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Education and Training in Microsurgery: A Current Global

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Education and Training in Microsurgery: A Current Global Overview

ABSTRACT

Objective

Microsurgical skills are challenging to acquire and maintain, also presenting significant educational differences among practitioners. By exploring the current state of microsurgical training from the surgeon's perspective, (including demographics, education experience and infrastructure details), this paper aims to give a first piece of information to enrich and promote debate and research.

Methods

A comprehensive literature review was conducted to synthesize pre-published data on microsurgical training. Following this initial step and adhering to international guidelines for survey research, a new survey was designed to update existing information and address identified data gaps. The survey was distributed via personal contacts and scientific forums, ensuring respondent anonymity. It included exploratory questions across the following descriptive areas: a) respondent demographics; b) training experiences; c) microsurgical knowledge; and d) training center characteristics.

Results

The survey gathered responses from 72 individuals across 25 countries and 9 specialties. Expertise of the participants was evenly distributed: 36.2% were trainees or recent graduates, 33.3% had an intermediate level, and 30.4% were experienced professionals. A unanimous consensus was reached on the superior efficacy of team training. Nearly half (43%) reported a lack of training facilities in their cities, while 15% identified financial constraints and 14% accessibility issues as major obstacles. Most participants (85%) expressed that microsurgical technique learning/training should be a priority.

Conclusion

This exploratory international survey offers an initial glimpse into the underexamined field of microsurgical training. Based on a modest sample, the findings reveal disparities in access, infrastructure, and instructional methods. Though preliminary, the data aim to spark discussion and guide future, more comprehensive research efforts.

Keywords: miscrosurgery education, skill training, neurosurgery.

INTRODUCTION

Since the introduction of the microscope into surgical practice, the field of microsurgery has undergone significant evolution, marked by growing demand for advanced technology, robust evidence, and refined skills[1].

Surgeons across various specialties responded to this demand and honed their expertise through diverse methods, simulations, and strategies—leading to the establishment of dedicated laboratories and institutions focused on microsurgical education, training, and research. This phenomenon quickly expanded worldwide in an effort to meet the need for effective instruction across different settings, countries, and cultures.

The international community has acknowledged the complexity of these issues, prompting the development of foundational recommendations[2–7]. Despite such recognition and subsequent initiatives, the global landscape of microsurgical education and training remains largely uncharted. This lack of data presents challenges for crafting strategic action plans or even establishing a basic informational framework essential for identifying potential solutions.

The present paper aims to explore selected aspects of this broad topic through a global survey tool, examining the current status of microsurgical teaching and training. Key areas of inquiry included respondent demographics, assessments of microsurgical procedures, current concepts in the field, and analysis of training center/station availability.

METHODS

A literature review was conducted using multiple online platforms (Pubmed®, Scielo®, ResearchGate®), revealing existent evidence assessing microsurgery training related topics [(3-7)]. For this review the following search-sentences were used: “microsurgery training”, “microsurgical education”, “microsurgery training accessibility”, “microsurgery international recommendations”. Based on these findings, a comprehensive lecture and analysis was made to collect information about how microsurgery training was approached, considering certain differences as: country of origin, socio-economic factors at origin, concepts/program approached, costs and accessibility related topics.

After this first evaluation, data scarcity was detected about programs and concepts approached at a training facility/session; costs and accessibility to training opportunities; level of coverage of educational demand; effectiveness and satisfaction of the trainee after a training session; methods and simulation models used for teaching; and people demanding for microsurgical education.

A survey was designed to address these data gaps and evaluate this scenario effectively, following the Harvard University Program on Survey Research [8] directives and recommendations.

Survey design rationale

Each one of the survey questions was designed using a mix of closed-answer and likert-type questions. Further details about this design are available in the appendix section of this paper (Appendix), as well as in the referenced citations [9-12]. The survey topics were organized into four sections (Table 1):

a) Basic information about the respondent.

b) Microsurgery training & procedural evaluation

c) Microsurgery general concepts understanding.

d) Training centers information

Data were collected through a Google Form link and distributed via personal contacts and specialized forums. The original Google Form link remains accessible (but not collecting data) in the "Additional Material" section at the end of this document.

The final dataset was then created from collected responses. Exclusion criteria were applied to:

- Records coming from the same IP or email address (avoiding including duplicated records)
- Records coming from uncomplete filled forms (avoiding partial information bias)
- Records coming after the end of proposed period for this study (From 15th December 2024 to 15th February 2025).

The data were then imported into a Microsoft PowerBI(r) file for more effective handling. Statistical analysis was performed to measure and segregate data meaningfully, revealing associations that will be discussed in detail later in this paper.

Survey overview (Table 1)

The following table intends to summarize and present the main structure of the complete survey, by describing sections, questions and strategy proposed for each one.

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RESULTS

Basic information section

Seventy-two surveys were collected after exclusion criteria were applied. Among them, ten surgical specialties were represented (assistants included), with 51 neurosurgeons making up 70,8% of the respondents (Figure 1). The participants' expertise (measured in numbers of years of professional exercise) was evenly distributed: 36.2% (25) were beginners, 33.3% (24) were intermediate practitioners, and 30.4% were experienced (23) (Figure 2). Similar distribution was found when expertise segregation was made by years after microsurgical education (this situation involved surgical specialties residents).

(Figure 1)

(Figure 2)

The study included participants from 25 countries across Latin America, North America, Europe, Asia, and Africa (Figure 3). After indexing each country by using the United Nations Inequality Index, the majority of records (68%) came from mid-low-income countries (Figure 4). The rest was evenly distributed among the other income levels (14% low income; 11% high income; 7% mid-high income).

(Figure 3)

(Figure 4)

Microsurgery training & procedural evaluation section

When analyzing about assessing procedures, 57.7% of respondents evaluated results solely based on surgical outcomes (Figure 5), meanwhile just 22% reported using specific methods for procedure evaluation. When asked about the proper definition of "procedure" just 43% provided a satisfactory definition. Regarding the opinion about objectivity of hand skill evaluations (Figure 6), two categories contained the majority of responses (80,3%): complete (25 responses) a significantly objectiveness (36 responses).

(Figure 5)

(Figure 6)

A total of 84.5% of respondents identified a direct correlation between training and improved surgical outcomes, and 88.7% expressed a willingness to take an objective skills evaluation test. The fifth question of this section had a specific distraction factor which allowed to approach two main topics:

a) Forty-five percent of the respondents checked the answer affirming that the teaching methodology was "mostly be watching at the operation room...", and this situation was considered to segregate the rest of the answers in three categories: I- Those who ONLY choose this option, 10%; II- Those who ALSO choose this option, 35%; and III- Those who DID NOT choose this option, 55% (Figure 7A).
b) From the resulting 55%, the rest of the options were evaluated separately: **Microscope handling** appeared as the most selected option (47 answers); Choices about **Instruments selection**, **Hand skills training**, and **Microsurgical Strategy** ranged from 40 to 45 answers; and finally, a third range (from 25 to 30 answers) for **Team training**, **Procedure evaluation**, and **Optical concepts**. Interestingly, the choices among the group of "also choosing only by watching" accounted 109 other options too, while "did not choosing only by watching" accounted 154 other options too (Figure 7B).

(Figure 7)

When analyzing Figure 8A, the number of program topics selected by each respondents appears with a clear predominance of just one item selected (16 responses). All other options range from 7 to 9 responses, including those choosing eight responses (which among the options also appears selected the "mostly by watching" modality).

A closer look to these results revealed that, among the responses of "just 1 program item", the vast majority where only instructed about "**Microscope handling**". The topics "**Team Training**" and "**Strategy analysis**" does not have any responses among this group (Figure 8B).

(Figure 8)

When asking particularly about hand skill training, 60% of the respondent manifested to had been trained specifically for this goal (Figure 9A).

(Figure 9)

Participants on this survey asked that they received further training/education in microsurgery (after finishing a first basic instance) in 64% of the cases, while an extra 17% is planning to do so in the near future. Eighty-nine percent of the people answering this survey wanted to be objectively assessed about their microsurgical skills (Figure 9B).

Questions about the topic "Team Training" generated answers about:

a) *perceived benefits*, most people think positively about training as "complete team" (the only question answered unanimously); as "second surgeon" (93%) and also as "scrub nurse" (81%);
b) *the active role of the scrub nurse*, the majority of respondents (71%) manifested that "active" or "more active" participation while training will be correct.

A summary of these mentioned numbers appears depicted at Figures 10 and 11.

(Figure 10)

(Figure 11)

Microsurgery general concepts understanding

Figure 12 depicts understanding about question for general concepts. Half of this question (blue bars at the figure) were correct, and the rest were incorrect (light-red bars at the figure).

(Figure 12)

The complete summary can be appreciated at the figure, but some remarkable situations were highlighted:

- Results showed that 35.2% of respondents interpreted the microscope ONLY as an optical device.
- Additionally, 8% of participants had erroneous understanding of working distance.
- A poor understanding of focus and depth of field was detected (52.1% and 11.3% respectively).
- Around 70% believed that illumination should remain the same for all instances during the procedure.
- Just nearly-half (51,4%) of the respondents perceived microsurgical pre-procedure planning as necessary.

Training centers information

Accessibility: just 54% of respondents have a training center in their city. Among those having a center in their cities, it was unaffordable or inaccessible for 29% of grand total (Figure 13).

Infrastructure: Regarding the availability of essential training infrastructure at their workplace (microscope, instruments, proper guidance or protocol, access to simulators), 47% reported having all these elements, 18% had some of them, and 35% lacked all necessary resources for skill training at their institutions.

(Figure 13)

There was a general acceptance (96%) of the opportunity to be introduce to self-assessment training methods.

DISCUSSION

Microsurgical education plays a key role in the development and refinement of surgical skills. Achieving this requires continuous pursuit of targeted programs and validated methodologies suitable to be used at different infrastructure and socioeconomic contexts. Addressing these challenges is essential for meaningful progress in the field.

Several scientific publications have examined various dimensions of microsurgical training. These studies have introduced performance scoring systems,[9–10] explored the implementation of novel optical technologies,[11] evaluated manual dexterity through different approaches,[12] and emphasized the importance of training in improving surgical outcomes. In addition, maintaining skill proficiency remains a critical concern for microsurgical centers and laboratories.[13]

To effectively meet these evolving needs, an initial local assessment is necessary to evaluate how microsurgical education is adapting to current demands. Once baseline information is established, more specific strategies can be employed. These may include pre- and post-course evaluations, direct surveys for training feedback, suggestion logs, and external reviews of teaching quality.

This survey gathered responses from a broad range of participants, including surgical assistants, second surgeons, and trainees—thereby expanding its scope. Several conclusions can be drawn from the data, which will be presented according to the survey's original structure and corresponding results.

Basic information about the respondent

The first four figures provide a general overview of the individuals who participated in this survey. Respondents represented a broad range of microsurgery professionals, spanning all levels of experience and coming from numerous countries. By including perspectives from scrub nurses and second surgeons, the survey introduces a novel viewpoint intended to help fill gaps in the broader understanding of microsurgical education.

The results show considerable variation in the respondents' educational backgrounds, which appear to be linked to socioeconomic factors. This pattern was explored using cross-referencing between country and the Inequality-adjusted Human Development Index, which served as a filter for segmenting and analyzing the data.

Microsurgical infrastructure, simulators, supplies, and devices are expensive and often difficult to access, contributing to higher training costs and limited availability. Unfortunately, this situation seems to correlate with surgical outcomes and levels of expertise. By gaining a clearer understanding of these challenges and how to assess them, potential solutions may begin to emerge.

Several promising initiatives are now in development to address these issues, many of them focused on remote training programs designed for regions most affected by geographic or financial barriers. For these programs to be effective, they must be evidence-based and supported by solid academic frameworks.

Microsurgery training & procedural evaluation

Most participants (approximately 75%) reported using non-specific methods to evaluate the microsurgical stage of a procedure. This likely contributes to the lack of precise information about microsurgical performance, particularly in identifying whether suboptimal results stem from technical failures—such as those related to the microscope, instruments, strategy, or manual skill. In our sample, the most frequently mentioned evaluation criterion was surgical outcome (55%). However, this approach's inaccuracy is notable, as the microsurgical stage represents only one among numerous factors influencing surgical outcomes—highlighting the need for more specific and dedicated evaluation tools.

When assessing opinions on the impact of microsurgical hand skills, 85% of respondents directly correlated such skills with improved outcomes. Curiously, although widely recognized as a highly positive attribute, microsurgical skill appears to be undervalued in practice: only 60% of the trainees who were instructed under a dedicated program—which itself represented just 25% of the total sample—reported receiving specific training in hand skills.

The concept “procedure” was accurately defined by the 45% of respondents, suggesting that the issue extends beyond the absence of proper assessment methods to a deeper disconnect from foundational principles.

While skill assessment has historically been difficult to teach and measure, the need for objective evaluation now appears to be a shared concern among microsurgical professionals: 80% of respondents believe such objectivity is possible—either completely or to a significant extent. Despite years of study and the existence of well-regarded methods within the surgical community, implementing objective assessments continues to present challenges.

Regarding how these concepts are taught, the collected data reveals limitations in both content and instructional modality of training programs. Only 40% of respondents indicated they had access to a dedicated program with sufficient curriculum, while most incomplete programs focused solely on device handling. Lower socioeconomic status was correlated with reduced access to quality training. Two key findings support this last observation:

- Just two respondents´ countries affirmed to have dedicated and full programs for microsurgical education. Both came from a Very-High Income level country.
- Most of responses affirmed to have just 1 topic in their programs (more information about this evaluation can be found at the appendix section, “survey rationale”), frequently taught by “mostly watching...” modality. All of these answers came from Mid-Low-Income level country.

As previously noted, the completeness and appropriateness of microsurgical training programs remain inadequately defined. Based on our preliminary research—including a systematic review of academic databases, expert consultations, and local institutional experience (as detailed in the Methodology section)—several core topics should be integrated into microsurgical education. These include foundational concepts such as device operation, instrument handling, procedural techniques, strategic planning, and optical principles essential for optimizing the microsurgical environment.

The “Team Training” modality received highly favorable feedback. It was the only item to reach full consensus: 100% of respondents agreed that team training contributes to improved

surgical outcomes. Within this group, 93% supported active roles for a second surgeon and 81% endorsed involvement of a scrub nurse during training. Role-switching exercises were accepted by 56% of participants, although 7% explicitly opposed active training for a surgical assistant. This latter finding may reflect dynamics beyond the scope of this paper.

Microsurgery general concepts

This section presents a "True or False" multiple-choice assessment designed to evaluate participants' understanding of key optical concepts, a foundational topic within any microsurgical training program. Analysis of the responses revealed several noteworthy findings that help establish a baseline of conceptual comprehension:

- Only 35.2% of respondents identified the microscope exclusively as an optical device.
- Eight percent demonstrated a misunderstanding of the concept of working distance.
- The concepts of focus and depth of field were inconsistently understood, with error rates of 52.1% and 11.3%, respectively.

These concepts are considered essential for accurate interpretation and effective interaction within the microsurgical environment. Moreover, the results may point to deficiencies at various stages of the educational continuum, including curriculum design, teaching methodologies, accessibility to educational resources, and quality of on-site supervision. Further investigation is warranted to assess the potential impact of these gaps on surgical performance and patient outcomes..

Training centers information

The need for microsurgical instruction has steadily increased since the introduction of the surgical microscope nearly a century ago. However, the availability of education and training opportunities has not kept pace. Today, several barriers are believed to continue hindering proper microsurgical instruction.

Only 57% of respondents reported having a training center in their city. Among them, 36% found the training either unaffordable or somehow inaccessible.

Regarding access to a microsurgical station at their own institution—including a microscope, instruments, structured guidance or protocol, and simulators—47% reported having all necessary elements, 18% had some, and 35% lacked all resources required for skill development.

A strong majority (96%) expressed support for the opportunity to engage in self-assessment training methods.

Based on these findings, it is reasonable to conclude that implementing compact training stations and validated protocols for remote instruction and supervised practice could offer a viable solution for nearly 70% of surgeons in need of proper microsurgical education. This approach is particularly valuable because it can be adapted even to low-resource settings.

CONCLUSION

Recognizing the importance of microsurgical training, this exploratory global survey sought to shed light on a topic that remains largely underexamined and difficult to assess (including operators' general data, their experience as students/trainees, understanding of fundamental concepts, and training centers' availability).

Drawing from a modest sample, the findings offer a preliminary glimpse into the current state of microsurgical education, and an overall insight revealed disparities in access, infrastructure, and instructional methods.

While not exhaustive, this initial dataset is intended to stimulate discussion, raise awareness, and serve as a foundation for more rigorous and expansive future investigations.

LIMITATIONS

This study's findings are subject to several limitations inherent in its design and scope. Primarily, the reliance on a limited sample of the global microsurgical community restricts the

generalizability of our results. A larger, more diverse sample would be necessary to enhance accuracy and better represent the broader population of microsurgical practitioners.

As a survey-based study, it is susceptible to inherent biases, including potential sampling and response biases, which may influence the reported outcomes. Furthermore, surveys can lack the depth and context required to fully capture the complexity of participants' experiences. Challenges such as question misinterpretation, recall bias, and survey fatigue may also impact data reliability.

A significant limitation stems from the scarcity of specific data on the topics explored, which are inherently difficult to capture. Many institutions involved in microsurgical assessment and education operate outside formal societies or international programs, making them challenging to track. Similarly, numerous microsurgery practitioners remain beyond the reach of conventional survey methods. Consequently, our participant pool, particularly with a majority of responses from neurosurgeons, may not adequately represent the general microsurgical population and could introduce an additional source of bias.

Given these constraints, our primary objective was to present initial findings and stimulate discussion rather than establish definitive norms. While acknowledging these limitations, this exploratory step is crucial for initiating discourse on a topic that would otherwise remain largely unexplored.

Data availability statement-none

Finding-none

Conflict of interest-none

Acknowledgement- none

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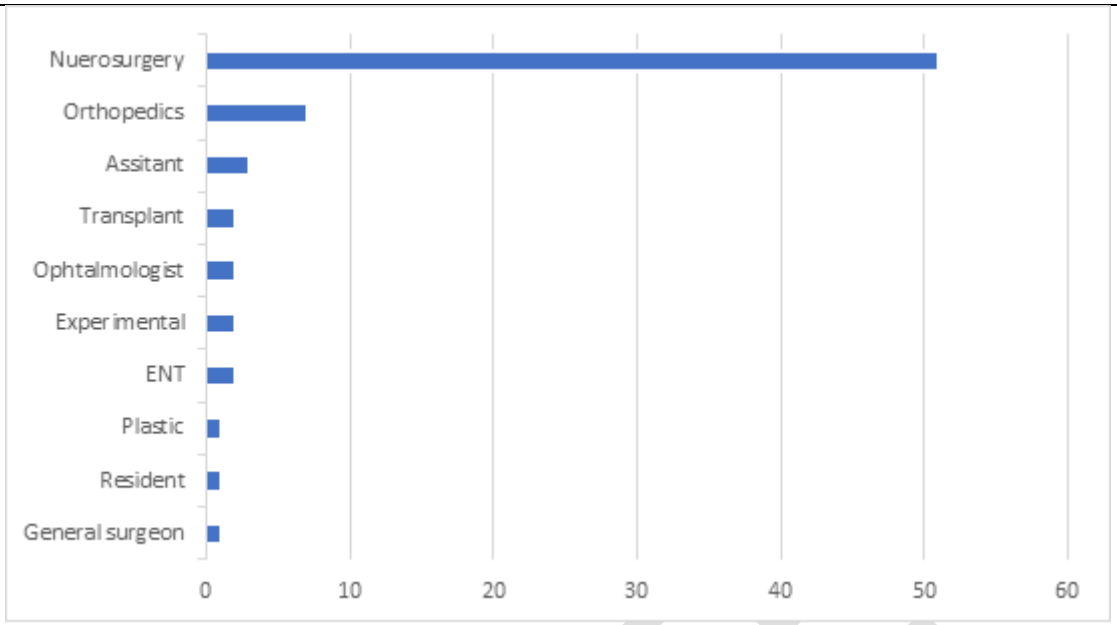
ADDITIONAL MATERIAL

1) Link to explore and fill the survey for new additions (this paper only include records from December 2024 to February 2025):

https://docs.google.com/forms/d/e/1FAIpQLScpgx_jDHWRClQh0HBBUewvWOQ3s8Vb-_78cuF-rMJmMz2s0A/viewform

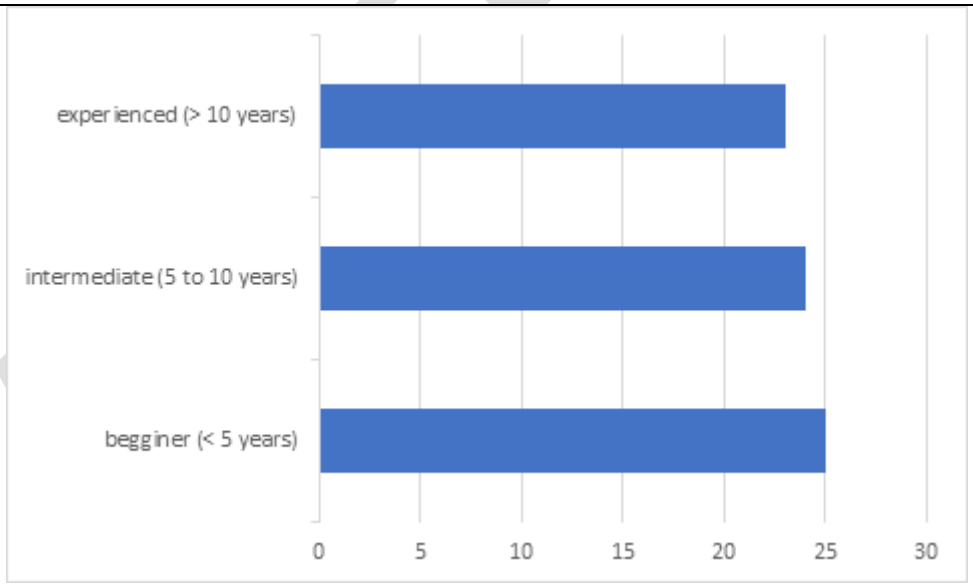
2) Appendix File: Questions Rationale.

Figure 1. Microsurgical specialties represented in this survey.



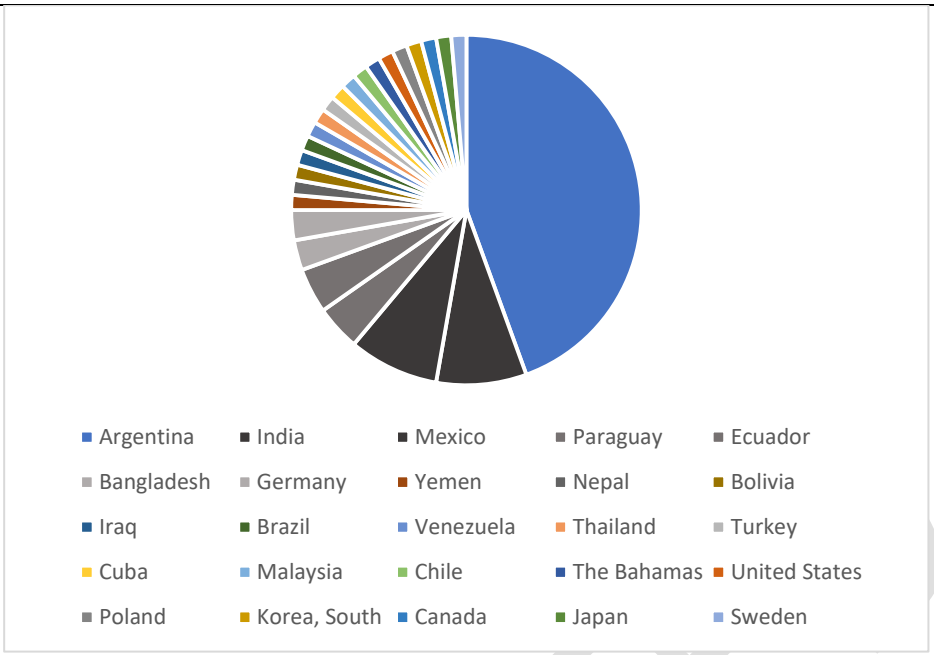
Bars represent each identified specialty of the respondent. Closed question with fixed options. Options "other" was available, with no registries for this option. Source: own elaboration.

Figure 2. Expertise level of the respondents.

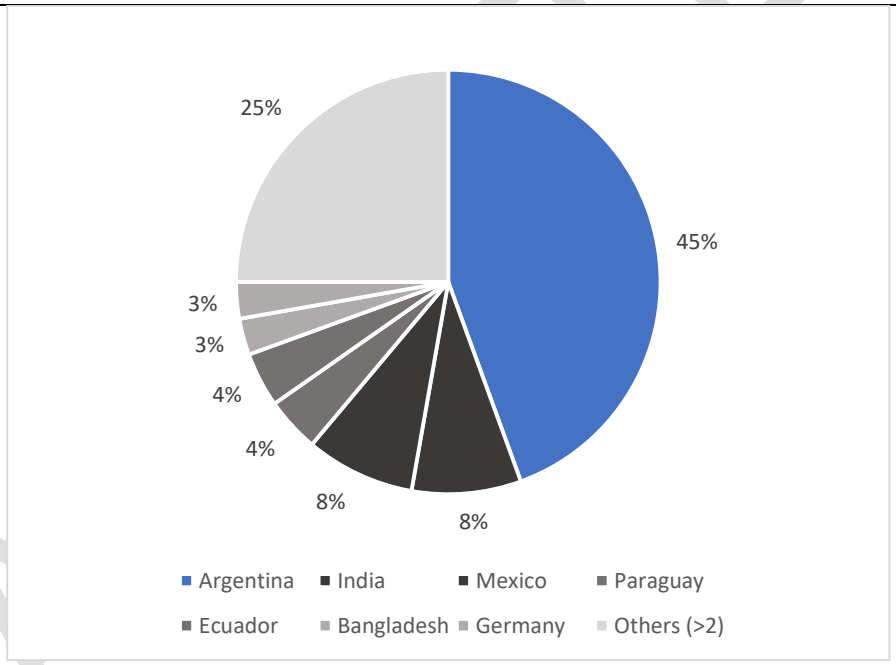


Bars represent each level of expertise. Bar length corresponds to number of respondents on this category. Closed question with fixed options. Source: own elaboration.

Figure 3. Participant countries. (A)

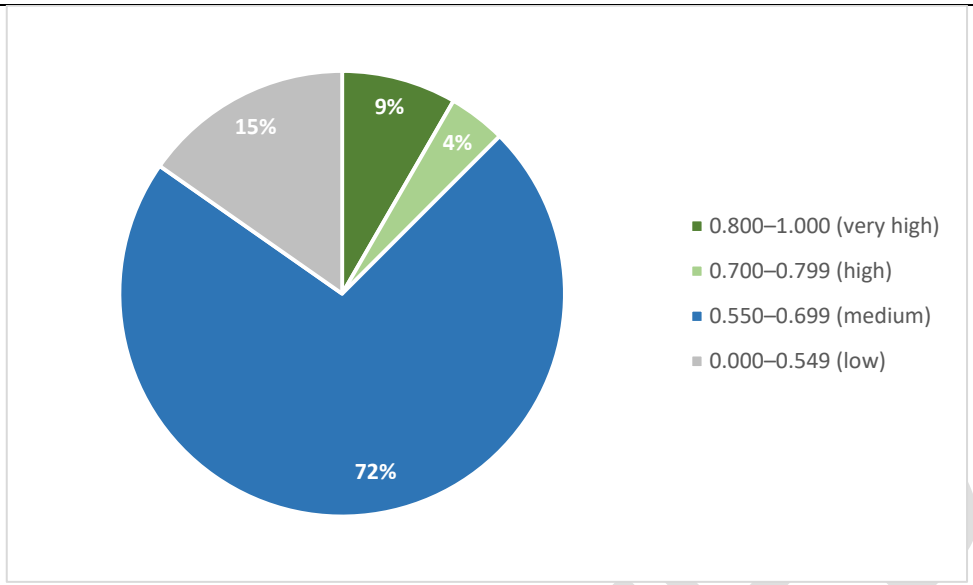


Participant countries (simplified vision). (B)



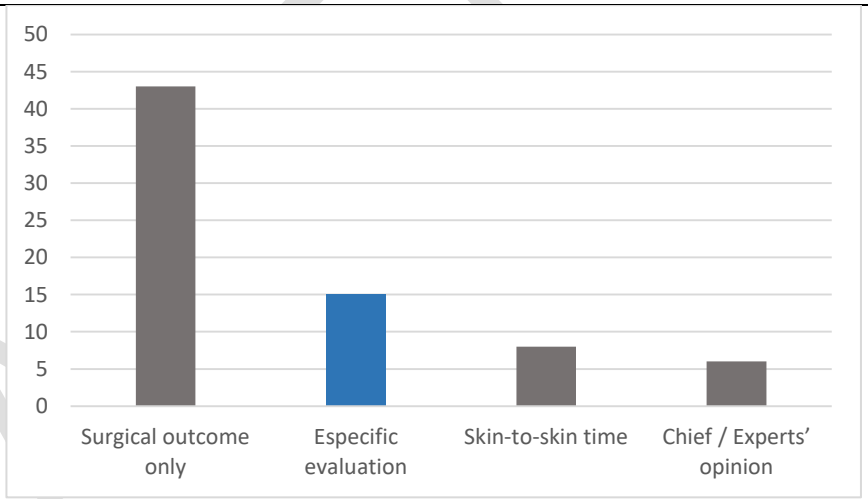
(A) All countries represented in one graphic. (B) Simplified view: answers with just 1 respondent were grouped in "others" (25%). Source: own elaboration.

Figure 4. Survey representation by Inequality Human Development Index (IHDI – United Nations).



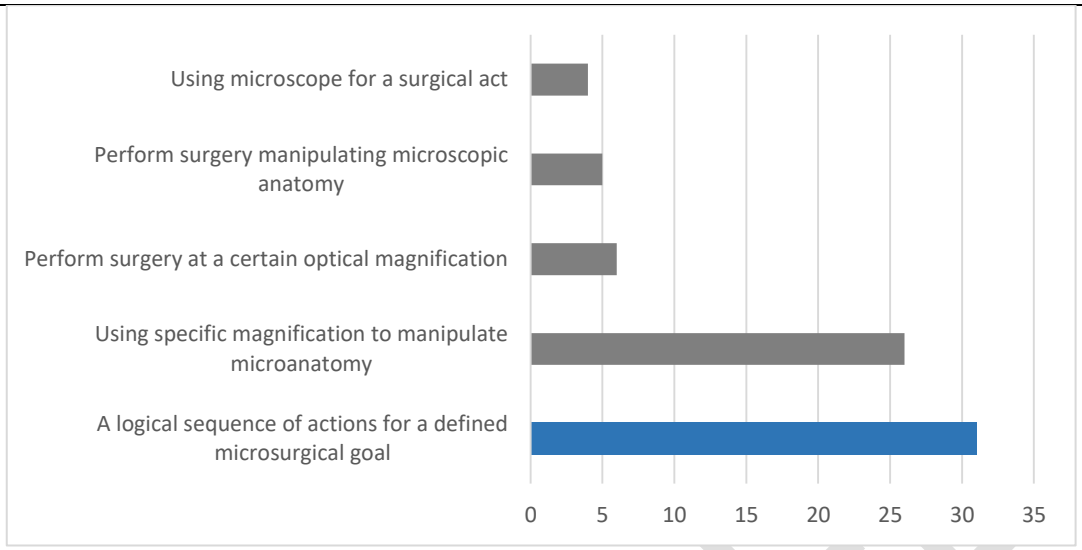
Each country was classified by its IHDI level (United Nations, Human Development Report 2025). Stratification from Low to Very High also follow the same report. Source: own elaboration.

Figure 5. The method for microsurgical procedure evaluation.



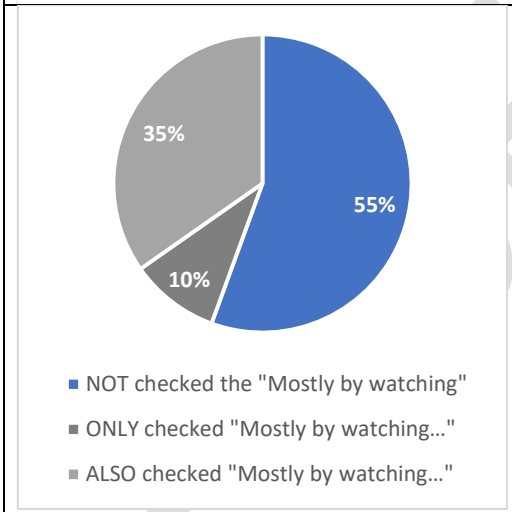
Closed question with fixed options. Bars height account numbers of responses per category. Source: own elaboration.

Figure 6. The “Microsurgical Procedure” definition.



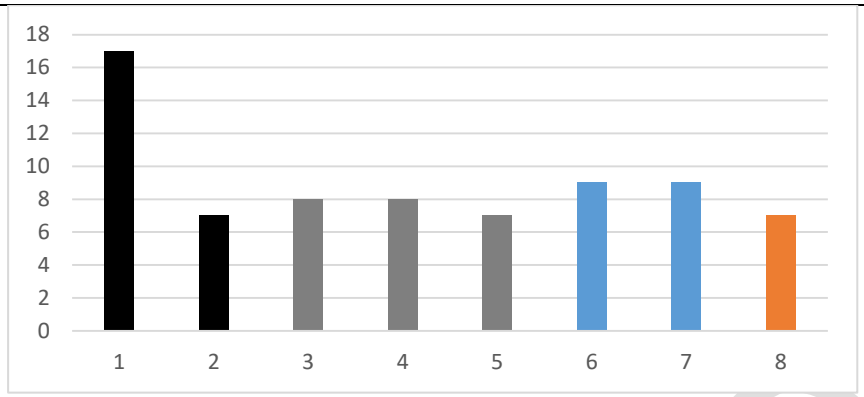
Closed question with fixed options. Bars height account numbers of responses per category. Source: own elaboration. (Text of the options has been shortened to better visualize the figure. Source: own elaboration).

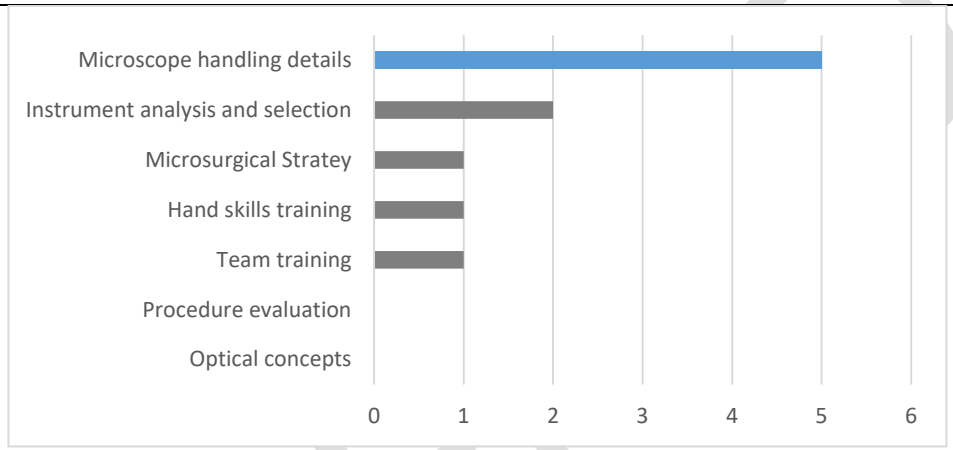
Figure 7. Teaching modality and Program topics



(A)Pie chart: proportion of responses by modality of teaching. (B)Bars: accounting number of responses per selected topic. Question with fixed answers including one distractor/hidden option. Source: own elaboration.

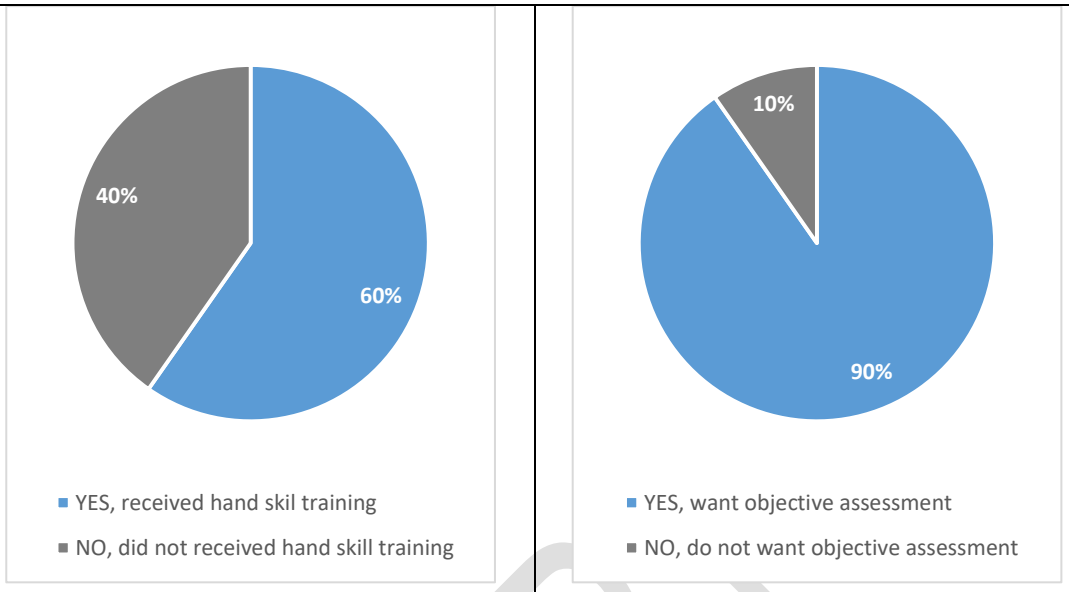
Figure 8. Number of program topics selected by each response AND analytics for group “1 response”.





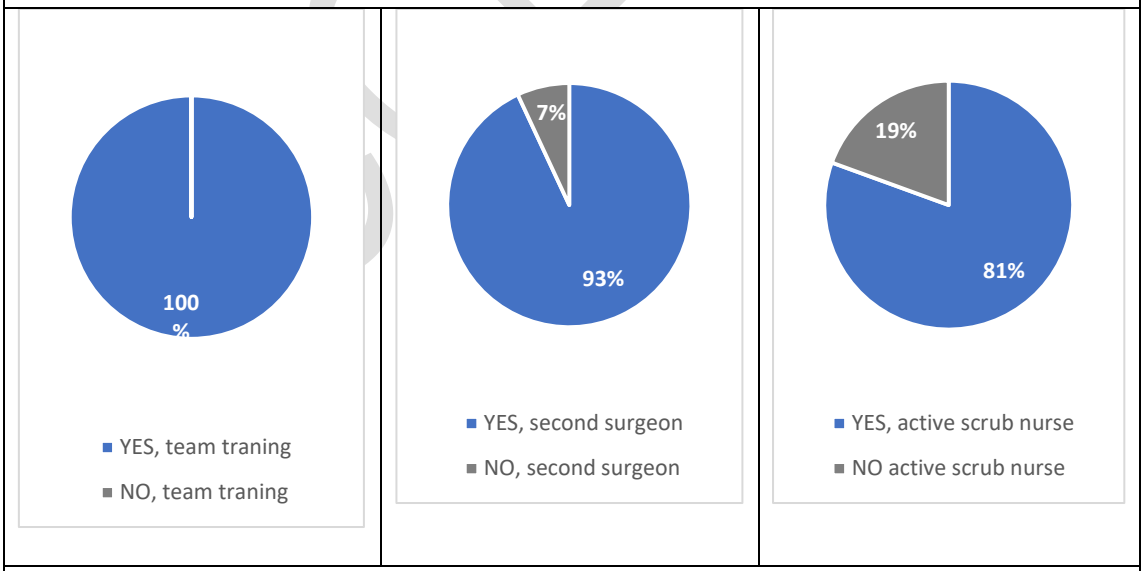
(A)Vertical bars: number of program topics per each respondent. (B)Horizontal bars: accounting number of responses per selected topic AMONG those who choose just 1 program topic (text for the topics has been adapted from the original question to improve visualization). Information gathered by analysis of the previous question. Source: own elaboration.

Figure 9. Proportion of microsurgical students that have received specific hand skill training AND the proportion who will request for objective evaluation.



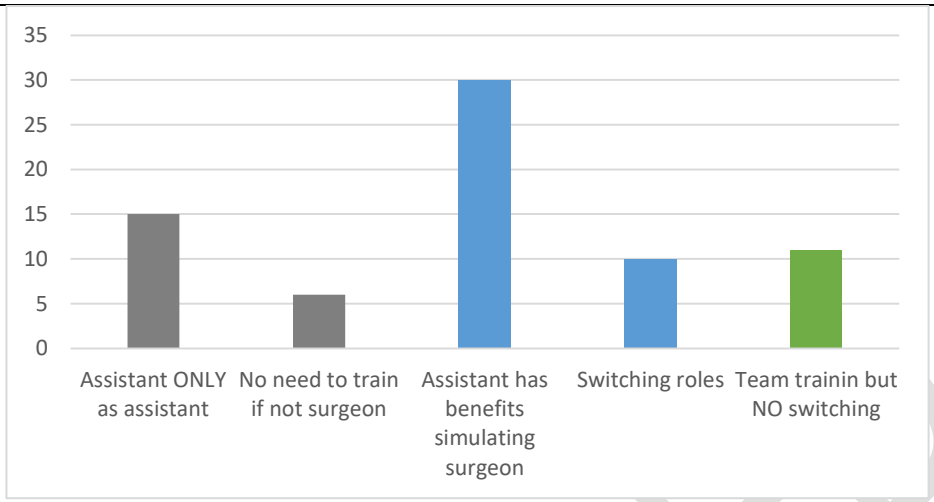
(A)Left pie: presenting proportion of respondents receiving or not hand skill training. (B)Right pie: respondents manifesting the will to be objectively evaluated. Closed question with fixed options. Source: own elaboration.

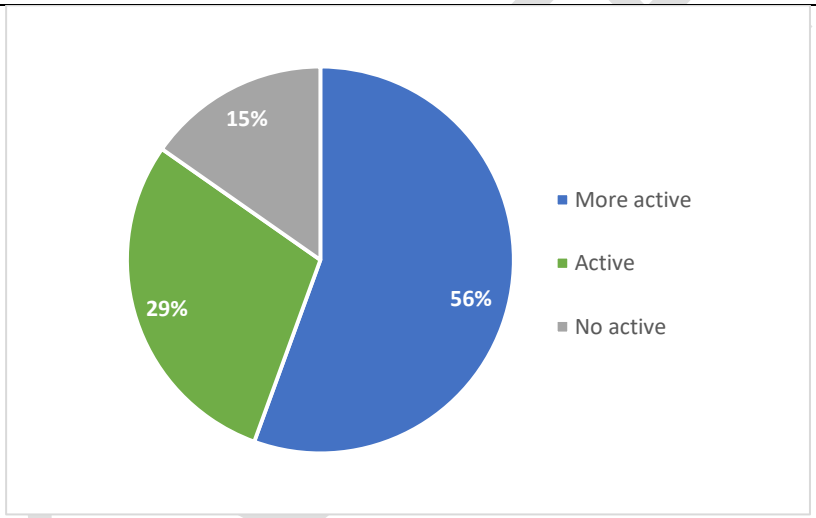
Figure 10. Opinions about active training as Team, Second Surgeon, and Scrub Nurse.



(A)LEFT PIE: team training perceived beneficial. (B) CENTRAL PIE: second surgeon training perceived beneficial. (C)RIGHT PIE: scrub nurse training perceived beneficial. Closed question with fixed options. Source: own elaboration. Source: own elaboration.

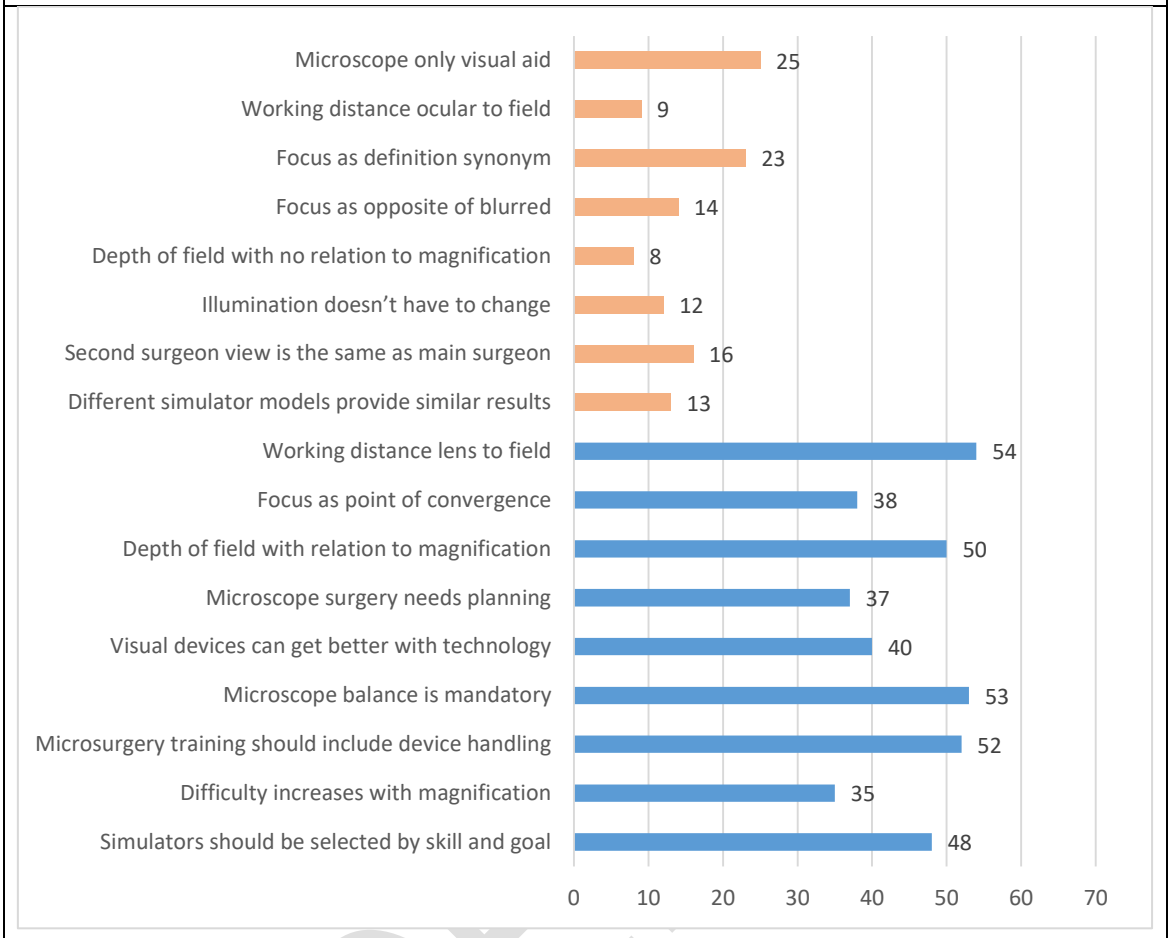
Figure 11. Opinions about different modalities of team training including Assistant/Scrub nurse.





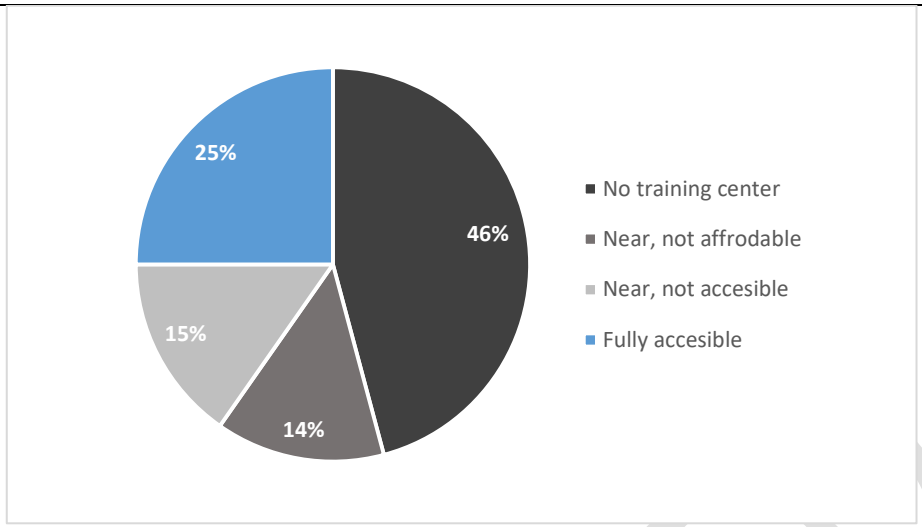
(A)Vertical bars: number of responses per category (options were classified in non-active, active, and more active and identified by colors, matching the next pie chart). (B)Pie: Proportion of respondents segregated by opinion of activity for the Assistant. Closed answer, fixed options. Source: own elaboration.

Figure 12. Responses (True or False) for fundamental microsurgical concepts.



All options from the question are depicted with horizontal bars. The number of responses is shown by the bar length and its label. LIGHT RED: options presented a WRONG answer that was marked as TRUE. BLUE: options presented a CORRECT answer that was marked as TRUE. Source: own elaboration.

Figure 13. Training Centers accessibility.



The total of respondents is represented in this chart and proportions are calculated as per the grand total.

Source: own elaboration.

Table 1. Survey structure overview.

SECTION	QUESTION	STRATEGY
(a) Basic information about the respondent:	(1) Which is your surgical specialty?	Structured, closed-ended question with a predefined list of microsurgical specialties. An open-ended option (referred to as "other" with the option to enter a new specialty) was offered, which was reviewed and refined at the end of the survey.
	(2) How many years ago did you completed residency or similar specialized training?	Structured, closed-ended question with predefined options.
	(3) What is your experience in microsurgical procedures? (please only take into account the number of interventions performed independently as the MAIN surgeon)	Structured, closed-ended question with predefined options.
	(4) Where have you received, or are currently receiving, your training?	Structured, closed-ended question with predefined options. The list of countries was acquired from the UN database. A last option named “non-listed country” was added.
(b) Microsurgery training procedural evaluation:	(1) How do you evaluate your microsurgical technique?	Structured, closed-ended question with predefined options.
	(2) Please choose the most accurate definition for the concept MICROSURGICAL PROCEDURE.	Structured (“Multiple choice” like. Just one answer correct), closed-ended question with predefined options.
	(3) In your opinion, can the operator's microsurgical skills/technique be OBJECTIVELY assessed?	Structured (Likert scale like), closed-ended question with predefined options.

	(4) Do you think that learning/training microsurgical skills (using simulators, laboratories, specific exercises, taking courses, etc.) is important to obtain better SURGICAL OUTCOMES? (The term "skills" refers to the ability or dexterity of the operator's hand movements in a specific task and scenario).	Structured (Likert scale like), closed-ended question with predefined options.
	(5) During your residency (or similar training programs), have you learned any of the following? Check all that applies.	Structured ("Multiple choice" like), closed-ended question with predefined options.
	(6) After finishing your specialty education (residency or other similar programs), have you taken any courses for learning/training/refining microsurgical knowledge/abilities?	Structured, closed-ended question with predefined options.
	(7) If there was a method to objectively test, evaluate, and qualify your microsurgical skills, would you take such a test?	Structured, closed-ended question with predefined options.
	(8) Do you think that training as a second surgeon can have a good impact on the outcome of a microsurgical procedure (please note that the term "SECOND SURGEON" refers to the surgeon who also operates, helping the main surgeon).	Structured, closed-ended question with predefined options.
	(9) Do you think that training as an assistant (performing a simple surgical task) can have a good impact on the outcome of a microsurgical procedure (please note that the term "ASSISTANT" refers to the surgical instrument technician / scrub nurse).	Structured, closed-ended question with predefined options.
	(10) Please, chek all the boxes that you consider correct (please note that the term "ASSISTANT" refers to the surgical instrument technician / scrub nurse; the term "SECOND SURGEON" refers to the surgeon who is also operating, assisting the primary surgeon).	Structured, closed-ended question with predefined options.
	(11) Do you think that a microsurgical procedure could be more effective if the complete team has previous experience working toghether?	Structured, closed-ended question with predefined options.
	(12) If someone asks you to try a new microsurgical optical device that offers significant and improved features but requires an adaptation training period, would you try it?	Structured, closed-ended question with predefined options.
(c) Microsurgery general concepts understanding.	(1) OPTICAL RELATED CONCEPTS: please check all the boxes with correct sentences.	Structured ("multiple choice" like, test modality) closed-ended question with predefined options.
(d) Training centers information	(1) Do you have any microsurgical training centers in your region? (city or country)	Structured, closed-ended question with predefined options.
	(2) In the case your answer was « yes » in the previous question, please choose the more accurate answer for your situation:	Structured, closed-ended question with predefined options.
	(3) Do you have a training lab in your institution or a place where you can train your skills? (Minimally, a training unit should have a microscope, microsurgical instruments in acceptable condition, and some kind of supervision of your training improvements)	Structured, closed-ended question with predefined options.
	(4) Do you think your institution could benefit from a place like a "microsurgery training unit"? (For training skills, technical and technology research, academic production, procedure improvement	Structured, closed-ended question with predefined options.

	analysis, etc.)	
	(5) If you had the chance to join a self-assessment, self-training, remotely supervised, objectively evaluated, accessible, and affordable program, would you join?	Structured, closed-ended question with predefined options.

Note: This table

Highlights:

. This paper aims to explore the current state of microsurgical training from the trainees' perspective, including their expectations, experiences, knowledge, and regional and socioeconomic differences.

. Given the importance of microsurgical training, this global survey aimed to elucidate the current status of microsurgical training and expectations of respondents. Trainees show an interest in microsurgery but are seeking easily accessible, affordable and professional training.

. There is also currently a lack of proper infrastructure and training programs mainly focusing on microsurgery.

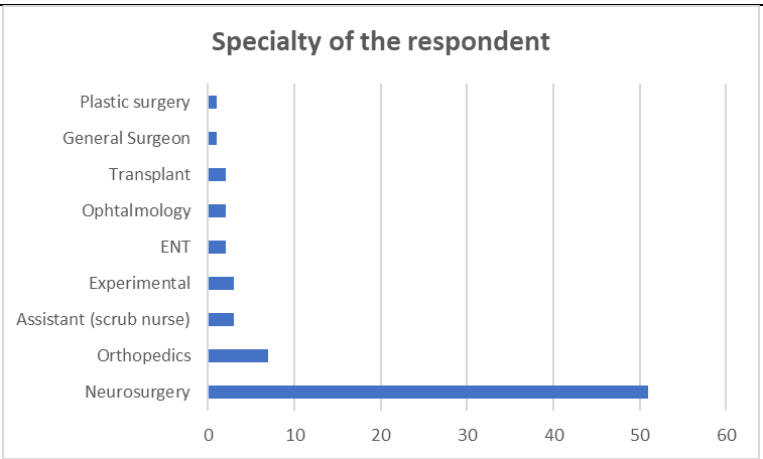
Appendix 1: survey rationale extension

Survey sections and the rationale behind each question. Each section attempted to approach a complete topic, and questions within the section were designed to illustrate a concrete answer.

a. Basic information about the respondent:

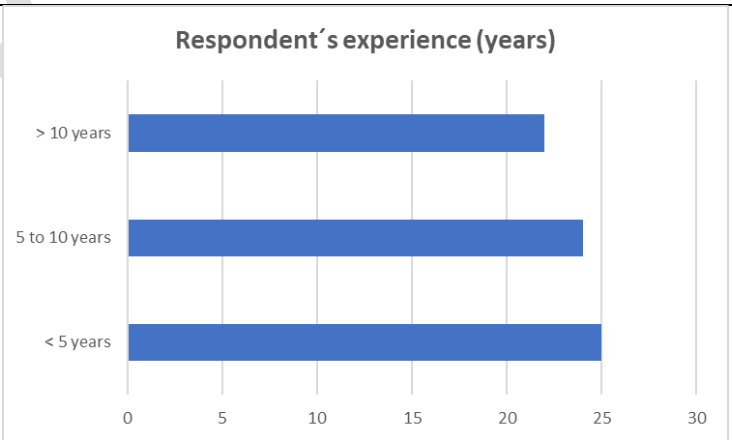
1. Question: **Which is your surgical specialty?**

   A list of the most frequent specialties was presented, added with the option to insert a new one. Note that the "technician / assistant / scrub nurse" option was included.

Question's background	Final Graphic representing results
Aiming to identify different fields of microsurgical specialties represented in this survey. Variability in this answer could mean a more complete description, as well as denoting significant differences among them and the microsurgery education and application.	

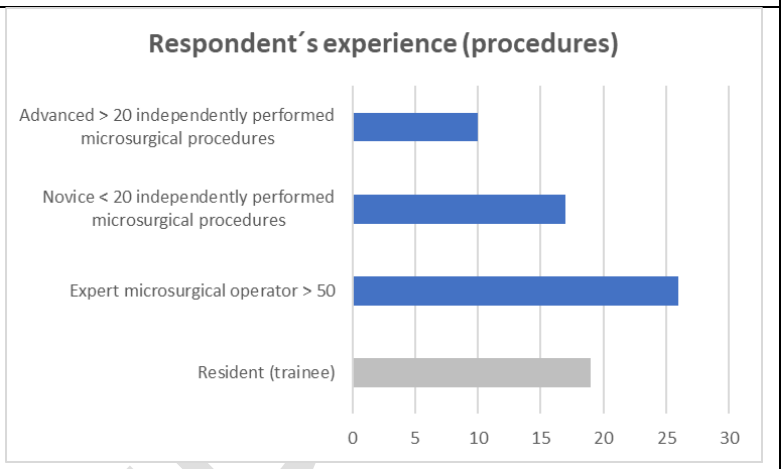
2. Question: **How many years ago did you complete residency or similar specialized training?**

   Three options were provided to measure the experience of the respondent, using years after the end of specific education.

Question's background	Final Graphic representing results
This question aimed to know about the respondent's experience. Measuring the variable in years after finishing formal education allowed to include residents who received his microsurgical traning (still not practicing independently, but with some valuable experience to comment).	

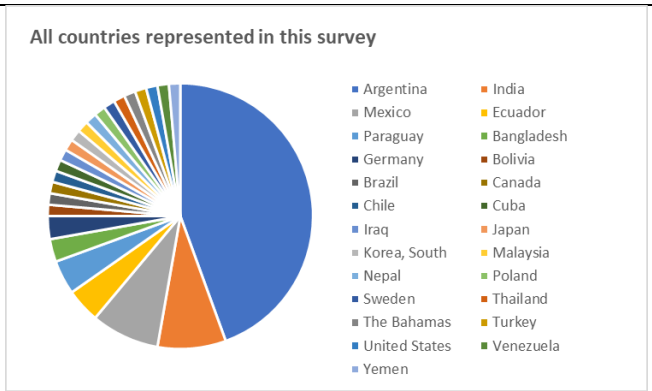
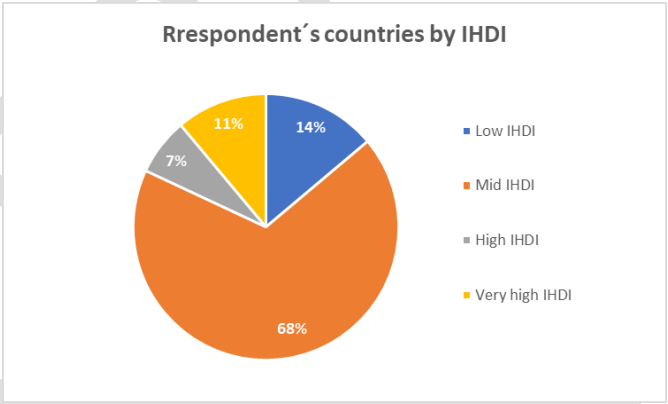
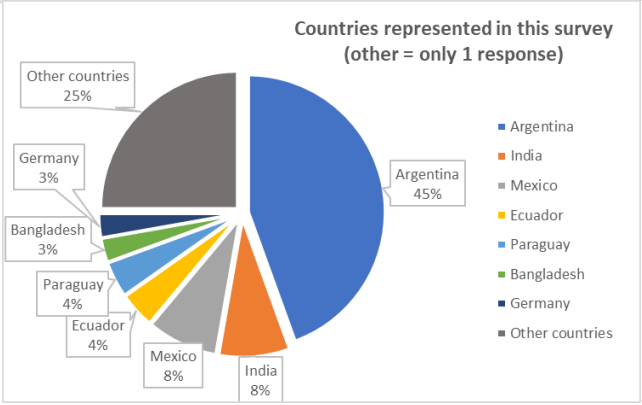
3. Question: **What is your experience in microsurgical procedures? (please only take into account the number of interventions performed independently as the MAIN surgeon)**

Four options were presented, following recomendations about when an operator should be considered expert. The number of microsurgical procedures performed independently as main surgeon appears as the most reliable criterion. The 20 and 50 procedures level was considered appropriate to segregate this answer, following recent studies of the microsurgical learning curve [18].

Question's background	Final Graphic representing results
The goal of this question was to have the possibility to segregate a more particular vision of the microsurgical experience. At some stages of this survey, the comments from an expert/advanced/novice could add valuable data for a proper interpretation. Also, identifying the "residents" group resulted in good information for a more thorough description of the population involved in this survey.	

4. Question 4: **Where have you received, or are currently receiving, your training?**

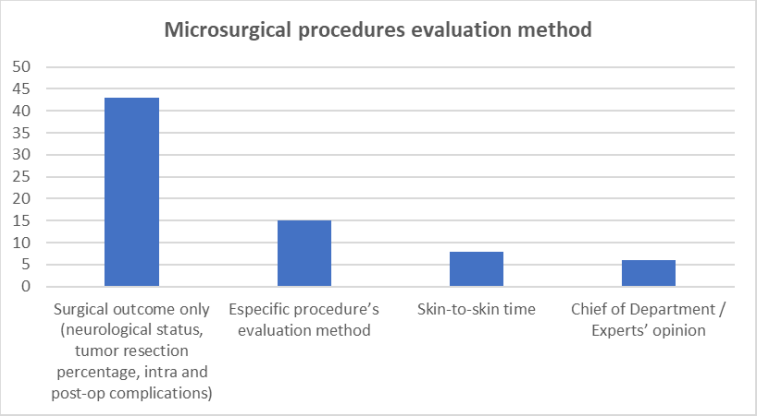
   A list of countries was provided, including the option "other", just in case the list didn´t have the correct option or spelling. The most recent United Nations Development Program report [9] was consulted to build this list and match further cross-information.

Question's background	Descriptive final graphics
Answers will show the level of world-wide representation. Then each country was classified by its level of Inequality-adjusted Human Development Index (IHDI) from the United Nations report. By doing this, the database can be segregated by applying this factor and compare situations among socio-economic status (accessibility, program completeness, responses accuracy, etc). In addition, a third graphic was added to simplify the overview about participating countries (countries with just one respondent were grouped).	  

b. Microsurgery training procedural evaluation:

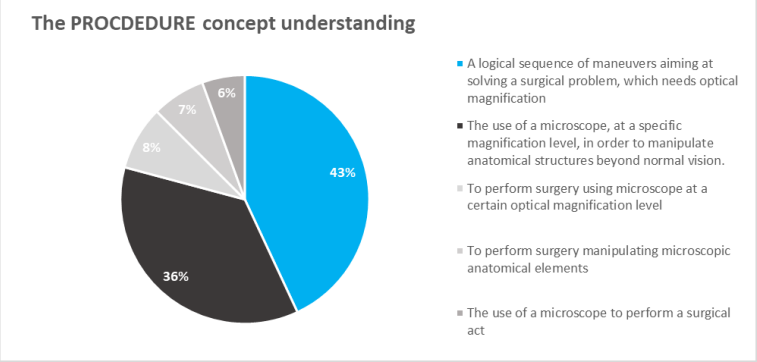
1. Question: **How do you evaluate your microsurgical technique?**

   Four options were provided to identify which kind of evaluation applies to each respondent's situation. The three more frequently non-specific observed methods, against some other specific methods.

Question's background	Final Graphic representing results
Firstly, this question aimed to investigate how much a specific method is used to assess the procedure's effectiveness. (International recommendation). Secondly, non-specific methods were provided separately to avoid confusion by including them as a specific one.	

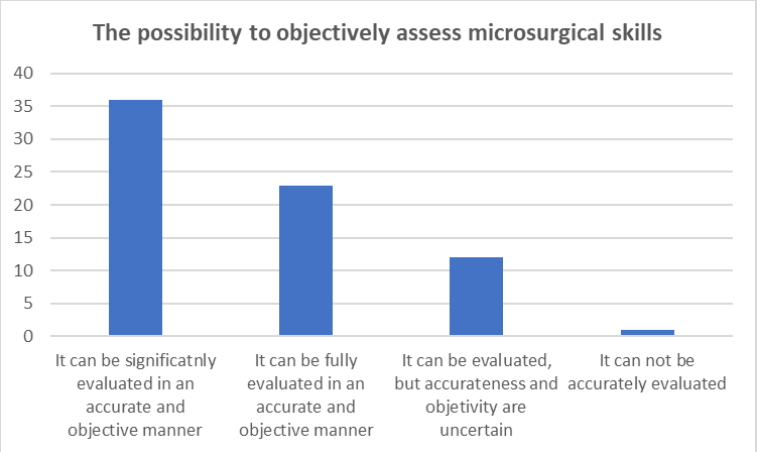
2. Question: **Please choose the <u>most accurate definition</u> for the concept MICROSURGICAL PROCEDURE.**

   Five options were provided, giving the correct one and four distractors. Distractors were designed to mix options which did not include the main request for properly define the term (a logical sequence + surgical goal + optic magnification needed).

Question's background	Final Graphic representing results
The question aimed to know the proportion of the respondents knowing an appropriate concept for PROCEDURE. This concept, besides being a fundamental one, allows to investigate if the respondent has received appropriate basic education, about procedures assessment, training and evaluation.	

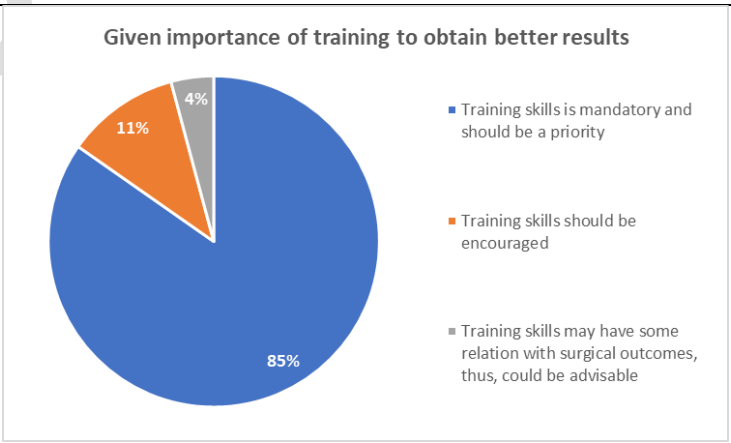
3. Question: **In your opinion, can the operator's <u>microsurgical skills/technique</u> be OBJECTIVELY assessed?**

   Likert scale options were given to stratify the answer. The option for "absolute or complete objectiveness" was added also as a distractor, due to the consideration that 100% objectiveness cannot be reached in the surgical practice/simulation.

Question's background	Final Graphic representing results
Evidence exists promoting objective measurement of quantity and quality of movement [10-13]. This is a cornerstone step to valid evaluations and certifications. An obstacle to including objective-aimed protocols is the reticent behavior from the trainee/operator.	

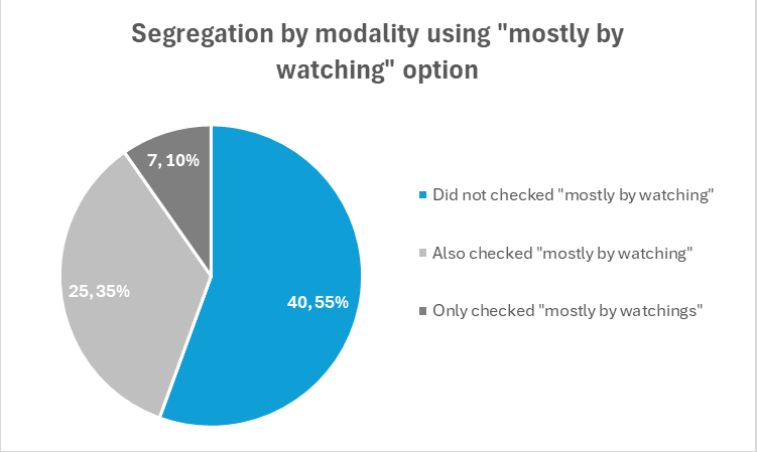
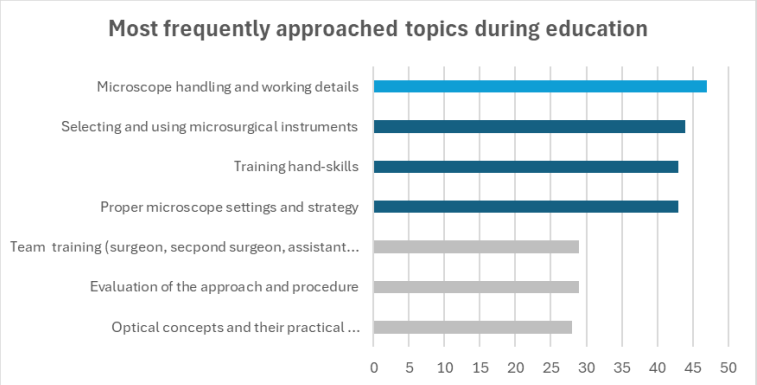
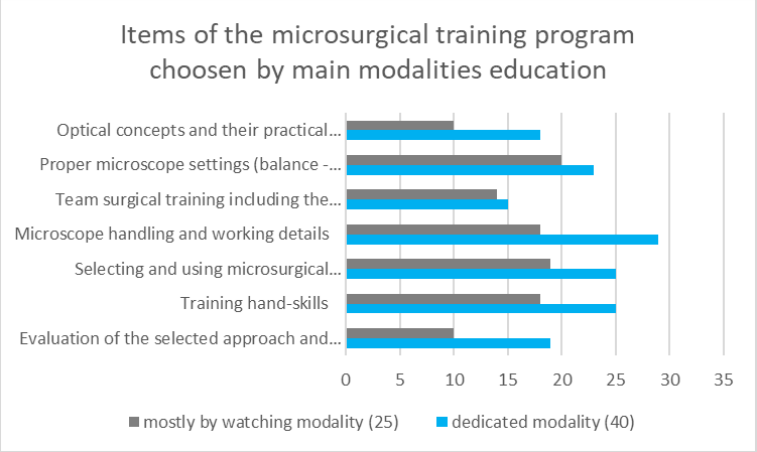
4. Question: **Do you think that <u>learning/training microsurgical skills</u> (using simulators, laboratories, specific exercises, taking courses, etc.) is important to obtain better SURGICAL OUTCOMES? (The term "skills" refers to the ability or dexterity of the operator's hand movements in a specific task and scenario).**

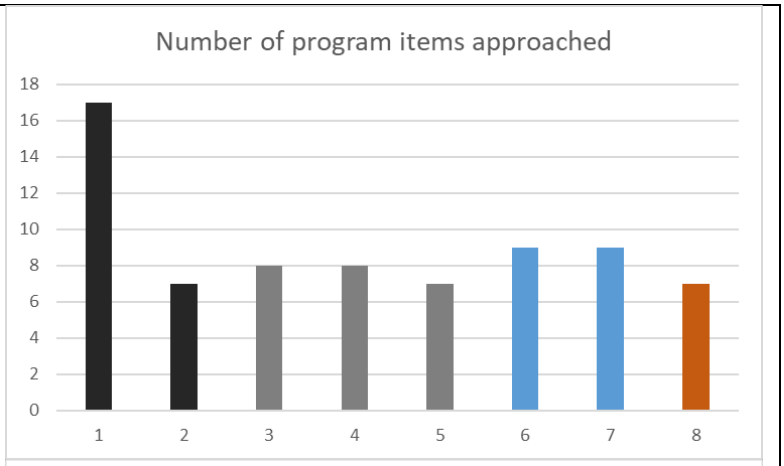
   Four options, Likert scale kind, were provided to answer this question.

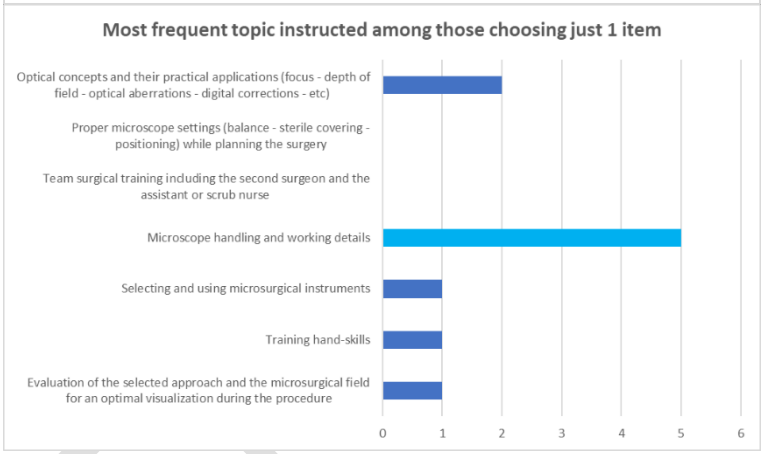
Question's background	Final Graphic representing results
The link between training skills and better surgical results may vary among surgeons. This question intends to assess how strong that link is nowadays. An important part of the problem is the lack of specificity about the terms "training" and "skills", so it was defined in the question.	

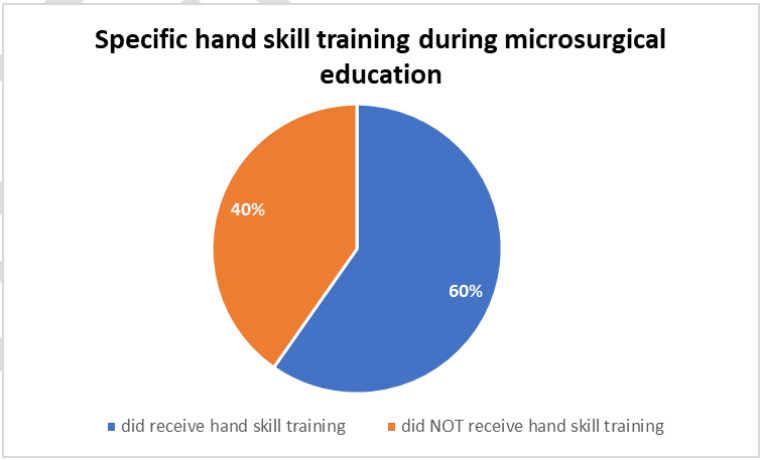
5. Question: **During your residency (or similar training programs), have you learned any of the following? Check all that applies.**

This question lists 7 items considered of main importance at every microsurgical training course. One extra option was also added, considering the most frequent modality seen in our context: “mostly seeing while working in the operation room”, with no regular laboratory stages.

Question's background	Final Graphic representing results
The concept SKILL is as wide and ambiguous as TRAINING is. There is no particular nor defined program to teach and train microsurgery. Due to this, we aimed to investigate which topics were approached by the training program attended by the respondent. A distraction question was included here to assess the proportion of respondents who were taught with a non-dedicated modality as “mostly by seeing during a procedure...”. This situation not only informed about a poor modality, but also to suspect a general deficiency if any other topics were also checked. Using this distraction question as filter, we identified three groups: - Trainees taught by only watching modality - Trainees taught by a specific and dedicated program - Trainees taught by a mixed modality program	  

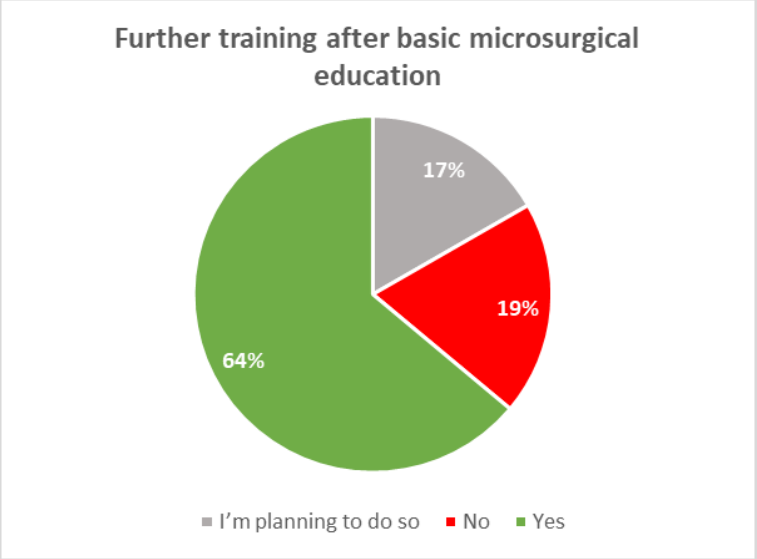

Number of program items approached
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8


Most frequent topic instructed among those choosing just 1 item
Optical concepts and their practical applications (focus - depth of field - optical aberrations - digital corrections - etc)
Proper microscope settings (balance - sterile covering - positioning) while planning the surgery
Team surgical training including the second surgeon and the assistant or scrub nurse
Microscope handling and working details
Selecting and using microsurgical instruments
Training hand-skills
Evaluation of the selected approach and the microsurgical field for an optimal visualization during the procedure
0
1
2
3
4
5
6


Specific hand skill training during microsurgical education
40%
60%
did receive hand skill training
did NOT receive hand skill training

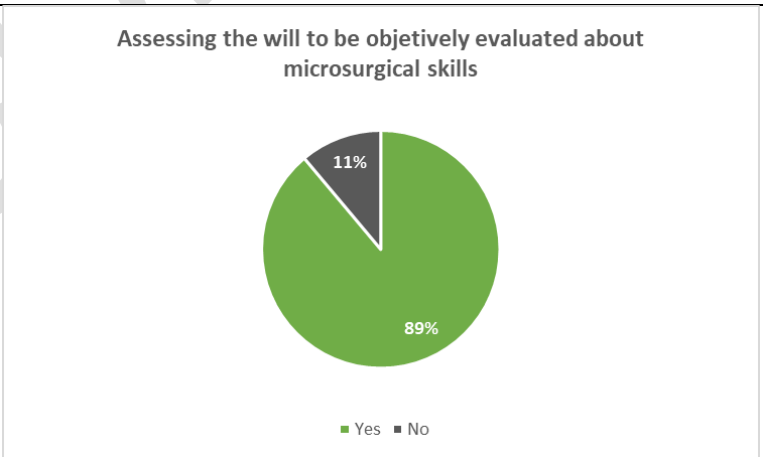
6. Question: **After finishing your specialty education (residency or other similar programs), have you taken any courses for learning/training/refining microsurgical knowledge/abilities?**

   Three options were given: positive, negative, and possible answers.

Question's background	Final Graphic representing results
It is not unusual to see operators that frequently take different courses and training sessions, but also there are other people who don't attend any further microsurgical updates. The proportion of the operators that does want to improve by taking further microsurgical education is unknown. This question aimed to assess this situation.	

7. Question: **If there was a method to <u>objectively test</u>, evaluate, and qualify your microsurgical skills, would you take such a test?**

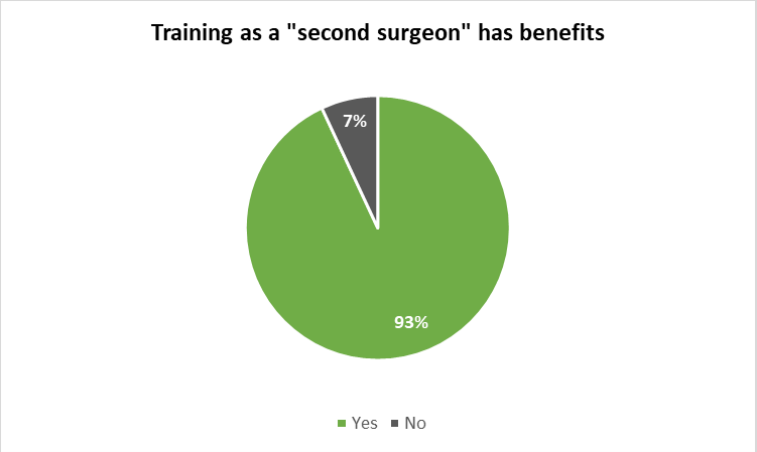
   Closed question. Answer yes / no.

Question's background	Final Graphic representing results
Objective assessment of skills is not easy to reach due to many reasons. One of them is the operators´ will to be objectively evaluated. This situation could be particularly sensitive among experienced operators. This question aims to investigate the relevance of this situation.	

8. Question: **Do you think that training as a second surgeon can have a good impact on the outcome of a microsurgical procedure (please note that the term**

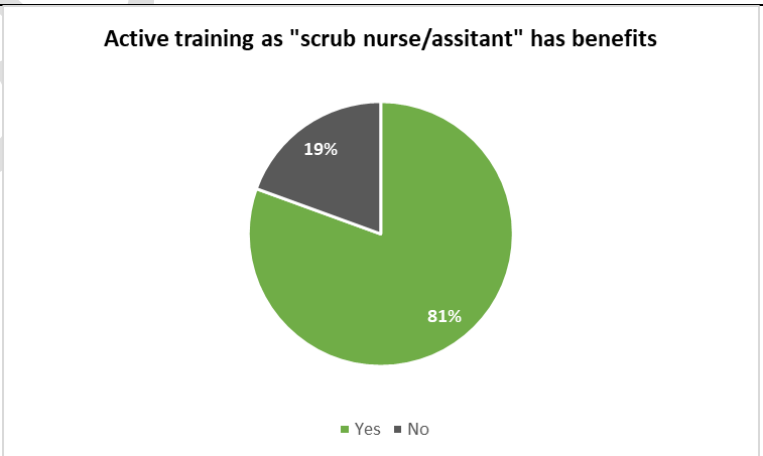
"SECOND SURGEON" refers to the surgeon who also operates, helping the main surgeon).

Closed question for yes / no answer.

Question's background	Final Graphic representing results
Team training has been widely recognized as a valuable topic, improving not only surgical results but also surgical team effectiveness and reliability. This question's goal is to determine, among the respondents, the proportion of those who had a positive view about the benefits of including a second surgeon to assist during training..	

9. Question: **Do you think that training as an assistant (performing a simple surgical task) can have a good impact on the outcome of a microsurgical procedure (please note that the term "ASSISTANT" refers to the surgical instrument technician / scrub nurse).**

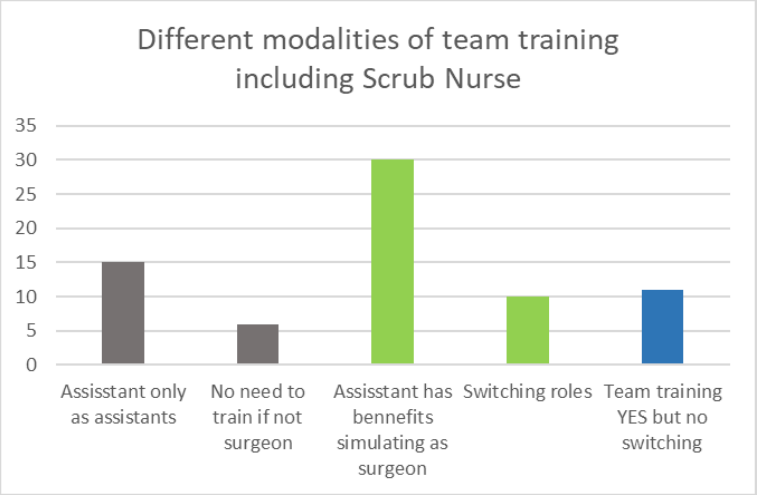
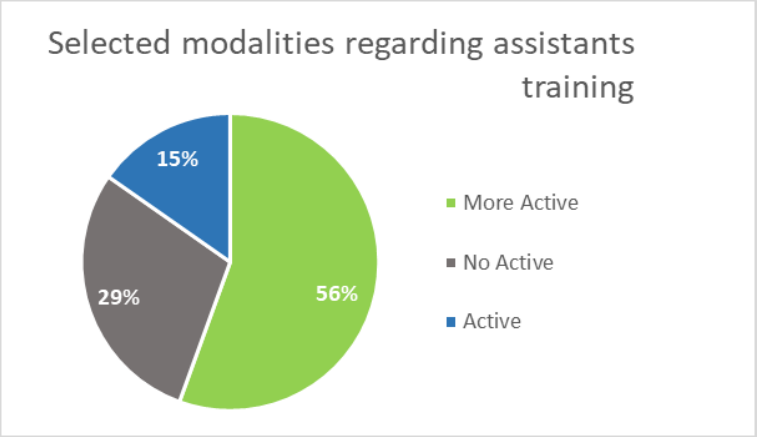
   Closed question for yes / no answers.

Question's background	Final Graphic representing results
While team training, the roles of each team member could be switched and practiced by other members, thus enriching interaction. The assistant (scrub nurse) could play a surgical role to evidence situations which need special care or different assistance. This question aims to know the opinion of microsurgical operators about this situation.	

10. Question: **Please, chek all the boxes that you consider correct (please note that the term "ASSISTANT" refers to the surgical instrument technician / scrub**

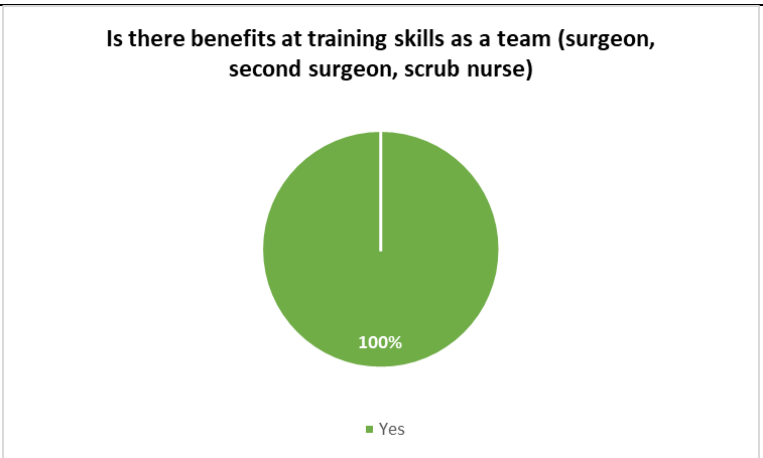
nurse; the term "SECOND SURGEON" refers to the surgeon who is also operating, assisting the primary surgeon).

Five options were given to the respondent to answer about different modalities of team training which included assistants. These options navigate the spectrum from "No participation" to "Active and switching roles" during training.

Question's background	Final Graphic representing results
Among different points of view, the role of the assistant has been studied, and strategies have been questioned: switching roles has a good reputation while training teams, but no experience have been published in this field and some opposition has been detected at this point This question and given options intend to check understanding of the term and opinion about these different modalities. The answer options can be classified based on the level of the assistant's activity during a training session: "Not active, active, or more active."	 

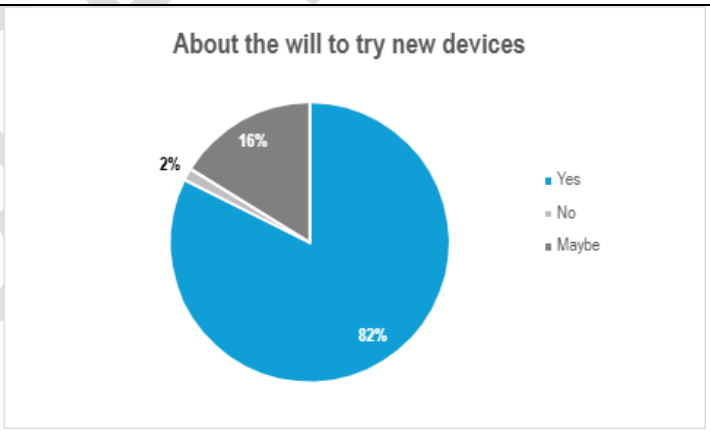
11. Question: **Do you think that a microsurgical procedure could be more effective if the complete team has previous experience working toghether?**

    Closed question for Yes / No / Maybe.

Question's background	Final Graphic representing results
This question aims to summarize many aspects in just one opinion: does team training have any impact on the effectiveness of a microsurgical procedure?	

12. Question: **If someone asks you to try a new microsurgical optical device that offers significant and improved features but requires an adaptation training period, would you try it?**

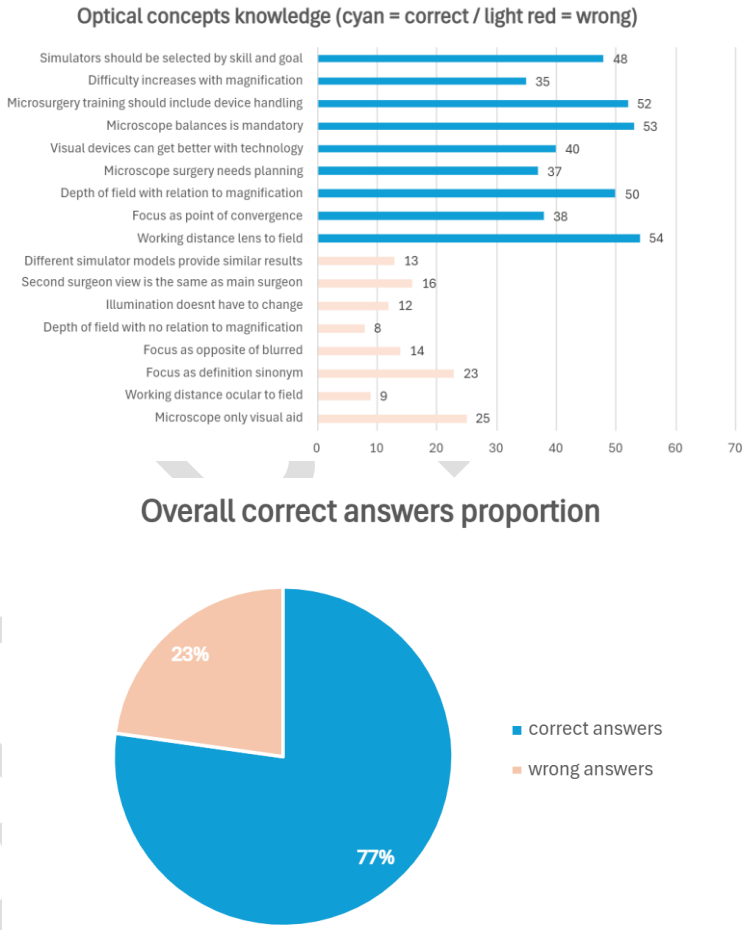
    Closed question for Yes / No.

Question's background	Final Graphic representing results
Microsurgery always grows side by side with technology. Recently some new devices pushed boundaries of hand skills and instruments precision, but it is not difficult to evidence certain inersia to try new things, even more when developing a particular skill is time and cost demanding. This question aims to detect the level of acceptance for new technology / devices.	

c. Microsurgery general concepts understanding.

1. Question: **OPTICAL RELATED CONCEPTS: please check all the boxes with correct sentences.**

   Main concepts have been summarized in 17 sentences. These sentences were presented in True or False mode for the respondent to check only the correct answers.

Question's background	Final Graphic representing results
This question aimed to assess the level of knowledge about main theoretical concepts that improve or may improve practica performance. These questions were considered fundamentals for this goal and recommended to be approached by a microsurgical training program.	

d. Training centers information

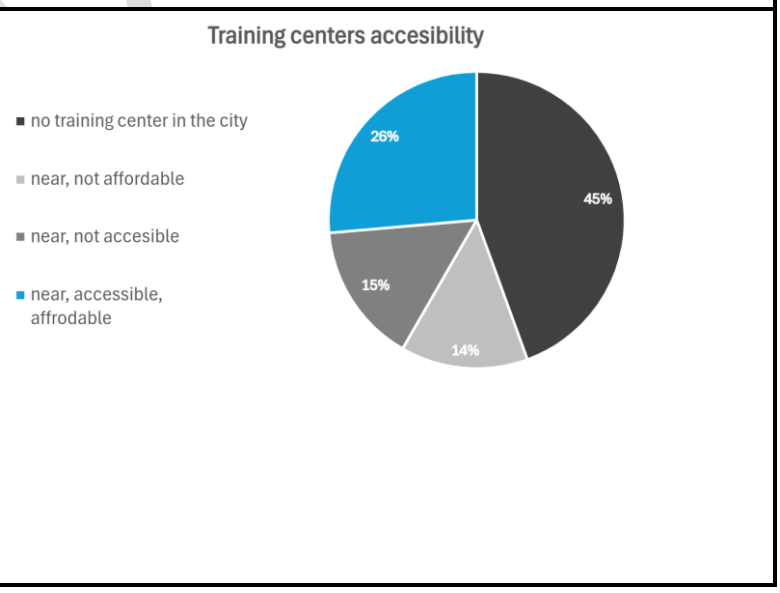
1. Question: **Do you have any microsurgical training centers in your region? (city or country)**

   Closed question for Yes / No answers.

Question's background	Final Graphic representing results
One of the main difficulties for microsurgery education is the possibility of local training. This question aims to start gaining information from respondents all over the world about this situation.	

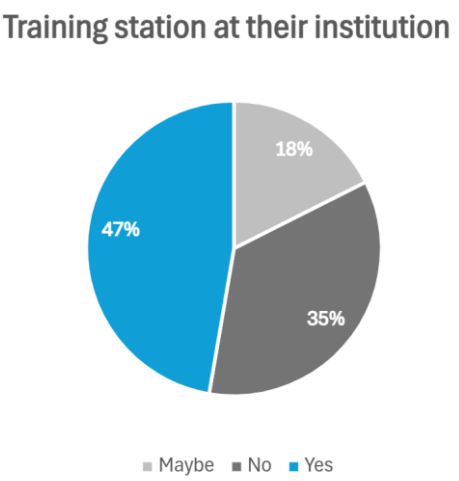
2. Question: **In the case your answer was « yes » in the previous question, please choose the more accurate answer for your situation:**

   To enrich the previous question and avoid missed interpretations, some options were given to the respondent to specify if the center for microsurgical education is: both affordable and accesible / accesible but not affordable / not accesible nor affordable.

Question's background	Final Graphic representing results
A common situation is to have a microsurgical training center, but for different reasons is not easy to access (due to requirements, high demands, low budgets to offer sufficient sessions, long distances to reach the institution, logistics costs) or is not affordable for most operators (high costs to attend a course or to stay in a different city).	

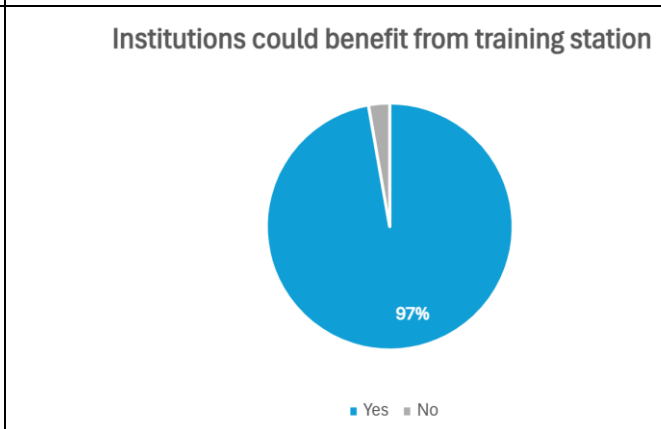
3. Question: **Do you have a training lab in your institution or a place where you can train your skills? (Minimally, a training unit should have a microscope, microsurgical instruments in acceptable condition, and some kind of supervision of your training improvements)**

   Closed question for Yes / No / Maybe. This last option was included because in many places there is a small lab with not all the requirements. To correctly interpret this situation, international and experts' guidance was revised, and a list of minimal infrastructure was suggested [2, 3, 5, 14, 15].

Question's background	Final Graphic representing results
Learning, training and improving microsurgical skills does not include just a once-in-a-life session. Meticulous and permanent updates and training are needed. For this reason, a minimal set to perform this training is highly recommended at each institution performing microsurgical procedures. This question aims to investigate the status of this situation worldwide.	

4. Qeustion: **Do you think your institution could benefit from a place like a "microsurgery training unit"? (For training skills, technical and technology research, academic production, procedure improvement analysis, etc.)**

   Close question for Yes / No answers.

Question's background	Final Graphic representing results
At those places (with no infrastructure for microsurgical training), the first step for a positive change is the perception of the need. This perception becomes stronger when the microsurgical lab is intended as a place for learning, training, experimenting and for academical production. The goal for this question is to obtain information about this perception.	

5. Question: **If you had the chance to join a self-assessment, self-training, remotely supervised, objectively evaluated, accessible, and affordable program, would you join?**

   Closed question for Yes / No / May be. This final option clarifies that "may be" could be applied depending on some specifications of the training program.

Question's background	Final Graphic representing results
A major situation in microsurgical education is the availability of certified professionals for appropriate instruction. To engage in this situation, a remotely supervised instruction protocol could apply as a solution, but the acceptance of this method and its validation should be assessed carefully.