items needed to be rated on a 5-point Likert scale.

Interestingly, surgeons rated all five items as equally relevant (ranging from a mean score of 3.51 to 3.78). The item with the highest score sees AI as a support tool to validate decisions that clinicians would make anyway.

The following Table 9 reports the results.

Discussion

The results of our survey are in line with previous studies [13], with trauma and emergency surgeons showing interest in AI but still having several doubts and concerns about its actual application and potential as a decision-making aid.

Table 6 Challenges in clinical decision-making

	Item	Mean	SD
1	Sometimes the clinical scenario presented is different than the surgeon would have perceived during an independent assessment	3.61	0.95
2	Data are often incomplete	3.54	1.00
3	Patients are often informed of expected outcomes using data from aggregate patient populations without adjusting for their personalized risk profile	3.51	1.06
4	Recent experiences with a certain patient population or operation often affect disproportionately surgical decision-making than remote ones	3.50	0.98
5	Errors and mistakes are likely all along the way	3.49	1.09
6	Decisions must often be made before all relevant data can be retrieved	3.44	1.10
7	Potential outcomes are often predicted using personal beliefs rather than evidence-based guidelines	3.38	1.11
8	In-house calls happen often	3.35	1.00
9	It is often too complicated to form a complete list of all likely diagnoses, all life-threatening diagnoses, and all unlikely diagnoses that may be considered if the initial workup excludes other causes	3.34	1.04
10	A surgeon tends toward action when inaction may be preferable	3.28	1.07
11	The surgeon often falsely perceives that weaknesses and failures disproportionately affect their peers	3.17	1.01
12	It is often too complicated to recognize the strengths and limitations of available tests	3.12	1.02
13	Digital technologies (e.g., artificial intelligence) support how I take clinical decisions	3.10	1.14

When enquired about the most effective tools to support clinical decision-making, surgeons declare to rely more on training, clinical guidelines, and the support of their multidisciplinary staff and colleagues. Interestingly, these three items represent central and "classical" elements in the trauma and emergency surgery context [14] and in the action of the leading scientific societies like the WSES, which promotes training modules for both physicians and nurses [26], clinical guidelines covering several aspects of the clinical profession [27], and studies on multidisciplinary team dynamics [14, 15]. AI and Machine Learning tools got one of the lowest rates (3.56), with the highest standard deviation (1.07). The broad standard deviation interval may represent a gap in the surgical community, with some surgeons firmly believing in the potential of such new technologies and others still having severe concerns about their practical application.

Interestingly, while no significant differences emerge when considering the institution and the position held, geographical differences occur in the sample, with some countries giving higher scores than others. It would be interesting to investigate further while such differences emerge, for instance, in terms of cultural mindset, training opportunities, availability of technology or tech partners, and presence of technological surgical leaders or ambassadors. Moreover, when analyzing the sample under different lenses simultaneously (institution, role, and country), residents do not appear to be technology enthusiasts and believers, despite their younger age and the definition of digital natives.

When considering the decision-making process dynamics, trauma and emergency surgeons underline the need for sound decision aids. Indeed, the most rated elements refer to the potential gap between reality and the surgeon's initial assessment and the lack of accurate data. Even in this case, most respondents did not believe that AI offers valuable support for decision-making. Like in the case of decision aids, the contribution of AI to decision-making got the highest standard deviation, depicting the two extreme views, with enthusiastic adopters in contrast with skeptics.

Regarding the knowledge about AI, while most surgeons declare to be familiar with the concept of AI, many exhibited only a partial understanding of AI. Interestingly, many surgeons recall big data technology, and some associate AI primarily with robotics. While robotic surgery may represent one promising application of AI in surgical science [13, 28, 29], AI in its current state offers sound decision-making support, like in the case of the POTTER algorithm as an emergency surgery risk calculator [5, 6].

The current general skepticism of trauma and emergency surgeons about AI is also confirmed by the given rate on the relevance of AI-based tools for decision-making as they appear today, with a mean of 3.06. One more time, a high standard deviation interval depicts divergent opinions and beliefs in the surgical community. Still, the future looks brighter, with a higher perceived relevance on a five-year horizon.

Table 7 Examples and ways of rating the given answers to the question: What is your understanding of AI applied to surgery?

Rated as	Given answer	Reason for rating
Concordant	"Capability of a machine to imitate intelligent human behavior."	The statement recalls the ability of AI to mimic human behavior
	"It is capability of a computer system to mimic human cognitive functions."	
	"A set of computer systems aiming at performing tasks normally based on human intelligence, starting from repetitive task and upscaling upon results."	
	"Artificial intelligence is a technology which enables a machine to simulate human behavior. Machine learning is a subset of AI which allows a machine to automatically learn from past data without programming explicitly."	
	"Artificial intelligence is the ability of a computer system to mimic human cognitive functions. Through AI, a computer system may simulate also the reasoning that people use to acquire new information and make decisions."	
	"The ability of machines to learn complex data and then generate predictions can assist clinical decisions and which can be used to improve clinical care in surgery."	The statement stresses the learning aspect and the capability to handle complex data to support decision-making
	"[AI] help[s] in the surgical daily practice obtained thanks to shared experience, obtained from several colleagues, throughout the collection of big data analyzed and optimized by means of computational analysis"	
	"AI/ML are not yet applicable in an extensive way to surgery. However, some relevant applications, particularly during the diagnostic phase (especially radiology), can influence surgical indication. After surgery, some examples of AI/ML algorithms are used in pathology to define the diagnosis better, thus the patient's prognosis."	The statement shows a good understanding of the goals and potential of AI applied to surgery
	"[AI] works by combining large amounts of data with fast, iterative processing and intelligent algorithms, allowing software to automatically learn from data patterns or characteristics."	The statement shows a good understanding of how the technology works
Inconclusive	"Application of big data."	Although big data may be linked with the functioning of AI, the statement is incomplete
	"Simulation."	Although simulations may be linked with the functioning of AI, the statement is incomplete
	"Telemedecine; robotic training."	Although telemedicine/e-health and robotic surgery may be somehow linked with the functioning of AI, the statement is incomplete
	"Use of artificial intelligence for learning."	The statement recalls only one scope, which is, by the way, not well identified
	"Technology using to facilitate decisions."	
	"Useful for risk stratification and some decision-making."	
	"It can help in making decisions and developing new techniques."	
	"A predictive model"	
Discordant	"I don't have a deep understanding of how these work, although I have seen several publications on this lately."	In the statements, participants admit they have poor or no knowledge about AI applied to surgery
	"I don't know."	
	"None."	
	"Nothing."	
	"I don't know AI applied to surgery."	
	"Robotic surgery."	Although the literature is starting to discuss AI-empowered surgical robots, the actual robotic surgical systems do not work with AI
	"Robots."	
	"AI applied to surgical field."	Redundant/repetition

Table 8 Understanding of AI applied to surgery – Main results

Aims	#	%
Mentions the potential in supporting clinical decision-making	409	63
Mentions the potential in supporting learning/training activities	57	9
Technologies linked with AI		
Big data	130	20
New technologies in general	107	16
Robotics	22	3
Simulations	16	2
Virtual/augmented realities	8	1
Telemedicine	1	0
No other technologies mentioned	366	56
Total	650	

Table 9 Goals and benefits of AI applied to surgery

	Item	Mean	SD
1	It helps in evaluating/validating decisions I would take	3.78	1.01
2	It supports in taking complex clinical decisions;	3.73	1.10
3	It helps in scouting and reviewing publications;	3.70	1.03
4	It reduces the span of options;	3.53	1.01
5	It supports taking decisions regarding simple problems, so I can focus on high-value activities	3.51	1.10

The same picture and the divergent trust in using AI-based decision tools emerge in the question about the goals and benefits. Interestingly, the degree of technology acceptance appears generally low, with surgeons being rather skeptical when it comes to AI ensuring better support and outcomes than traditional tools. Such a low degree of acceptance opens up new research avenues to investigate the main concerns in the practical adoption of AI or the ethical bias connected to it. In such a perspective, one primary concern may reside in the lack of technical knowledge regarding AI, which emerges from several questions, especially that on the understanding of AI. Moreover, when enquired about legal responsibility (a topic to which medical doctors are particularly sensitive), surgeons modestly rate the need to share their legal responsibility with either the manufacturer, those in charge of maintenance, or the data manager, and so the need to rethink the informed written consent when new technologies are involved.

Limitations

Although our survey got a reasonably high response rate and 650 participants (approximately 70%), the sample is not equally distributed geographically. Indeed, most participants work in Europe and, more specifically, in Italy. The specific situation of the Italian and European contexts, including the actual access to AI-based technology and the medical education related to it, may have biased some of our results. Our limitations, along with the international community's perceived interest in AI [13], may stimulate new in-depth studies and investigations.

Conclusion

In concluding our work, we return to the premises and research gaps that inspired it. AI-based applications are gaining traction in surgery as decision-making aids, and the surgical community is showing interest in them. Trauma and emergency contexts are often challenging, and surgeons perceive the need for sound decision-making tools.

Our results underline how the emergency surgical community seems to include surgeons who strongly believe in the potential contribution of AI technology and who may act as enthusiastic early adopters [19] and those who are reluctant, feeling more comfortable relying upon more classical aids like guidelines, traditional training, and multidisciplinary groups' support. Some countries seem to have greater comprehension and trust of AI-based tools. Younger surgeons, who some presume to be keener on using new technologies, do not appear to have greater trust or understanding of AI compared with mid-career and senior surgeons.

Given the potential of AI in clinical practice [7, 20, 30] and the speed of development, the role of scientific societies like the WSES and surgical training programs are crucial to expanding knowledge regarding AI-enabled decision aids, disseminate new approaches, and encompass them in training modules and clinical guidelines, to bridge the gaps between technology enthusiasts and those who misunderstand and mistrust AI. In addition, AI-enabled decision aids in surgery should seek to gain the trust of surgeons by establishing transparency and by demonstrating performance advantages that improve patient care.

Appendix 1

1. On a scale from 1 to 5, where 1 = not suitable and 5 = very suitable, which are the tools that, in your opinion, may facilitate clinical decision making?

Likert scale 1 to 5

1. Mobile electronic medical records and online tools, including telemedicine
2. Training
3. Networking and international experiences
4. Multidisciplinary committees and meetings
5. Publications
6. Clinical guidelines and cases
7. Time spent to engage patients
8. Non-technical skills
9. Risk stratification by additive scores using static variable thresholds.
10. Regression modelling and calculations
11. Machine learning and Artificial intelligence

2. Think of how you take clinical decisions. On a scale from 1 to 5, where 1 = strongly disagree and 5 = strongly agree, how would you rate the following statements?

Likert scale 1 to 5

1. It is often too complicated to form a complete list of all likely diagnoses, all life-threatening diagnoses, and all unlikely diagnoses that may be considered if the initial workup excludes other causes.
2. It is often too complicated to recognize the strengths and limitations of available tests.
3. Errors and mistakes are likely all along the way.
4. Data are often incomplete.
5. Decisions must often be made before all relevant data can be retrieved
6. In-house calls happen often
7. Sometimes the clinical scenario presented is different than the surgeon would have perceived during an independent assessment
8. The surgeon often falsely perceives that weaknesses and failures disproportionately affect their peers
9. A surgeon tends toward action when inaction may be preferable
10. Patients are often informed of expected outcomes using data from aggregate patient populations without adjusting for their personalized risk profile
11. Recent experiences with a certain patient population or operation often affect disproportionately surgical decision-making than remote ones.
12. Potential outcomes are often predicted using personal beliefs rather than evidence-based guidelines
13. Digital technologies (e.g. artificial intelligence) support how I take clinical decisions

3. Are you familiar with the terms Artificial Intelligence/Machine Learning?

Yes/No

AI and decision making in trauma and emergency contexts

1. Yes
2. No

4 What is your understanding of Artificial Intelligence/Machine Learning applied to surgery?

open question

5. On a scale from 1 to 5, where 1 = not relevant and 5 = very relevant, how relevant do you think that Machine learning and Artificial intelligence-based tools are today for clinical decision making?

Likert scale 1 to 5

6. On a scale from 1 to 5, where 1 = not relevant and 5 = very relevant, how relevant do you think that Machine learning and Artificial intelligence-based tools will be for clinical decision making in a five-year horizon?

Likert scale 1 to 5

7. On a scale from 1 to 5, where 1 = strongly disagree and 5 = strongly agree, how would you rate the following statements concerning the goal and benefits of Machine learning and Artificial intelligence-based in supporting clinical decision making?

Likert scale 1 to 5

1. - it helps in scouting and reviewing publications;
2. - it reduces the span of options;
3. - it supports taking decisions regarding simple problems, so I can focus on high-value activities;
4. - it supports in taking complex clinical decisions;
5. - it helps in evaluating/validating decisions I would take.

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Abbreviations

AI: Artificial intelligence; WSES: World society of emergency surgery; CHERRIES: Checklist for reporting results of internet e-surveys; IRB: Institutional review board; SD: Standard deviation.

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LC and FDM conceived the idea of the study. LC and FDM wrote the research protocol. LC, FDM, LA, FaCa, SD, HK, TJL, and PP reviewed the research protocol. LC and FDM took care of the data collection. LC, DP, and FDM took care of the data analysis. LC, FDM, DP, and TJL wrote the first draft of the manuscript. VA, LA, JB, WB, GB, FaCa, FeCo, SD, BDS, IF, PF, GiM, GRM, JM, MM, PP, FR, AV, and HK critically reviewed the manuscript. All authors approved the final version of the article.

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