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The Global State of Contemporary Andrology Practice: A Comprehensive Analysis of Clinical Practice, Training Pathways, and Emerging Challenges

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Purpose: This study evaluates the current state of andrology practice worldwide, identifies challenges faced by clinicians, and explores training, certification, and research opportunities. It also seeks to redefine the qualifications necessary to be recognized as an andrologist and to propose areas for standardization and improvement.

Materials and Methods: A global, cross-sectional survey was conducted using a 48-question online questionnaire designed by international experts. The survey, distributed in English, covered various domains of modern andrology practice. Responses from 405 participants across 59 countries were analyzed using R version 4.1.2, with categorical variables reported as frequencies and percentages.

Results: Among respondents, 47.3% held medical doctor (MD) degrees, with urologists (31.1%) and clinical andrologists (25.3%) being the most represented specialties. Formal, board-certified andrological training was reported as available in only 48.1% of countries. While half of the respondents identified as andrologists based on experience, only one-third did so through certification, obtained from diverse, nationally recognized organizations. The primary areas of practice included male infertility (36.7%), male sexual dysfunction (27.2%), and sexually transmitted infections (14.5%). Many participants were actively engaged in assisted reproductive technologies, imaging, and andrological surgical emergencies. Despite strong interest in clinical, basic, and translational research, respondents highlighted significant challenges, including inconsistent training pathways, insufficient certification standards, and the complexity of managing diverse andrological conditions.

Conclusions: Andrology is an evolving multidisciplinary specialty where board-certified urologists, clinical andrologists, and re-

productive medicine specialists collaborate to address male reproductive and sexual health challenges. Despite their advanced competencies in medical, surgical, and laboratory interventions, specialists face significant global disparities in training and certification. This survey highlights the urgent need for standardized training, evidence-based guidelines, and unified certification to ensure consistency, enhance patient care, and advance andrology's academic and clinical excellence worldwide.

Keywords: Andrology; Infertility; Male; Medical education; Sexual health; Surveys and questionnaires

INTRODUCTION

Andrology (from Ancient Greek: ανήρ anēr, genitive ανδρός, Andros 'man' and—λογία,—logia) which denotes a field of study is an interdisciplinary medical specialty that focuses on the physiology and pathophysiology of male fertility and the diagnosis and treatment of male fertility disorders. Additionally, in many countries, it encompasses erectile and ejaculatory disorders, delayed puberty, and hypogonadism in men.

It was only during the second half of the 20th century that andrology gained steady relevance as a basic and clinical field [1]. The term "Andrology" was first proposed in 1951 when basic scientists related to different clinical backgrounds such as urology, endocrinology, and dermatology discovered their common interest in the field of male reproduction [2].

Given the alarming decline in birth rates in highly industrialized countries in Europe and the USA, andrology, along with reproductive medicine and gynecology, has gained significant socio-political relevance [3,4]. Meanwhile, the meta-analysis by Carlsen et al [5] and subsequent studies showing a global decline in semen quality has further focused scientific interest on this subject [6-9].

Andrology sits at the crossroads of numerous medical and scientific specialties, such as endocrinology, urology, pediatrics, dermato-venereology, environmental health, reproductive competence, puberty disorders, sexual health, public health, assisted reproductive technologies (ART), and male contraception, and hence is distinguished by its multidisciplinary nature. Thus, andrology is a medical field that studies the pathophysiology of the male reproductive, sexual and endocrine systems throughout men's whole lives, from development to maturity and senescence [2,10]. Furthermore, being a relatively modern field, it has the advantage of incorporating all the latest updated advancements in basic and clinical sciences, including genetic studies, molecular biology, ultrastructural studies, and artificial intelligence [11-13].

The rapidly increasing knowledge related to andrology requires a high level of dedication and engagement with contineous education [14,15]. In this context, several efforts have been made to establish andrology as an independent field through additional qualifications and specialized training. This initiative ensures high-quality andrological care and helps patients identify specialized professional physicians. It also motivates younger colleagues to pursue this discipline. Meanwhile, specialized training in andrology is vital for achieving excellence among residents and preparing them to meet the unique needs of this patient population.

However, certification processes for andrologists vary widely across the globe, with different requirements, training programs, and credentialing standards, contributing to a lack of standardization in the field. As a result, the term "andrologist" refers to different groups of experts in different countries, and there is no uniform agreement on the medical and/or surgical practices within this field, leading to discrepancies in treatment approaches and marked variations in standards of care across different countries.

A comprehensive understanding of the global landscape in andrology is essential. Hence, a global survey to assess andrology training, education, certification, and practices was designed to understand the current status of andrology in different countries and to identify gaps and regional variations in training and clinical practice. Such a study would enable targeted improvements and resource allocation, help making recommendations for standardized curricula to ensure consistent, high-quality worldwide training, and enhance

professional development by fostering international collaboration and sharing of best practices. It would be benificial to establish clear benchmarks in andrological education and to ensure that future andrologists are equipped with the latest tools and knowledge for optimal patient care and thus improve male reproductive health outcomes globally.

MATERIALS AND METHODS

A cross-sectional, online survey was designed and distributed as per CHERRIES (Checklist for Reporting Results of Internet E-Surveys) criteria [16]. To assess the scope and role of andrologists worldwide. This comprehensive survey gathered the respondents' demographics, certification pathways, andrology work experience, the scope of andrology practice, medical imaging and surgical andrological activities, role in ART and andrological emergencies, andrology skills, research engagement, and collaboration with other specialities, professional developments, and their challenges. The survey questionnaire underwent several rounds of expert reviews and revisions before finalizing a 48-question format to ensure the inclusion of all relevant aspects. The overall survey strategy is illustrated in Fig. 1.

The final questionnaire was divided into three sections:

- Demographic data (Q1–Q10): Age, country, profession, practice setting, and years of experience
- Professional pathway (Q11–Q26)
- Professional skills and challenges (Q27–Q48)

The survey was created using Google Forms to ensure global access through a secure platform, thereby safeguarding participants' personal information. It was made available online from April 29th, 2023 to July 11th, 2023. The survey link was distributed to the specialists through direct emails to members of the Global Andrology Forum (GAF). Moreover, it was distributed via social media channels and the websites of several professional societies in urology, andrology, and sexual medicine (the invitation letter and survey questions are presented in Supplement 1). The participants were informed about the survey's purpose and objectives and were requested to complete the online questionnaire. The questionnaire was provided in English and employed standard medical terminology. This global online survey received approval from the GAF ethical committee, with an approval number IR-02-23-102 on 04-03-2023.

The answers to the questionnaire were described as numbers and percentages of each choice. For questions where the participant could choose more than one answer, each response frequency was calculated from the total number of participants. The R version 4.1.2 programming language (www.r-project.org) was used to create the figures.

RESULTS

1. Demographics

Initially, data were collected from 498 respondents. After identifying and removing duplicates based on unique email addresses, 467 unique responses remained for further analysis. Respondents who did not identify themselves as andrologists or did not work in the management of male infertility or male sexual dysfunction (MSD) were excluded from the study. This resulted in a final study population of 405 respondents. The respondents represented 59 countries, with the highest participation from Egypt (78/405, 19.2%), as shown in Fig. 2.

Among the 405 participants, 345 (85.2%) were males and 60 (14.8%) were females. The average age of the participants was 44.1±12.1 years. The survey respondents have varied qualifications, predominantly medical degree (MD). Although their professional titles differ, of them are urologists or andrologists. Their practice settings are also diverse, with the majority being in the private sector, as shown in Table 1.

2. Certification pathways

The respondents of the survey varied in how they identified themselves as andrologists. They indicated that they primarily identify themselves as andrologists, with the majority being urologists (350/1,340, 26.1%), followed by clinical andrologists (295/1,340, 22.0%) and fellowship-trained reproductive urologists (219/1,340, 16.3%). The remaining respondents belong to a diverse range of specialties, including endocrinologists, embryologists, dermatologists, and others. Interestingly, 195/405 (48.1%) reported the unavailabilty of a formal board-certified training program in andrology in their country of practice. In contrast, 151/405 (37.3%) do have such a program, and 59 respondents (14.6%) are uncertain.

Eventually, approximately half of the respondents

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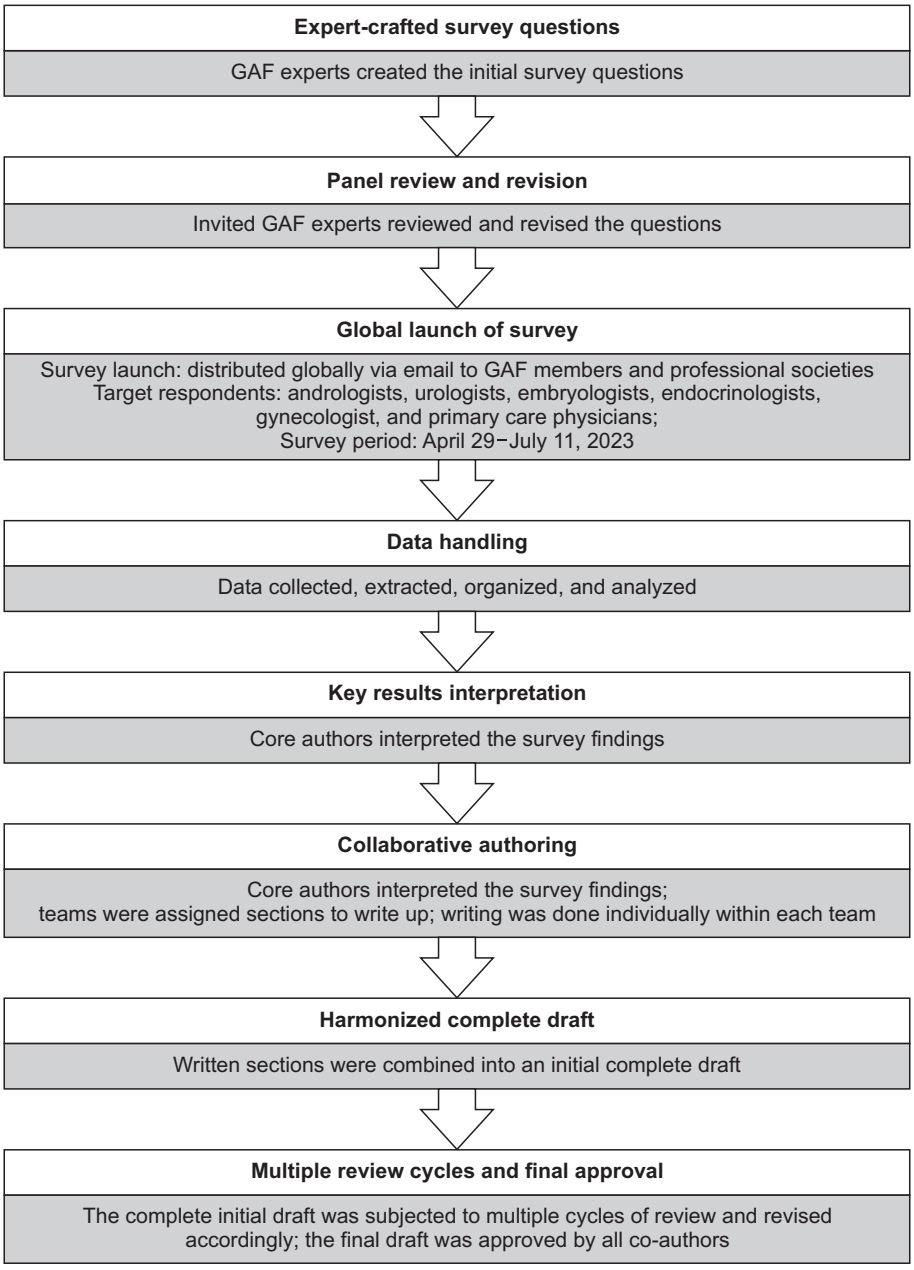
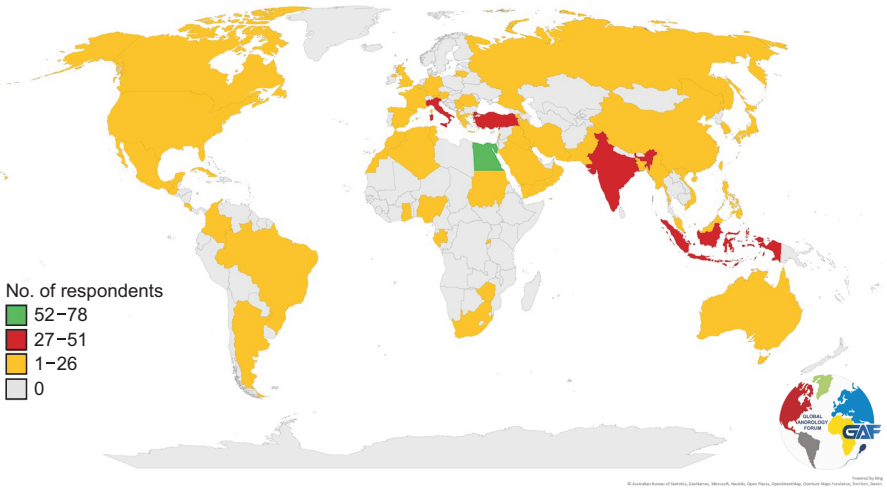


Fig. 1. The overall survey strategy. GAF: Global Andrology Forum.

based their identification as andrologists on experience, while only about one-third did so by certification, as illustrated in Fig. 3.

Additionally, there was considerable variation in the lengths of andrology training programs among the respondents, with three- and one-year durations being the most prevalent, as shown in Fig. 4.

The respondents exhibited diverse pathways to earning their certification in andrology. Various andrology organizations offered certifications, including official schools of specialization in andrology, professional societies, post-residency fellowships at certified training centers, and certification agencies. The andrology certificates held by the respondents varied in their level of recognition. The majority of these certificates were recognized at the national level only, with only one-quarter receiving international recognition. Additionally, only about two-thirds of the respondents were af-



Egypt	(n=78)	Iraq	(n=5)	Germany	(n=2)	Kuwait	(n=1)
Türkiye	(n=45)	Japan	(n=4)	Hong Kong	(n=2)	Lebanon	(n=1)
Indonesia	(n=38)	Malaysia	(n=4)	Albania	(n=1)	Lithuania	(n=1)
India	(n=33)	Saudi Arabia	(n=4)	Armenia	(n=1)	Mauritius	(n=1)
Italy	(n=30)	United States	(n=4)	Australia	(n=1)	Oman	(n=1)
Brazil	(n=17)	Argentina	(n=3)	Austria	(n=1)	Philippines	(n=1)
Vietnam	(n=15)	Bangladesh	(n=3)	Bahrain	(n=1)	Rwanda	(n=1)
Mexico	(n=12)	Costa Rica	(n=3)	Barbados	(n=1)	Serbia	(n=1)
Iran	(n=11)	France	(n=3)	Belgium	(n=1)	South Africa	(n=1)
Greece	(n=10)	Morocco	(n=3)	Myanmar	(n=1)	South Korea	(n=1)
Nigeria	(n=10)	Russia	(n=3)	Canada	(n=1)	Taiwan	(n=1)
Romania	(n=8)	United Kingdom	(n=3)	Cuba	(n=1)	Tunisia	(n=1)
Sudan	(n=7)	Algeria	(n=2)	Gabon	(n=1)	Yemen	(n=1)
Pakistan	(n=6)	China	(n=2)	Ghana	(n=1)	Zimbabwe	(n=1)
Spain	(n=6)	Colombia	(n=2)	Guatemala	(n=1)		

Fig. 2. Global map of respondents of the survey (n=405).

filiated with national andrology societies within their country of practice, as demonstrated in Table 2.

The availability of andrology fellowships also varies among respondents whereas 90/151 (59.6%) reported its availability, 43/151 (28.4%) reported its unavailability, and 18/151 (11.9%) were uncertain.

3. Andrology work experience

The respondents had varying years of their experience, with about one-third reporting 1 to 5 years' experience in andrology. They also had diverse practice areas, with roughly one-third specializing primarily in male infertility and one-quarter specializing in MSD, as shown in Table 3.

The andrological tasks performed by the survey respondents included many different related fields of practice such as clinical consultations, surgical work, research and conferences. These respondents addressed that most of their working time have been spent in the clinic (32.1±16.6 hours/week), followed by the surgical time (8.8±9.5 hours/week), followed by the research time (8.3±9.9 hours/week).

4. Scope of andrology practice

The participating andrologists were engaged in a wide range of both medical and surgical andrological activities, with their levels of involvement varying from country to country and from center to center. The main conditions treated by respondents within our survey are illustrated in Fig. 5.

5. Medical and imaging andrological activities

The respondents were involved in a variety of activities related to the imaging evaluation of patients with andrological issues, such as penile Doppler ultrasound (US), transrectal US, and scrotal US. Additionally, they offered a wide range of medical treatments and assessments, primarily focusing on male infertility, MSD, antioxidant treatments, and hormonal therapy for hypogonadism. These activities are detailed in Table 4.

6. Surgical andrological activities

The respondents also reported conducting a variety of surgical procedures, including varicocele repair, microsurgical testicular sperm extraction (mTESE), testic-

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Table 1. Demographic data of the qualifications, professional titles, and practice setting of the respondents

Characteristic	Number (%)
Professional degree	
MD	232 (47.3)
PhD	131 (26.7)
MSc	113 (23.0)
Others	15 (3.0)
Professional background	
Urologist	127 (31.4)
Clinical andrologist	103 (25.4)
Embryologist	32 (7.9)
Fellowship-trained reproductive urologist	31 (7.7)
Endocrinologist	20 (4.9)
Dermatologists	19 (4.7)
Resident	16 (4.0)
Laboratory andrologist	17 (4.2)
Researcher	14 (3.5)
Gynecologist	12 (2.9)
Biologist/ Biochemist	10 (2.5)
Geneticist	2 (0.5)
Ultrasound imaging specialist	1 (0.2)
Rehabilitation medicine specialist	1 (0.2)
Practice setting	
Private	253 (38.2)
Academic	214 (32.3)
Public	195 (29.4)

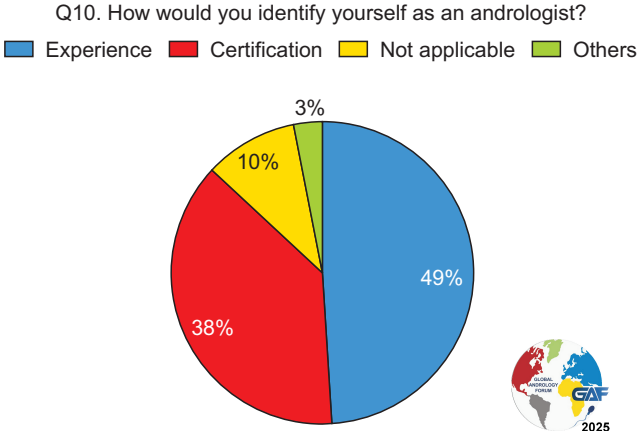

Fig. 3. Identification of andrologists based on their certification status.

ular sperm aspiration (TESA), among others, as shown in Table 5.

7. The role of respondents in ART

The roles of respondents in ART varied. Three-quarters of the participants (290/397, 73.0%) reported having a role in ART, while the remaining 107 participants

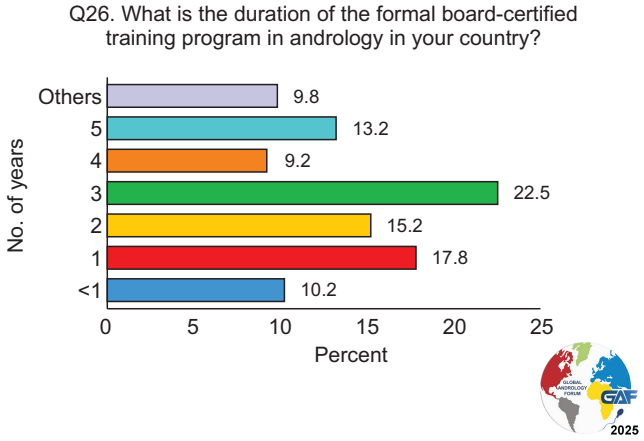

Fig. 4. The durations of the andrology training program.

Table 2. Sources of andrology certification, levels of certificate recognition, and availability of andrology societies by country

Characteristic	Number (%)
How is the certification in Andrology earned?	
Official school of specialization in Andrology	108 (26.7)
Not applicable (by experience)	96 (23.7)
Professional societies	91 (22.5)
Post-residency fellowship in certified training center	89 (22.0)
Credential agency	21 (5.1)
Level of certificate recognition	
National	186 (66.0)
International	73 (25.9)
Regional	23 (8.1)
Presence of a professional society in the country of practice?	
Yes	283 (69.9)
No	87 (21.5)
I don't know	35 (8.6)

(27.0%) indicated they had no role. The roles spanned both medical and surgical treatments, as detailed in Table 6. Additionally, the responses from our survey showed that the sperm retrieval procedures were mostly done by urologists (344/783, 43.9%) and andrologists (276/783, 35.2%), but other different specialties were also involvened; gynecologists (118, 15.1%), general surgeon (39, 5.0%), *in vitro* fertilization (IVF) specialist (2, 0.3%), and other specialties (4, 0.5%).

8. The role in andrological emergencies

The respondents had varied roles in handling andrological surgical emergencies. Nearly two-thirds (179/274, 65.3%) of the participants managed these emergencies. While one-third of the respondents (95/274, 34.7%) reported no experience in these emergency surgeries. The

Table 3. Experience of andrologists in years and primary areas of practice

Characteristic	Number (%)
Experience as an andrologist (y)	
<1	19 (4.7)
1–5	128 (31.6)
6–10	63 (15.6)
11–15	51 (12.6)
16–20	45 (11.1)
>20	94 (23.2)
Not applicable	5 (1.2)
Main areas of practice	
Male infertility	381 (38.0)
Sexual dysfunction	249 (24.8)
Sexually transmitted infections	156 (15.6)
Mainly urology	75 (7.5)
Genitourinary reconstructive urology	58 (5.7)
Male aging/partial androgen deficiency of aging men	4 (0.4)
IVF/assisted conception/embryology	9 (0.9)
Semen analysis/sperm freezing	6 (0.6)
Disorder of puberty/hypogonadism	6 (0.6)
Female sexual dysfunction/female infertility/ obstetrics	6 (0.6)
Male contraception	2 (0.2)
Genetics/ molecular biology	2 (0.2)
Chronic prostatitis/chronic pelvic pain syndrome	2 (0.2)
LGBTQ (lesbian, gay, bisexual, transgender, queer or questioning)	2 (0.2)
Others	45 (4.5)
Total	1,003 (100)

IVF: *in vitro* fertilization.

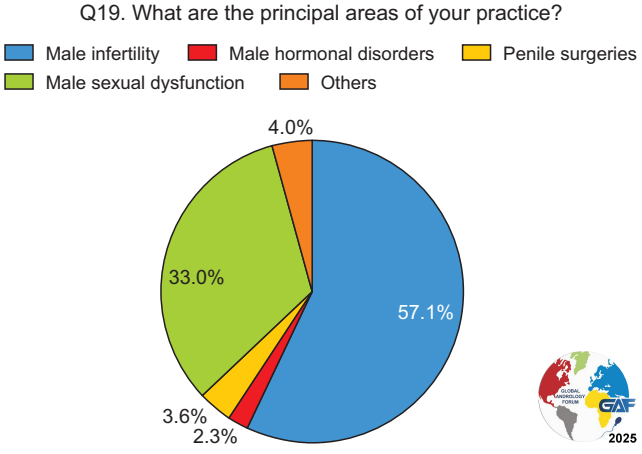

Fig. 5. The most common conditions treated by andrologists.

Table 4. Various medical, imaging modalities, and procedures practiced by the andrologists

Activity	Number (%)
Male infertility evaluation (Semen analysis, SDF testing)	344 (9.3)
Antioxidant therapy	321 (8.7)
Diagnosis and treatment of male sexual dysfunction	310 (8.4)
Hormone therapy for hypogonadotropic hypogonadism	309 (8.3)
Pharmacological treatment	302 (8.1)
Testosterone replacement therapy	302 (8.1)
Diagnosis and treatment of sexually transmitted infections	269 (7.3)
Scrotal ultrasound and Doppler examination	245 (6.6)
Intracavernosal injection of vasoactive medications	240 (6.5)
Sex therapy for ED and PE	240 (6.5)
Transrectal ultrasound examination	194 (5.2)
Penile duplex study	181 (4.9)
Intralesional injection therapy for Peyronie's disease	154 (4.2)
Extracorporeal shock wave therapy	109 (2.9)
Nocturnal penile tumescence and rigidity	95 (2.6)
Platelet rich plasma	91 (2.5)
Total	3,706 (100)

SDF: sperm DNA fragmentation, ED: erectile dysfunction, PE: premature ejaculation.

Table 5. Various surgical activities practiced by the andrologists

Activity	Number (%)
Varicocele repair	297 (8.2)
Microsurgical testicular sperm extraction	275 (7.6)
Testicular sperm aspiration	270 (7.5)
Conventional testicular sperm extraction	251 (7.0)
Percutaneous epididymal sperm aspiration (PESA)	249 (6.9)
Minor surgery such as circumcision	248 (6.9)
Cautery of genital warts...	248 (6.9)
Vasectomy	238 (6.6)
Surgery for undescended testicles or orchiopexy	230 (6.4)
Penile implant surgery	207 (5.7)
Penile curvature surgery	190 (5.3)
Trans uretheral resection of the ejaculatory ducts (TURED)	163 (4.5)
Genital duct reconstruction	162 (4.5)
Fine needle aspiration (FNA) mapping	146 (4.0)
Orchiopexy for abdominal testes	145 (4.0)
Penile reconstructive surgery	123 (3.4)
Surgical treatment of urinary incontinence in men	86 (2.4)
Electroejaculation	55 (1.5)
Others	27 (0.7)
Total	3,610 (100)

most common surgeries included the surgical correction of testicular torsion (10.1%), and treatment of testicular trauma (9.9%), among others, as detailed in Table 7.

9. Laboratory skills for andrologists

The andrologist possesses many significant skills that are used in everyday clinical practice and are varied between individuals. The most common laboratory andrological skills performed by the respondents are standard semen analysis, sperm DNA fragmentation, and sperm freezing, as listed in Table 8. Furthermore, most of the respondents (352/404, 87.1%) reported that the urologists in their countries of practice were eligible to perform laboratory andrological procedures. A small number (15/404, 3.7%) reported that the urologists were not eligible, and the remaining (37/404, 9.2%) were uncertain.

10. Research engagement and collaboration with other departments

The respondents showed a significant interest in

Table 6. Various roles of the andrologist in assisted reproductive technologies

Activity	Number (%)
Assessment of infertile men	252 (17.6)
Medical treatment of the male	231 (16.2)
Follow up after treatment	213 (14.9)
Surgical sperm retrieval (TESA-cTESE-mTESE-PESA-MESA)	209 (14.6)
Semen analysis	154 (10.8)
Attending treatment planning session with IVF specialist (gynecologist) before starting the controlled ovarian stimulation	106 (7.4)
Semen processing	96 (6.7)
Sperm or embryo freezing	73 (5.1)
Gamete handling (IVF/ICSI)	64 (4.5)
Perform electroejaculation	31 (2.2)
Total	1,429 (100)

TESA: testicular sperm aspiration, cTESE: conventional testicular sperm extraction, mTESE: microsurgical testicular sperm extraction, PESA: percutaneous epididymal sperm aspiration, MESA: microsurgical epididymal sperm aspiration, IVF: *in vitro* fertilization, ICSI: intracytoplasmic sperm injection.

Table 7. The common emergencies practiced by andrologists

Activity	Number (%)
Testicular torsion	272 (10.1)
Testicular trauma	267 (9.9)
Scrotal abscess	264 (9.8)
Penile fracture	262 (9.7)
Low flow priapism	253 (9.4)
Penile trauma (blunt or open)	238 (8.8)
High flow priapism	226 (8.4)
Paraphimosis	213 (7.9)
Intermittent/stuttering priapism	212 (7.9)
Fournier's gangrene	190 (7.1)
Penile strangulation injury	167 (6.2)
Childhood priapism	124 (4.6)
Others	7 (0.2)
Total	2,695 (100.0)

Table 8. Laboratory skills of andrologists in daily practice

Skills used in the area of practice	Number (%)
Standard semen analysis	362 (10.1)
Sperm DNA fragmentation	300 (8.4)
Sperm freezing/semen bank	235 (6.6)
Semen processing for IUI/IVF/ICSI	225 (6.3)
Microbiological tests (cultures and sensitivity)	179 (5.0)
Genetic lab and counseling	158 (4.4)
Microbiological tests (PCR detection of microbiological infections)	148 (4.2)
ICSI/embryo selection	144 (4.0)
ICSI/gamete micromanipulation	138 (3.9)
Genetic testing	135 (3.8)
Embryo freezing/embryo banking	133 (3.7)
ROS assessment	131 (3.7)
CASA	130 (3.6)
Quality assurance and control in the semen lab	122 (3.4)
Biochemistry assays for accessory sex gland function	111 (3.1)
Uploading embryos for ET	103 (2.9)
ICSI/embryo micromanipulation with blastomere biopsy and fixation	103 (2.9)
Immunological tests	95 (2.6)
Quality assurance and control in the IVF lab/embryo bank	90 (2.5)
Histology/pathology interpretation & immunohistochemistry	77 (2.2)
Sperm FISH	74 (2.1)
Assessment of acrosome reaction	73 (2.0)
Our lab supports the service of HIV couples	63 (1.8)
Histology/pathology processing only	63 (1.8)
Our scope of work includes Sperm donor and Egg donor	59 (1.7)
Our lab supports sex selection for social reason	57 (1.6)
Our lab supports sex selection for X linked disease only	54 (1.5)
Total	3,562 (100)

IUI: intrauterine insemination, IVF: *in vitro* fertilization, ICSI: intracytoplasmic sperm injection, ROS: reactive oxygen species, CASA: computer-assisted sperm analysis, ET: embryo transfer, FISH: fluorescence *in situ* hybridization, HIV: human immunodeficiency virus.

conducting andrological research, with the majority (319/393, 81.2%) actively participating in research projects. Among those involved in research, over half of them (287/524, 54.7%) were engaged in clinical research, with the rest (237/524, 45.3%) focusing on basic and translational research.

The study designs among the respondents were diverse. Most designs were observational (266/740, 36.0%), followed by interventional (208/740, 28.1%), systematic reviews and meta-analyses (156/740, 21.0%), laboratory work excluding animal studies (76/740, 10.3%), and studies involving animals only (34/740, 4.6%). Additionally, three-fourths of the respondents (209/272, 76.9%) were involved in multi-center research studies, while the remaining (63/272, 23.1%) were conducting single-center research.

The respondents emphasized the importance of collaborating with other departments to provide the best outcomes of research with the majority (281/315, 89.2%) reporting that such collaborations were already in place. In clinical departments, these partnerships are most established with gynecology, reproductive endocrinology, and urology. In academic departments, collaborations are frequently formed with molecular biology and histopathology, as illustrated in Table 9.

11. The Professional developments of andrologists

The respondents highlighted many academic activities to enhance and update their andrology knowledge, mostly through attending medical conferences and workshops, reading journals and studies, and collaborating with colleagues in the field, as shown in Fig. 6.

Table 9. Clinical and academic departments collaborating in andrological research

Specialty	Number (%)
Clinical specialty	
Gynecology	273 (20.0)
Reproductive endocrinology	239 (17.5)
Urologists	223 (16.3)
Clinical/chemical pathology	109 (8.0)
Psychiatry	106 (7.8)
Diagnostic/interventional radiology	105 (7.7)
Oncology	80 (5.9)
Internal medicine	76 (5.6)
General surgery	62 (4.5)
Neurology	30 (2.2)
Vascular surgery	26 (1.9)
Forensic medicine/toxicology	21 (1.5)
Genetics	5 (0.4)
Radiology/interventional radiology	2 (0.1)
Psychologists	2 (0.1)
Clinical pharmacology	2 (0.1)
Others	5 (0.4)
Total	1,366 (100)
Academic specialty	
Molecular biology and genetics	211 (26.3)
Histology/pathology	194 (24.2)
Biochemistry	142 (17.7)
Microbiology	96 (12.0)
Physiology	81 (10.1)
Anatomy	57 (7.1)
Parasitology	9 (1.1)
Embryology and reproductive biomedicine	4 (0.5)
Medical biology	4 (0.5)
Other	4 (0.5)
Total	802 (100)

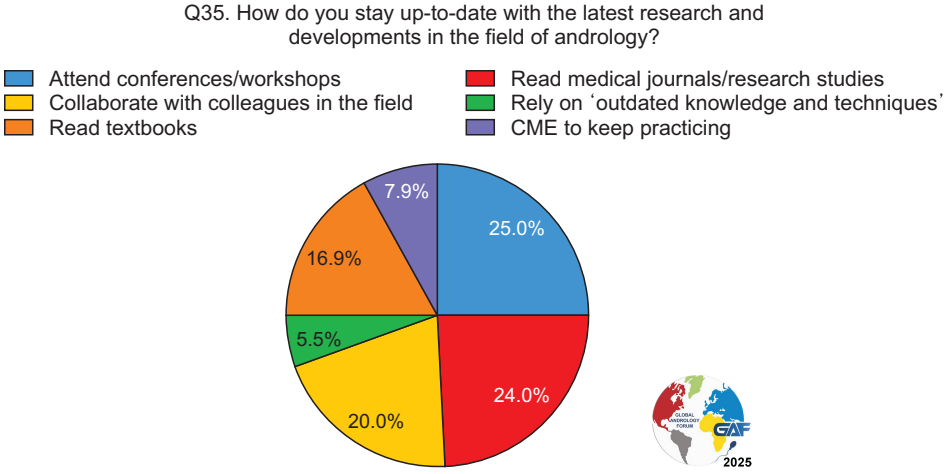

Fig. 6. The andrologist's activities for professional development. CME: continuing medical education.

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Furthermore, the respondents were interested to learn new treatment modalities to enhance their practice mainly stem cell therapy and andrology surgeries, as shown in Fig. 7.

12. The challenges of andrologists

The respondents highlighted many challenging clinical conditions they were facing in their everyday practice. Almost one fifth (19.0%) found managing specific complex clinical andrological problems *e.g.*, azoospermia, negative TESE, or patient/genetic counseling challenging. Varied addressed challenges were approval and recognition, expensive and uncovered treatments, lack of awareness among other health care professionals, public awareness, andrology practice done by other specialities, and lack of guidelines, as shown in Fig. 8.

The respondents identified several requirements to improve their practice and to overcome these challenges. Out of 1,500 total responses to this question, 440 respondents (29.3%) called for more training opportunities in procedures like TESE, TESA, and penile prosthesis, followed by 24.3% (365 respondents) suggesting more hands-on workshops. This was followed by 261 responses (17.4%) advocating for more andrology conferences, 232 (15.5%) preferring increased research opportunities, 180 respondents (12.0%) recommending more webinars, and 22 respondents (1.5%) suggesting other improvements.

Furthermore, the respondents identified various strategies to enhance their andrology practice. Out of 34 responses, 8 (23.5%) voted for structured training.

For each of the following suggestions, 3 respondents (8.8%) supported workshops and meetings, new innovative therapeutic modalities, scientific research, focused education, multidisciplinary programs, and the male reproductive health initiative. Additionally, for each of the following, two respondents (5.9%) favored legal regulation, expressed uncertainty, saw no need for changes, or suggested consulting subject matter experts.

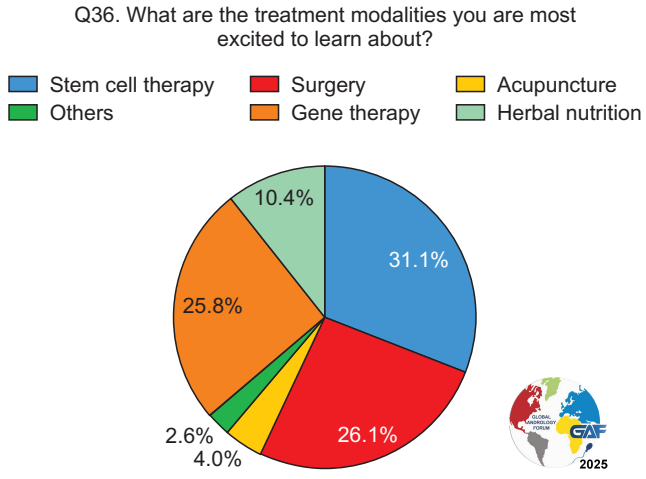

Fig. 7. The interest of andrologists in future treatment modalities.

13. The comparison between male and female andrologists

The comparison reveals distinct patterns in demographic, clinical, and academic engagement. In summary, female andrologists tend to be younger, spend more time in clinic settings, focus less on surgery, and show significant engagement in ART. Male andrologists have longer careers, publish more, are involved in more surgical procedures and emergencies, and show higher certification rates. Besides, the two groups dif-

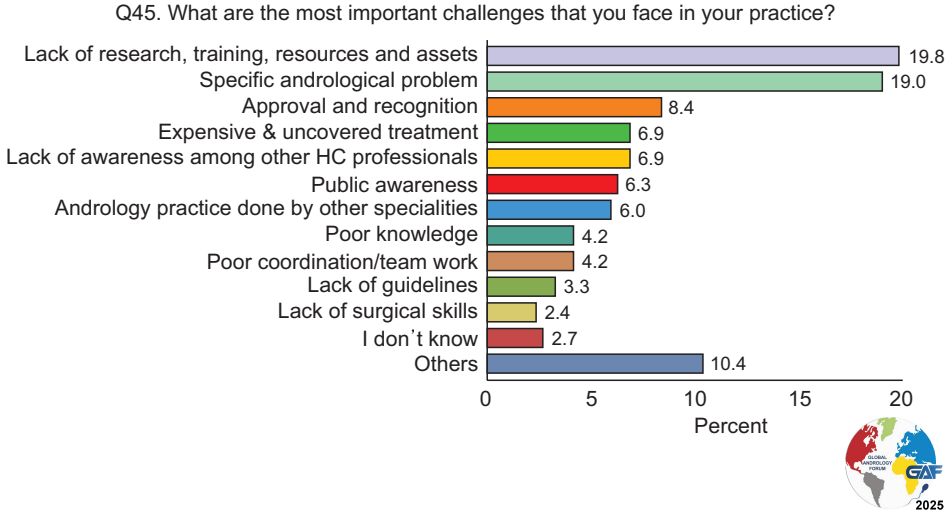

Fig. 8. The common challenges faced by the andrologists. HC: health care.

fer significantly in their professional paths and focus areas, reflecting diverse contributions to the field of andrology, as shown in Fig. 9.

14. Fellowship-trained reproductive urologist versus andrologist

The respondents reported variable evaluation of the differences between fellowship-trained reproductive

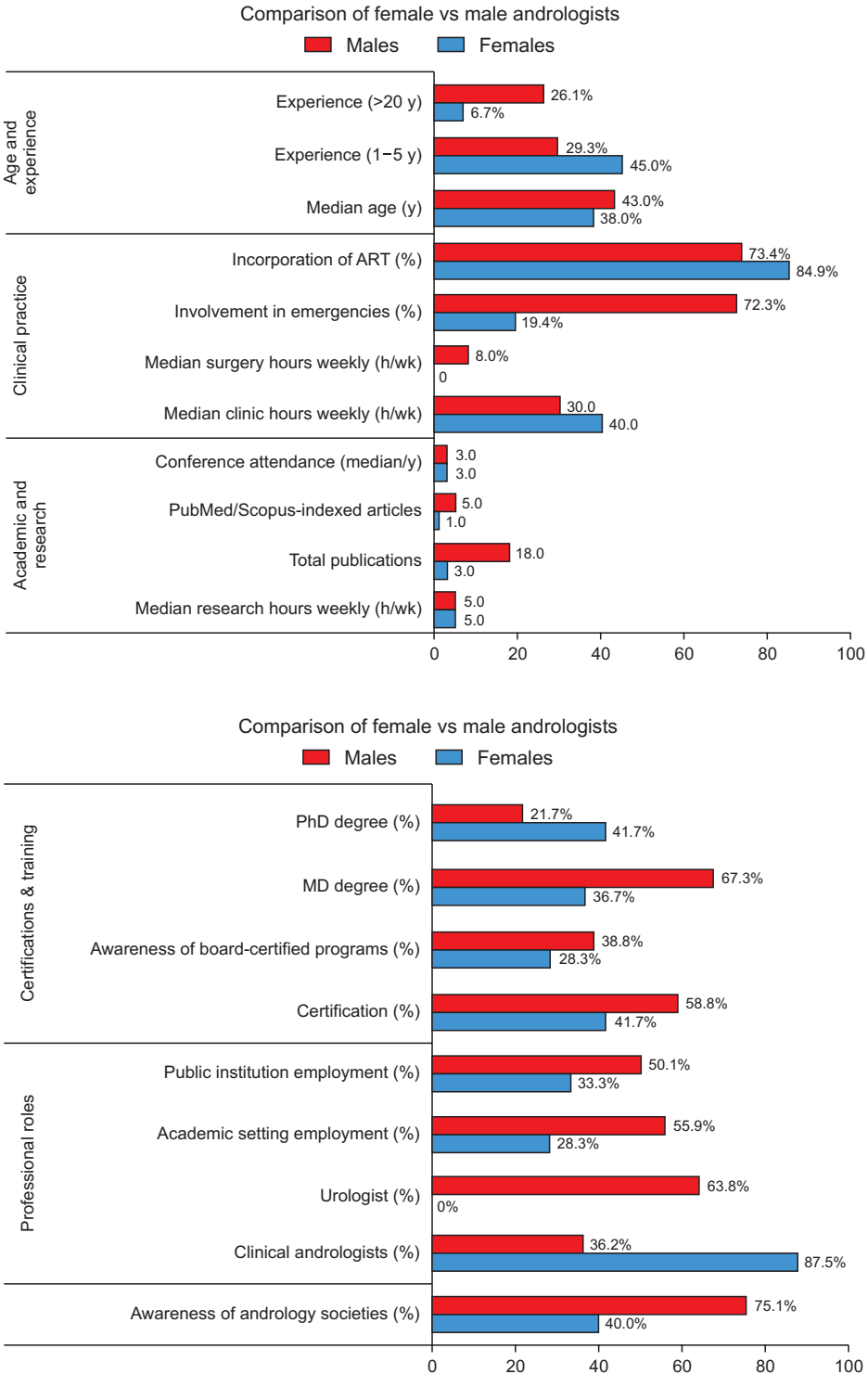

Fig. 9. Comparison of female *versus* male andrologists. ART: assisted reproductive technologies.

urologists *versus* andrologists. About a quarter of them (26.8%) ranked the urologists as having more surgical skills and favored andrologists for better laboratory evaluation and medical treatments. Other differences are shown in Table 10.

15. The demographics and practices of certified andrologists

Out of 682 respondents, 259 (38.0%) identified themselves as certified andrologists, with a median age of 41 years, ranging from 35 to 52 years. The majority of respondents were males 607/682 (89.0%), while 75/682 (11.0%) were females. Respondents spent a median of 30 hours per week in clinic (interquartile range [IQR]: 20–40 hours), with a median of 6 hours per week on surgery (IQR: 0–12 hours) and 5 hours per week on research (IQR: 2–10 hours). Regarding experience in andrology, 29.4% had 1–5 years of experience, 27.2% had over 20 years, 16.2% had 6–10 years, and 11.4% had 11–15 years or 16–20 years. Additionally, 4.0% had less than one year of experience.

Respondents had a median of 15 published articles (IQR: 3–44.3), with 4.5 articles published in indexed journals (IQR: 0–20). The median number of conferences attended per year was 4 (IQR: 2–6). 69.9% of respondents reported the presence of an andrology society in their country, while 21.5% reported no society, and 8.6% were unsure. Regarding formal training, 49.1% had access to a board-certified training program in andrology, 40.4% did not, and 10.5% were unsure.

A significant 80.4% of respondents were involved in ART practice, 70.9% dealt with andrological emergencies, and 84.9% were involved in research. In terms of academic qualifications, 71.9% held an MD, 20.2% had a Ph.D, and 14.5% had an MSc. The respondents worked in a variety of settings: 63.2% in private practice, 57.0% in academic institutions, and 57.5% in the public sector.

When it came to professional identity, 55.4% identified primarily as andrologists, while 44.7% identified as urologists. The highest percentages of respondents earned their professional degrees in Egypt (30.7%), followed by Indonesia (11.0%), Italy (9.2%), India (5.7%), Türkiye (5.3%), and Vietnam (5.3%), with other countries contributing smaller percentages.

16. Certified andrologists *vs.* non-certified andrologists

Our survey revealed that certified andrologists engage in a broader range of activities related to the treatment of male infertility and sexual dysfunction compared to non-certified andrologists. Certified andrologists were more likely to attend relevant conferences, participate in research, be involved in ART, and be affiliated with national andrology societies, and other activities listed in Table 11.

Additionally, our survey revealed that the certified andrologists are more involved in diagnostic imaging, testing, and medical treatment for various conditions related to male infertility and sexual dysfunction, compared to uncertified andrologists, as shown in Table 12.

Table 10. The differences between fellowship-trained reproductive urologists versus andrologists

Answer	Number (%)
In your opinion what are the basic differences in practice between fellowship-trained reproductive urologists *vs.* andrologist? (open text)	
Urologists have more surgical skills, whereas andrologists are focused on lab and medical treatment	62 (26.8)
No difference	41 (17.7)
Andrologists are more specialized and focused	38 (16.5)
Others	19 (8.2)
Andrologist is more experienced in sexology, ED and STIs	19 (8.2)
Andrologists may not hold medical degrees	18 (7.8)
I don't know	15 (6.5)
Andrologist is involved in all aspects plus sexology & STIs	11 (4.8)
Andrologists are focused in reproduction and infertility	3 (1.3)
Andrologists lack the training and skills	2 (0.9)
Urologists are focused in reproduction and infertility	2 (0.9)
Andrologists need more knowledge about urology	1 (0.4)
Total	231 (100)

STIs: sexually transmitted infections, ED: erectile dysfunction.

The survey also revealed that certified andrologists are more actively involved in surgical procedures and possess specialized skills. They perform a higher number of surgeries and clinical procedures related to male fertility and sexual dysfunction compared to non-certified andrologists, as shown in Table 13, 14.

17. Clinical andrologists *vs.* urologists

In comparison to clinical andrologists (no urology background), urologists spend more time in the clinic, perform more surgeries, and have a higher total number of publications, both overall and in the field of andrology. Andrologists have a higher percentage of female professionals and are more likely to have formal board certification in andrology in their home countries.

Clinical andrologists play a more prominent role than urologists in evaluating male infertility cases. They are more frequently involved in prescribing antioxidant therapies, hormone treatments for hypo-

Table 11. Variable clinical activities between certified versus non-certified andrologists

Clinical activity	Certified andrologist	Non-certified andrologist	p-value
	Yes	Yes	
Variable			
How many conferences do you attend every year?	4.0 (2.0–6.0)	3.0 (2.0–5.0)	0.001
Is there an andrology society/organization in the country where you practice?	179 (78.5)	104 (58.8)	0.001
Is there a formal board-certified training program in andrology in your country?	112 (49.1)	39 (22.0)	0.001
Does your practice include ART?	181 (80.4)	109 (67.3)	0.003
Does your practice include dealing with andrological emergencies?	122 (71.0)	57 (55.9)	0.011
Does your work include research?	191 (84.9)	128 (76.2)	0.029

Values are presented as mean (range) or number (%).
ART: assisted reproductive technologies.

Table 12. Diagnostic activities and medical treatments of certified versus non-certified andrologists

Clinical activity	Certified andrologist	Non-certified andrologist	p-value
	Yes	Yes	
Diagnostics and medical management			
Male infertility evaluation (semen analysis, SDF testing)	208 (91.2)	136 (76.8)	0.001
Antioxidant therapy	195 (85.5)	126 (71.2)	0.001
Diagnosis and treatment of male sexual dysfunction	197 (86.4)	113(63.8)	0.001
Hormone therapy for hypogonadotropic hypogonadism	195 (85.5)	114(64.4)	0.001
Pharmacological treatment	189 (82.9)	113(63.8)	0.001
Testosterone replacement therapy	191(83.8)	111 (62.7)	0.001
Diagnosis and treatment of sexually transmitted infections	174 (76.3)	95 (53.7)	0.001
Scrotal ultrasound and Doppler examination	159 (69.7)	86 (48.6)	0.001
Intracavernosal injection of vasoactive medications	158 (69.3)	82 (46.3)	0.001
Sex therapy for ED and PE	167(73.3)	73 (41.2)	0.001
Transrectal ultrasound examination	123 (54.0)	71 (40.1)	0.006
Penile duplex study	134 (58.8)	47 (26.6)	0.001
Intralesional injection therapy for Peyronie's disease	110 (48.3)	44 (24.9)	0.001
Penile extracorporeal shock wave therapy	72 (31.6)	37(20.9)	0.016
Nocturnal penile tumescence and rigidity	78 (34.2)	17 (9.6)	0.001
Penile platelet rich plasma	59 (25.9)	32 (18.1)	0.062

Values are presented as number (%).
SDF: sperm DNA fragmentation, ED: erectile dysfunction, PE: premature ejaculation.

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Table 13. Surgical procedures of certified versus non-certified andrologists

Surgical procedure	Certified andrologist	Non-certified andrologist	p-value
	Yes	Yes	
Microsurgical testicular sperm extraction	150 (65.8)	93 (52.5)	0.007
Testicular sperm aspiration	146 (64.0)	91 (51.4)	0.011
Percutaneous epididymal sperm aspiration	137 (60.1)	80 (45.2)	0.003
Conventional testicular sperm extraction	142 (62.3)	72 (40.7)	0.001
Penile implant	120 (52.6)	68 (38.4)	0.004
Trans urethral resection of the ejaculatory ducts	70 (30.7)	72 (40.7)	0.037
Vasal reconstruction	94 (41.2)	46 (26.0)	0.001
Fine needle aspiration (FNA mapping)	100 (43.9)	28 (15.8)	0.001
Surgery to lower undescended testicle (abdominal location)	58 (25.4)	64 (36.2)	0.020
Surgical treatment of urinary incontinence in men	34 (14.9)	41 (23.2)	0.034
Electroejaculation	40 (17.5)	9 (5.1)	0.001

Values are presented as number (%).

Table 14. The andrological skills of certified versus non-certified andrologists

Andrologist skill	Certified andrologist	Non-certified andrologist	p-value
Semen analysis (standard)	181 (79.4)	124 (70.1)	0.031
Sperm DNA fragmentation	154 (67.5)	96 (54.2)	0.006
Sperm freezing/semen bank	127 (55.7)	71 (40.1)	0.002
Genetic lab and counseling	85 (37.3)	49 (27.7)	0.042
CASA	77 (33.8)	34 (19.2)	0.001
Genetic testing	72 (31.6)	36 (20.3)	0.011
Immunological test	54 (23.7)	21 (11.9)	0.002
Our lab supports sex selection for social reason	38 (16.7)	15 (8.5)	0.015
Scope of work includes sperm donor and egg donor	21 (9.2)	28 (15.8)	0.043

Values are presented as number (%).
CASA: computer-assisted sperm analysis.

gonadism, diagnosing sexually transmitted infections, providing sexual therapy, treating premature ejaculation, performing penile duplex imaging, administering intralesional injections for Peyronie's disease, and conducting platelet-rich plasma injections.

On the other hand, the urologists perform more surgical procedures than andrologists, including varicocele repair, vasectomy, testicular surgeries, prostate surgeries, reconstructive surgeries, and incontinence management. In contrast, andrologists tend to focus on procedures like testicular aspiration for sperm retrieval and electroejaculation. Clinical andrologists also specialize in advanced techniques such as sperm freezing, semen processing, sperm selection in IVF labs, sperm banking, and sex selection for genetic and chromosomal abnormalities, as in Table 15.

DISCUSSION

The current study surveyed 405 professionals in andrology from 59 countries, capturing a broad and diverse representation of the global andrology community. Egypt had the highest participation rate (19.2%), which may indicate a strong involvement in this field. This could also reflect easier accessibility to the survey or greater engagement in the country, potentially due to the large number them are GAF members who frequently take part in GAF-related research. Furthermore, these results point to a growing interest among scientists in the MENA (Middle East and North Africa) region to pursue additional research on male infertility and sexual dysfunction, especially given previous findings highlighting a shortage of studies on these subjects within the region [17].

The demographic profile of the respondents showed

Table 15. Comparison between clinical andrologists and urologists in their practice and scope of work

Variable		Clinical andrologist	Urologist	p-value	Test
How many hours (in total) do you spend in the clinic each week?	Median (IQR)	30 (20–40)	32 (24–41.5)	0.014	Mann–Whitney U
How many hours of your time spent on surgery per week?	Median (IQR)	6.50 (2–12)	12 (8–20)	0.001	Mann–Whitney U
How many articles published in total?	Median (IQR)	10 (2–28.5)	25 (8.5–70.0)	0.001	Mann–Whitney U
How many articles in Andrology have you published in Int. journals indexed in PubMed or Scopus?	Median (IQR)	3.5 (1–11)	6 (1.3–29.8)	0.026	Mann–Whitney U
Your sex?	Female	7 (7.3)	1 (0.6)	0.005	Fisher exact test
	Male	89 (92.7)	157(99.4)		
Is there a formal board-certified training program in Andrology in your country?	Yes	63 (65.6)	44 (27.9)	0.001	Chi-square
How many years have you been working as an andrologist?	1–5	18 (18.8)	51 (32.3)	0.047	Chi-square
	11–15	8 (8.3)	22 (13.9)		
	16–20	18 (18.8)	15 (9.5)		
	6–10	19 (19.8)	23(14.6)		
	>20	30 (31.3)	41 (26.0)		
	<1	3 (3.1)	6 (3.8)		
Does your practice include ART? Or are you a member of an ART Clinic?	Yes	87 (90.6)	100(65.8)	0.001	Chi-square
Does your work include research?	Yes	83 (88.3)	120 (76.9)	0.026	Chi-square
Medical and imaging andrological activity					
Male infertility evaluation (SA, SDF testing)	Yes	92 (95.8)	138 (87.3)	0.025	Chi-square
Antioxidant therapy	Yes	90 (93.8)	135 (85.4)	0.044	Chi-square
Hormone therapy for hypogonadotropic hypogonadism	Yes	93 (96.9)	131 (82.9)	0.001	Chi-square
Diagnosis and treatment of sexual transmitted infections	Yes	83 (86.5)	118 (74.7)	0.025	Chi-square
Sex therapy for ED & premature ejaculation	Yes	89 (92.7)	100 (63.3)	0.001	Chi-square
Penile duplex study	Yes	62 (64.6)	79 (50.0)	0.023	Chi-square
Intralesional injection therapy for Peyronie's disease	Yes	56 (58.3)	68 (43.0)	0.018	Chi-square
Nocturnal penile tumescence and rigidity	Yes	47(49.0)	30(19.0)	0.001	Chi-square
Platelet rich plasma	Yes	31 (32.39)	33(21.0)	0.042	Chi-square
Surgical andrological activities					
Varicocele repair	Yes	75 (78.1)	154(97.5)	0.001	Chi-square
Minor surgery such as circumcision, burning genital warts...	Yes	55 (57.3)	134(84.8)	0.001	Chi-square
Vasectomy	Yes	58 (60.4)	128(81.0)	0.001	Chi-square
Orchiopexy	Yes	47 (49.0)	136 (86.1)	0.001	Chi-square
Trans urethral resection of the ejaculatory ducts	Yes	18 (18.8)	113 (71.5)	0.001	Chi-square
Fine needle aspiration (FNA mapping)	Yes	58 (60.4)	41 (26.0)	0.001	Chi-square
Surgery to lower the undescended testicle (abdominal location)	Yes	17 (17.7)	95 (60.1)	0.001	Chi-square
Penile reconstructive surgery	Yes	21 (21.9)	78 (49.4)	0.001	Chi-square
Surgical treatment of urinary incontinence in men	Yes	6 (6.3)	65 (41.1)	0.001	Chi-square
Electroejaculation	Yes	24 (25.0)	16 (10.1)	0.002	Chi-square
Andrological skills					
Standard semen analysis	Yes	82 (85.4)	103 (65.2)	0.001	Chi-square
Sperm DNA fragmentation	Yes	72 (75.0)	76 (48.1)	0.001	Chi-square
Sperm freezing/semen bank	Yes	62 (64.68)	57 (36.1)	0.001	Chi-square
Semen processing for IUI/IVF/ICSI	Yes	56 (58.3)	45 (28.5)	0.001	Chi-square
ICSI/embryo selection	Yes	33 (34.4)	28 (17.7)	0.003	Chi-square
ICSI/gamete micromanipulation	Yes	33 (34.4)	23 (14.6)	0.001	Chi-square
CASA	Yes	31 (32.3)	22 (13.9)	0.001	Chi-square
Embryo freezing/embryo banking	Yes	31 (32.3)	23 (14.6)	0.001	Chi-square
Quality assurance and control in the semen lab	Yes	26 (27.1)	20 (12.7)	0.004	Chi-square

Table 15. Continued

Variable		Clinical andrologist	Urologist	p-value	Test
Biochemistry assays for accessory sex gland function	Yes	29 (30.2)	27 (17.1)	0.014	Chi-square
ICSI/embryo micromanipulation including blastomere biopsy and fixation	Yes	22 (22.9)	18 (11.4)	0.014	Chi-square
Uploading embryos for ET	Yes	20 (20.8)	14 (8.9)	0.007	Chi-square
Immunological test	Yes	25 (26.0)	19 (12.0)	0.004	Chi-square
Quality assurance and control in IVF lab/embryo bank	Yes	23 (24.0)	10 (6.3)	0.001	Chi-square
Our lab supports sex selection for social reason	Yes	26 (27.1)	7 (4.4)	0.001	Chi-square
Our lab supports sex selection for X linked disease only	Yes	17 (17.7)	14 (8.9)	0.037	Chi-square

Values are presented as median (IQR) or number (%).
IQR: interquartile range, ART: assisted reproductive technologies, SA: semen analysis, SDF: sperm DNA fragmentation, ED: erectile dysfunction, IUI: intrauterine insemination, IVF: *in vitro* fertilization, ICSI: intracytoplasmic sperm injection, CASA: computer-assisted sperm analysis, ET: embryo transfer.

a majority of male practitioners (85.19%), aligning with the male-dominant global trends in andrology [18]. This was also noticed in patients with specific male disorders, such as prostate cancer, and their partners often prefer treatment from male physicians [19]. However, the involvement of female respondents (14.81%) highlights the increasing presence of women in the field, which is a positive step.

Notably, the study highlights the heterogeneity in how practitioners identify themselves as andrologists. Most of the respondents identified themselves as andrologist were either urologists with andrology experience, urologists with reproductive fellowship, or clinical andrologists with no urology background and are of different medical backgrounds. This diversity suggests that the field of andrology is composed of a wide range of professionals with different core competencies and training backgrounds. This finding is consistent with previous studies, which have emphasized that men's health should be approached through an interdisciplinary nature of andrology [20]. Also, the entry to be specialized in andrology is variable between countries. While in Germany, the subspecialty is open to professionals specializing in endocrinology, urology, and dermatology, Italy and Spain provide two-year master's programs in andrology, accessible to a broader group of physicians such as endocrinologists, urologists, and gynecologists. These programs are certified by the universities where they are conducted [21].

One significant finding of the study is the variation in the availability of formal board-certified training programs in andrology across different countries. Only 48.1% of respondents reported the presence of such programs in their country, whereas 37.3% indicated a lack of availability, and 14.6% were uncertain. This reflects a significant disparity in the standardization of andrology training worldwide. The lack of formal training opportunities may contribute to the reliance on experience as a basis for identifying as an andrologist, as reported by approximately half of the respondents. In contrast, only a third based their identification on certification, highlighting the variability in formal education pathways in this field. These findings have important implications for the future development of the field. The absence of standardized training and certification pathways could potentially limit the growth of andrology as a distinct medical specialty and may contribute to inconsistencies in practice standards globally. Efforts to establish more uniform training and certification programs could enhance the recognition of andrology as a specialized field and improve the quality of care provided to patients.

Additionally, this study reveals significant variations in the structure, certification, and practice of andrology training across different regions, highlighting the lack of standardization in this specialized field. The data showed that the lengths of andrology training programs among the respondents were diverse, with three-year and one-year programs being the most common. The variation in training durations reflects a disparity in the curriculum and intensity of training, which may affect the competencies of andrologists worldwide. This finding aligns with previous studies that have documented inconsistencies in the curriculum [22] dura-

tion and content of specialized medical training in the United States, impacting the overall standardization of care [21].

The pathway to earning certification in andrology also varied among the respondents. Certifications were offered by a range of organizations, including official schools of specialization, professional societies, post-residency fellowships, and certification agencies. This heterogeneity in certification sources indicates that the credentials held by practicing andrologists may differ in terms of training quality and recognition. The majority of certificates held by respondents were recognized only at the national level, with only a quarter achieving international recognition. The unification of international certification and accreditation systems will enhance better patient outcomes and ensure consistent and high-quality training. Additionally, these cross-border healthcare agreements are generally mutually beneficial for participating countries [23].

The study also identified variability in the availability of andrology fellowships, with 59.6% of respondents reporting the availability of fellowships, while 28.4% reported a lack of such opportunities, and 11.9% were uncertain. This uneven distribution of fellowship opportunities could limit access to advanced training in andrology, particularly in countries where fellowships are not available. Prior studies in other fields have emphasized the critical role of fellowship training in enhancing specialized clinical skills and promoting research competencies [24]. The lack of fellowship programs in certain regions may contribute to the uneven distribution of highly skilled andrologists globally, affecting patient outcomes.

Regarding experience, approximately one-third of the respondents reported having more than 15 years of experience in andrology. Although their practice areas were diverse, a significant portion are specializing in male infertility and MSD. This aligns with the literature, which shows that most andrologists tend to focus on these two core areas, given their high prevalence and the increasing demand for specialized car [25]. The data also showed that andrological practice involves a broad spectrum of clinical, surgical, and research activities. The majority of working hours are dedicated to clinical consultations (32.1±16.6 hours/week), followed by surgery (8.8±9.5 hours/week) and research (8.3±9.9 hours/week). These results suggest a balanced involvement in both medical and surgical facets of andrology, likely reflecting strong training in both areas, additionally, integrating surgical and clinical andrology is essential to improve the quality of care delivered to infertile couples [26].

The respondents' involvement in multiple facets of andrological practice, including male sexual disorders, male infertility, penile prosthesis, and male hormonal disorders, suggests a broad scope of practice within the field. However, the levels of engagement varied significantly from country to country and from one center to another, highlighting potential disparities in available resources, training opportunities, and healthcare infrastructure. These disparities could lead to uneven patient access to high-quality andrological care, depending on geographic location. The varying levels of involvement among andrologists are likely linked to differences in their training backgrounds. Previous research has highlighted the need to expand andrologists' education to encompass a wider spectrum of men's health concerns, extending beyond fertility and sexual function to address broader aspects of men's overall health [27].

Overall, the findings underscore the need for international collaboration to develop standardized training and certification processes in andrology. Enhanced cooperation between national and international andrology societies, educational institutions, and healthcare providers is crucial to harmonizing training curricula and fostering mutual recognition of certifications. Furthermore, increasing the availability of fellowship programs, particularly in underserved regions, would help bridge gaps in training opportunities and ensure a more equitable distribution of skilled andrologists worldwide. Future research should focus on developing guidelines for standardizing andrology training and evaluating the impact of these efforts on patient outcomes.

Furthermore, this study demonstrates a significant interest in andrological research among the respondents, with a substantial proportion actively engaging in research activities (81.2%). This high level of participation may reflect a growing recognition of the importance of andrology in understanding male reproductive health and its implications for overall health and quality of life. The fact that over half of the respondents (54.7%) are involved in clinical research suggests that there is a strong inclination toward direct patient-oriented studies, likely driven by the need to address

immediate clinical challenges in andrology. Meanwhile, the nearly equal representation of basic and translational research (45.3%) underscores the importance of understanding fundamental biological mechanisms that could inform clinical practice in the future.

Furthermore, the high involvement of respondents in multi-center studies (76.9%) reflects a growing trend toward collaborative research efforts that can provide more robust data and enhance the generalizability of findings. Multi-center studies are particularly important in andrology, where patient populations may be diverse, and single-center studies may not capture the full spectrum of clinical presentations and outcomes. These findings are consistent with existing literature that underscores the importance of multi-center collaboration in achieving high-quality, impactful research [28]. These data underscore the dynamic nature of andrological research, characterized by a strong commitment to clinical research, a significant emphasis on interdisciplinary collaboration, and a growing trend toward multi-center studies. These findings highlight the importance of fostering a collaborative research environment that bridges clinical and basic science disciplines to advance the field of andrology.

Collaboration between departments was highlighted as a key factor for successful andrological research. A significant majority (89.2%) reported existing collaborations, particularly between clinical departments like gynecology, reproductive endocrinology, and urology, and academic departments such as molecular biology and histopathology. This multidisciplinary approach is essential for addressing the complex and multifaceted nature of male reproductive health issues. Previous studies have also emphasized the value of such collaborations, and also the importance of knowledge and education of these specialties on how to deal with andrology problems to achieve the best outcomes [29].

Remarkably, the results of this study highlight the diversity and scope of the work carried out by andrologists across different regions and clinical settings. Andrologists engage in both medical and surgical activities, and their involvement in various aspects of andrology varies significantly depending on their country of practice and the institutions where they work. This variability underscores the importance of local healthcare structures and educational frameworks in shaping the roles and responsibilities of andrologists globally.

The study results highlighted that andrologists with urological backgrounds carry out a wider range of surgical procedures compared to andrologists with medical backgrounds. These include varicocele repair, vasectomy, mTESE, TESA, prostate surgeries, and reconstructive surgeries. On the other hand, andrologists with medical backgrounds typically concentrate on procedures such as TESA and electroejaculation. Additionally, they are also skilled in advanced techniques like sperm freezing, semen processing, sperm selection in IVF laboratories, sperm banking, and sex selection for addressing genetic and chromosomal disorders.

These procedures are critical in the management of male infertility and highlight the technical expertise required by andrologists. Surgical interventions like varicocelectomy are pivotal in improving sperm parameters and fertility outcomes in men with varicocele, as reported in the literature [30]. Additionally, mTESE has been shown to improve sperm retrieval rates in men with non-obstructive azoospermia (NOA), a challenging condition for which successful sperm retrieval is critical for ART [31].

A significant proportion of the andrologists in this study (75.0%) were involved in ART, underscoring their integral role in both the medical and surgical aspects of reproductive treatments. Sperm retrieval procedures, particularly mTESE and TESA, were often performed by andrologists or urologists, with some participation from specialists in other fields such as gynecologists and IVF specialists. The data show that while andrologists play a central role, the multidisciplinary nature of ART requires collaboration across various specialties. By Mulawkar et al. [32] highlighted the role of an andrologist to extend well beyond performing surgical sperm retrieval (SSR) procedures. They are highly qualified to identify the best candidates for SSR and determine the most suitable SSR technique. Comprehensive andrological assessment and intervention before ART may reduce the necessity for, or the complexity of, the ART procedure. Additionally, andrological interventions contribute to enhancing ART outcomes. The inclusion of andrologists in the ART team brings immense value.

The survey revealed that two-thirds of the respondents had experience managing andrological emergencies such as testicular torsion and trauma. This highlights the essential role andrologists play in acute andrological care. Prompt intervention in cases like testicular torsion is critical, as it can prevent irrevers-

ible damage to the testes and preserve fertility [33]. The involvement of andrologists in such emergencies, despite not being universal among respondents, points to a need for increased training and preparedness, especially in centers where access to emergency andrological care may be limited.

A wide variety of skills are required in the daily practice of andrology, with semen analysis, sperm DNA evaluation, and sperm freezing being among the most commonly reported competencies. These skills are critical in both diagnostic and therapeutic domains, particularly in infertility evaluation and sperm preservation for ART. The fact that the majority of respondents reported that urologists in their country were also eligible to perform andrological procedures suggests a significant overlap between these specialties. Urologists are often called upon to perform certain andrological procedures for which they may lack advanced microsurgical training. This is consistent with previous findings that highlight the shared responsibilities in managing male reproductive health and the crucial role of microsurgical training for both urologists and clinical andrologists specializing in male infertility. The success of these microsurgical procedures largely depends on the surgeon's proficiency with microsurgical techniques [34]. However, a minority who expressed doubts or concerns about the eligibility of urologists for such procedures suggest a potential lack of standardization in andrological training and practice.

In addition to their surgical expertise, andrologists were heavily involved in medical treatments for male infertility, sexual dysfunction, and hormonal therapies for hypogonadism. These activities are crucial for comprehensive diagnostic approach which could help in identifying treatable causes of infertility, recognizing conditions that require urgent intervention, and ensuring appropriate care. Having medical professionals with expertise in andrology and endocrinology in ART centers is a crucial step toward establishing precision medicine [35]. Imaging techniques like penile Doppler US and transrectal US are crucial tools in diagnosing conditions such as erectile dysfunction and prostate disorders, further demonstrating the diagnostic role of andrologists in male reproductive health.

Our study demonstrates a significant difference in the scope of practice and professional engagement between certified and non-certified andrologists. Certified andrologists are more actively involved in the treatment of male infertility and sexual dysfunction, aligning with their advanced training and specialized certification. Our study underscored a significant statistical difference in favor of certified andrologists in training for the diagnosis and treatment of MSD. These findings are aligned with a previous study that highlighted the importance of sex therapy in the field of andrology, which can assist patients in recognizing and addressing cognitive distortions and unhealthy behaviors, while also boosting their motivation for treatment. Consequently, sexual medicine is inherently transdisciplinary, and it is recommended to adopt a biopsychosocial model for the treatment of sexual dysfunction [36]. Certified andrologists, as revealed in our survey, are more likely to participate in continuing medical education through research, conferences, and workshops. This engagement is crucial for staying updated with the latest advances in the field, particularly in emerging treatments and technological developments. The GAF has launched a groundbreaking global online initiative aimed at bridging the gap between research and clinical practice in male infertility and sexual health. This platform will serve as a foundation for the advancement of high-quality research and expert recommendations [28].

A key distinction identified in our findings is the higher frequency of surgical interventions performed by certified andrologists. This reflects their specialized training, which typically includes a more in-depth focus on surgical techniques related to male reproductive health, such as microsurgery for varicocele repair or vasectomy reversal. Certified andrologists also reported greater involvement in ART procedures such as sperm retrieval for intracytoplasmic sperm injection (ICSI), which is a critical aspect of treating male factor infertility. Similar findings were highlighted by another study [37], which showed a significant increase in these surgeries after andrology certification of urologists.

Moreover, the current survey revealed that certified andrologists are more involved in research activities. This higher participation in research correlates with their advanced understanding of complex cases, which may lead to innovations in treatment strategies. The role of certified andrologists in shaping the future of male reproductive health cannot be overstated, as their clinical and research contributions directly influence patient outcomes. An important study allowed us to objectively confirm that both the quality and quantity of

continuing professional development positively impact the quality of medical practice [38].

In contrast, non-certified andrologists are less likely to engage in specialized procedures or research, which may limit their capacity to address the full spectrum of male infertility and sexual dysfunction issues. This suggests a potential need for better training opportunities and experts' opinion guidance for the best clinical practice, as the certified and well trained andrologist can perform more surgical cases, as highlighted in another important study [37].

Overall, the certification of andrologists appears to enhance not only clinical outcomes but also their professional development and contribution to the field. Future efforts should focus on expanding certification programs and encouraging continuing education to bridge the gap between certified and non-certified practitioners.

The challenges faced by andrologists in their clinical practice, as highlighted by the current study, reflect the complexities inherent in diagnosing and treating male reproductive health disorders. The most commonly encountered difficulties include azoospermia and unsuccessful TESE, which accounted for nearly half of the reported cases (45.2%). This is consistent with many other studies that have emphasized the difficulty in managing NOA. The need for optimization of the TESE results is essential through identification the best predictors of success, the medical and hormonal treatment, the use of microdissection method, and following the best technique [39]. Although, some studies focused only on patients-related factors to predict the success of mTESE like age, testicular size, follicle-stimulating hormone level, luteinizing hormone level, testosterone level, and anti-Müllerian hormone level [40], Other studies underscore the importance of surgeon- and technique-related factors. The procedure remains technically demanding and requires extended operating times, with an average duration of surgery ranging from 1.8 to 2.7 hours, with longer operative times being linked to a decrease in sperm retrieval success from 89% to 30% after 2 hours [41]. Similarly, a study demonstrat that a single urologist performing mTESE on 150 men with NOA noticed an increase in sperm retrieval rates, rising from 32% in the first 50 cases to 48% in the final 50 cases. The learning curve appeared to start after 50 cases and marking the plateau after 100 cases, with operating times decreasing from an average of 114±32 minutes in the first 50 cases to 85±18 minutes in the last 50 cases [42].

Our study also underscores other important challenges facing the andrologists which are related to the management of male infertility, idiopathic infertility, and genetic counseling. The same challenges were addressed by a new study which highlighted that to determine the most effective treatment of male infertility, a thorough and personalized diagnostic evaluation is essential to identify the root cause. Advances in genetic testing, epigenetic markers, seminal proteomics, and radiomics offer new insights into the etiopathogenesis of male infertility. Additionally, the future integration of AI into infertility practice could enhance diagnostic accuracy in many cases and offer prognostic insights for sperm retrieval and reproductive success, both naturally and through ART [43].

Another significant challenge is the lack of research, whether due to limited resources or insufficient experience in conducting studies, which can negatively affect the quality of work and future direction. The GAF presents a promising solution to this issue. GAF is a pioneering initiative that unites clinicians and researchers, both senior and junior, from around the world through an online collaborative platform. Its mission is to elevate the quality of research and address the current challenges in male reproductive and sexual health. By offering training programs, GAF aims to nurture a new generation of skilled and dedicated clinical researchers. Moreover, its collaborative research projects, which leverage the expertise of a global network of senior clinicians and researchers, strive to enhance the management of male infertility and sexual health issues, ultimately shaping the future of andrology [28].

1. Limitations of the study

When conducting a global survey on the role of andrologists in healthcare, several limitations may arise. Sampling bias could result from geographic distribution as the participation may be skewed towards certain regions or countries where access to the internet or the survey is better, leading to underrepresentation of some countries. Additionally, some countries may have fewer trained andrologists or lack specialized institutions, which could limit the sample diversity and global representativeness.

Furthermore, self-selection bias with those who choose to respond might have strong opinions about

the profession or more positive/negative experiences, leading to non-neutral or skewed data, and social desirability bias with those who are respondents may give answers they think are expected or acceptable, especially in sensitive topics related to patient outcomes or ethics.

Also, the role of andrologists can differ vastly across countries, depending on the healthcare system, culture, and local medical training. These variations may make it difficult to standardize survey questions or interpret results consistently.

CONCLUSIONS

Andrology is a multidisciplinary field encompassing medicine, surgery, and laboratory sciences. However, no study has comprehensively examined its global practice. This survey highlights the broad scope of disorders and emergencies managed by andrologists while exposing inconsistencies in training pathways and certification processes across countries. Many specialists lack access to structured training, research opportunities, and essential resources, limiting their ability to manage complex cases effectively.

Standardizing interprofessional education and formal training are crucial for equipping andrologists with the necessary expertise for advanced procedures and specialized care. Participation in research programs enhances their contributions to medical science, professional recognition, and career advancement. Additionally, professional andrology associations should implement practical educational programs that strengthen both clinical and surgical skills while ensuring continuous updates on emerging advancements.

The findings and recommendations from this survey can enhance training standards, refine clinical practice, and strengthen research in andrology, ultimately improving patient care worldwide.

Conflict of Interest

The authors have nothing to disclose.

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Author Contribution

Conceptualization: AA, RS. Statistical analysis: BS. Supervision: AA. Writing – original draft: TM, MAH. Writing – review & editing: All authors. All authors have read and agreed to the published version of the manuscript.

Supplementary Materials

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