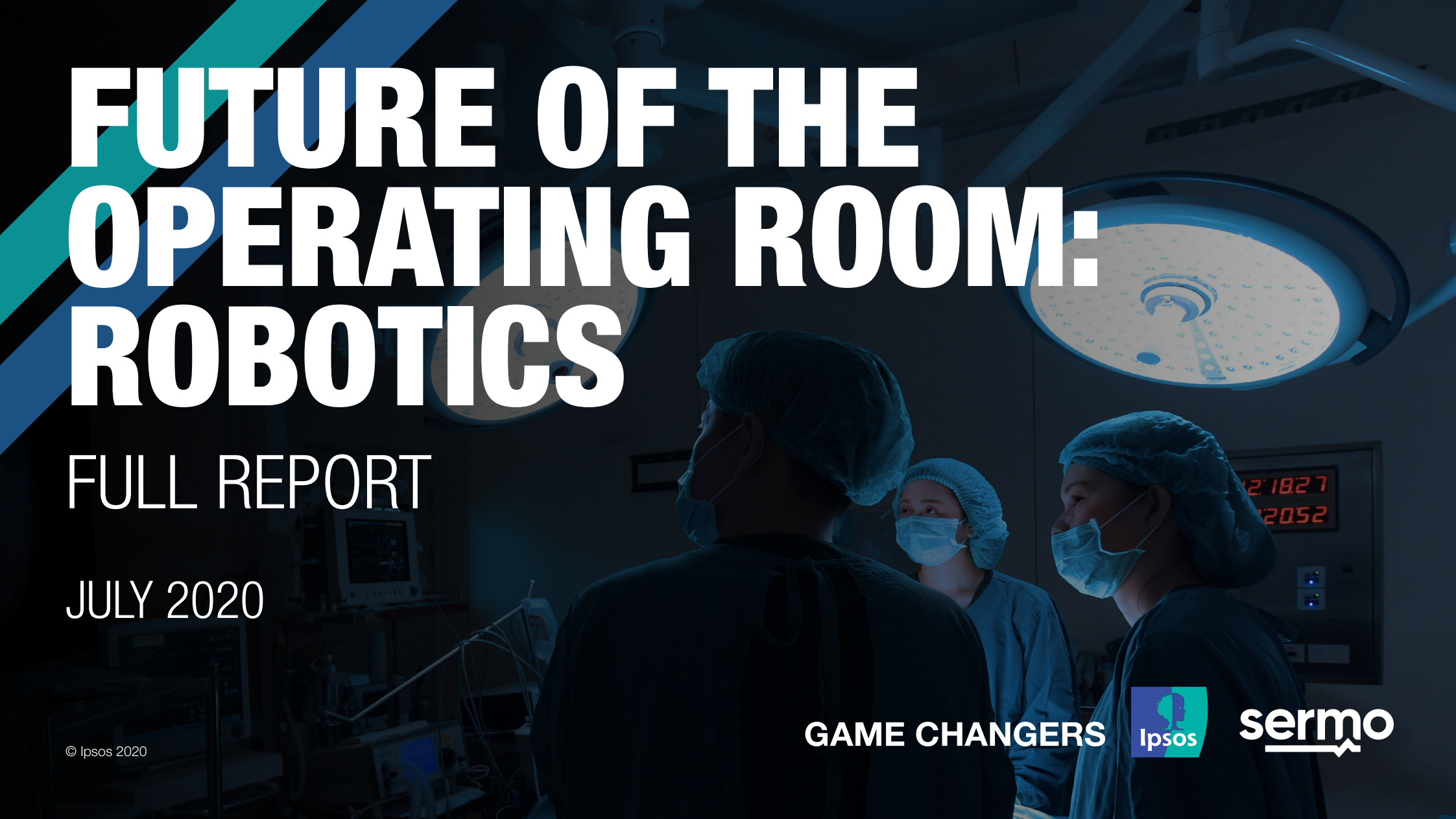
FUTURE OF THE OPERATING ROOM: ROBOTICS

FULL REPORT

JULY 2020



GAME CHANGERS

FUTURE OF THE OPERATING ROOM: ROBOTICS FULL REPORT

Foreword

Imagine a future when surgical robots have become small and affordable enough to be found even in non-specialised hospitals and outpatient clinics outside of a major metropolis...

Imagine a time when these robots can be put onto 'auto-drive' mode to complete certain parts of the operation faster and more accurately than humans…

Imagine a world where a specialist can conduct operations in several cities, in multiple countries – all in a days work from one centralised location…

The future is already here…

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Introduction

Operating rooms (ORs) are one of the most critical areas and highest cost centres of a hospital; in some cases making up over 40% of total expenses. This makes them a prime target for innovation to improve efficiency and precision. The past decade has seen a significant shift in the use of sophisticated and automated technology in the OR, including:

High-resolution displays and surgical cameras that steer surgeons through an operation, projecting a patients' body into a GPS- style map, allowing surgeons to see any section of the patient anatomy before operating

Despite the high cost, the number of **hybrid operating rooms** is growing by 15% to meet the global increase in number of surgeries performed. They work by adding advanced imaging systems onto existing traditional operating rooms, increasing procedural efficiency and avoiding costly surgical revision

Speech recognition software is changing the way medical teams in the OR interact, for example by video calling in colleagues outside of the OR for their advice. This 'Siri'-like software is also revolutionizing how surgeries are performed, including adjusting equipment or zooming into a particular image

Apps such as 'Touch Surgery', augmented and virtual reality are being used by the modern 'digital doctor' to learn new procedures via videos and simulations

Inpatient and day case surgeries have been driven by the uptake of minimally invasive surgery with OR design mirroring that trend; more recent digital technology is being used to set up **24/7 in-home monitoring systems** to keep tabs on patients remotely, from one high-tech hub

Smart hospital design is surpassing traditional OR design, creating the perfect environment for successful surgeries. Innovations include advanced operating tables, self-ordering supply cabinets, customised lighting solutions and strategic monitoring of airflow and temperatures. All of this and more can be monitored and controlled, using dashboards and touch screens

This report will focus on the impact that robotics has had on OR design, surgical practice and outcomes. We spoke to 10 leading robotic surgeons around the globe and collected quantitative data from 243 surgeons across the US and Europe to assess their take on what has worked well, where improvements are needed and what the future will hold for robotic surgery.

https://www.mddionline.com/future-digital-surgery
https://www.merraine.com/5-disruptive-technologies-that-are-revolutionizing-the-operating-room/
https://new.siemens.com/global/en/products/buildings/markets/smart-hospitals/operating-room.html

Brief history: From skepticism to standard of care

The idea of robotic surgery was initially developed for the military to enable surgeons to operate on wounded soldiers from a remote and safe location. They first entered the civilian operating room two decades ago.

One might think that robotics would have had an immediate and transformative effect on surgical practice and outcomes when it was first introduced in 1999 for urology, gynaecology and bariatric surgeries. However, much like electricity, the computer and the worldwide web, the 'Productivity Paradox' holds true – it takes, on average, 20 years for an innovation to reap productivity benefits. The thing about revolutionary technology is that it changes everything, and changing everything takes imagination. Instead of just replacing minimally invasive or open-surgical techniques with robots, surgeons and hospitals have had to redesign their ORs and ways of doing things to get the best out of robotics. As the efficiencies are being realised, and as technology advances, we see a broadening of robotic design and use for cardiothoracic, general, head & neck, orthopaedic & spine, neurological and paediatric surgery.

Specialty	Procedures robotics most used in
Neurology	Biopsies Electrode implantation Open skull procedures Endoscopic interventions
Cardio-thoracic	Interventional cardiology Mitral Valve repair Thoracic surgery
Head & neck	Tumour resection
Orthopaedic & Spine	Hip replacement Partial & total knee replacement Spinal implants
Urological	Prostatectomy Partial Nephrectomy
OBGYN	Hysterectomy Sacro-colpopexy
General surgery	Bariatric Colorectal Cholecystectomy Hernia repair

% of each procedure performed using robotics amongst robotic using surgeons

USA
Europe

Geographic reach

While use of robotic surgical platforms have been increasing, there are geographical differences to adoption:

- The volume of demand is highest in the USA at around 70% of global sales, due to procedure volume growth, the nature of the reimbursement system (robot-assisted is classified as minimally invasive, which is covered by insurers) and the trend amongst manufacturers to invest a larger portion of their efforts in the US.
- Reduced spending and smaller budgets for healthcare providers have limited the overall volume of installed robotic platforms in Europe, with 14% of global sales in the five major EU markets.
- Asian countries, particularly Japan, China and South Korea, with substantial investment in technological advancements, serve as new revenue pockets for the medical robotic systems markets.

High investment costs still limit the installation of robotics, mostly to large tertiary/university hospitals in key metropolitan cities, where there is the highest suitable case load.

50 things that changed the Modern Economy 'Dynamo' PODCASTInforma Pharma – Robotically Assisted Surgical Devices Dec 2019

Ipsos-Sermo PULSE survey Q1: Thinking about the past year of your practice, approximately what % of each of the following surgeries / procedures do you perform robotically?
Base n=73 US, n=170 EU, mix of urologists, OBGYN, general and GI surgeons performing robotic surgery

Competitive landscape: Manufacturers in the space

Two decades after its initial launch, patents for Intuitive's Da Vinci systems are expiring, opening up the market to new competitor products, thus changing the market dynamics.

Companies such as Stryker, Smith & Nephew, Zimmer Biomet and Globus Medical have all made acquisitions (and/or signed collaborations) to acquire or enhance robotic surgical platforms.

The following acquisitions have been made by large medtech players:

2015 – Johnson & Johnson entered a joint venture, Verb Surgical, with Verily Life Sciences. Verb plans to launch its digital MIS platform in 2020. After acquiring Orthotaxy in 2018 for its orthopedic-surgery digital prototype in 2018, Johnson & Johnson spent US$3.4 billion in February 2019 to acquire Auris Health, adding their digital endoscopy platform to the portfolio.

2016

2017

2018 – Medtronic acquired Mazor Robotics for US$1.7 billion (its biggest buy since Covidien) quickly integrating its own Stealth software to launch an upgraded version of the platform in June 2019, Medtronic has also announced its partnership with Karl Storz to integrate their 3D vision systems.

2019 – Siemens Healthineers paid US$1.1 billion for Corindus Vascular Robotics' minimally invasive surgery (MIS) platform for coronary, peripheral and neurovascular operations.

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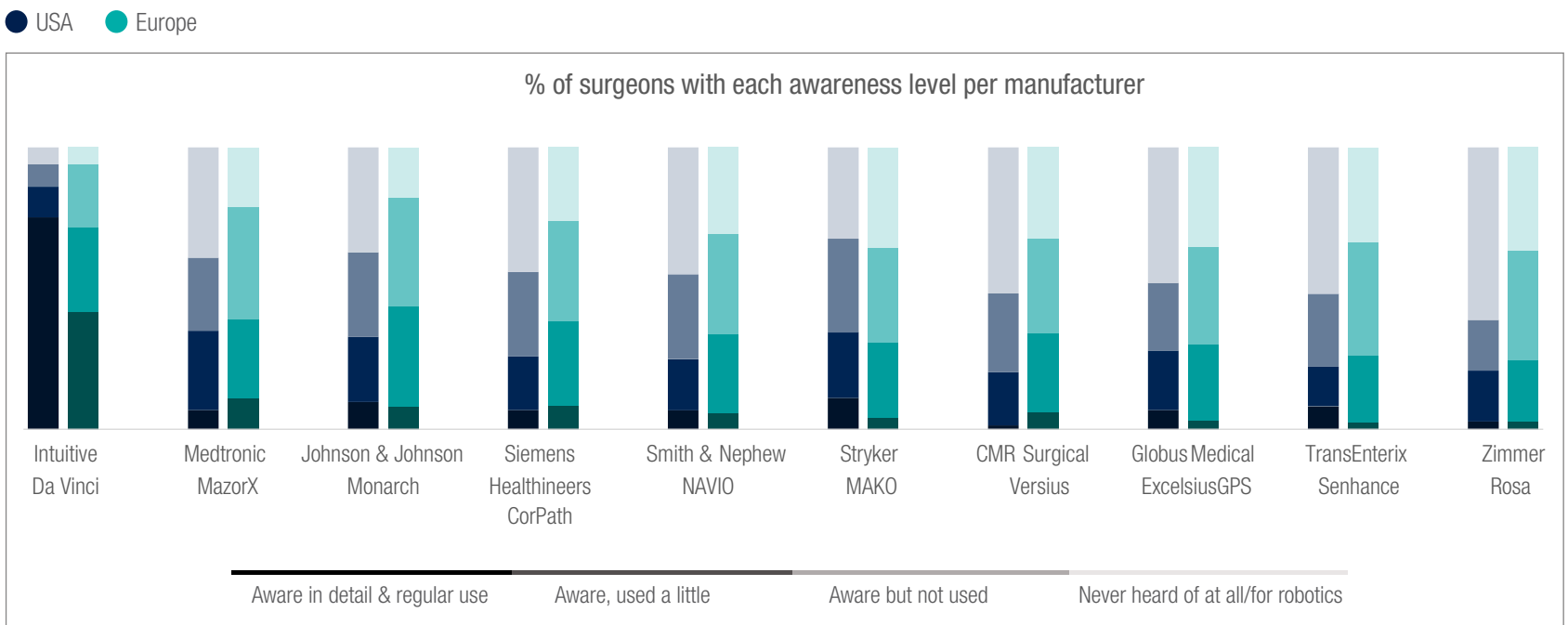
Top robotic manufacturers

Company	Products in the market or pipeline	Initial/latest launch dates	Area of intervention	Market Share 2018	Average Sales Price
Intuitive Surgical	Da Vinci System (S, Si, Xi, X, SP, Ion Lung biopsy)	2000/2019	Minimally invasive surgeries for serval indications	80.60%	$55,000-$2,500,000
Stryker	Mako surgical robotic line	2005/2017	Partial knee, total hip, total knee replacement	9.60%	$1,000,000
Accuray	Cyberknife System	1999/ 2009	Radiation oncology	2.80%	
Medtronic	Mazor X	2011/2019	Spine & brain surgery	1.90%	$850,000-
	Renaissance guidance system	2014/2015	Brain/ Spine		
	Mazor X Stealth Edition	Pipeline	Minimally invasive surgeries		
Smith & Nephew	NAVIO (PFS, Surgical)	2012/2017	Partial and total knee replacement	1.40%	$250,000-TBD
	NAVIO 7.0	Pipeline	Upgraded version adding ANTHEM total knee replacement		
Globus Medical	ExcelsiusGPS	2017	Minimally invasive and open orthopaedic and neurosurgical	1%	$750,000-1,000,000
Zimmer Biomet	ROSA ONE	2012/2019	Single platform for neurosurgical, spinal and knee	<1%	$750,000-1,000,000
Transenterix	Senhance Robotic Surgery	2017	Minimally invasive surgeries: abdominal, colorectal & OBGYN	<1%	$1,800,000-2,000,000
CMR surgical	Versius Surgical Robotic System	2019	Minimally invasive surgeries	<1%	
Johnson & Johnson	Monarch Platform	2018	Lung biopsy for diagnosis & treatment of cancerous tumours	<1%	$250,000-TBD
	Digital surgery platform	Pipeline: 2020	Minimally invasive surgeries and orthopaedic procedures		
	Magellan Robotic System	2012	Multispecialty peripheral vascular		
Siemens Health-ineers	Cor-Path vascular robotic system	2012/2016	Percutaneous coronary and peripheral vascular	<1%	
	CorPath GRX	2016/2019	Percutaneous coronary, peripheral vascular & neurovascular		

EY – Pulse of the Indusry_2019 www.ey.com/lifesciences ; Informa Pharma – Robotically Assisted Surgical Devices_Dec 2019

Competitive landscape: Awareness & impression

Intuitive is unsurprisingly the most widely used in all markets, especially in US; awareness & experience with Medtronic Mazor and J&J Monarch is also high. Transenterix and Zimmer have the lowest awareness in the robotics space



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Intuitive is a clear leader across all attributes and especially strong in the US. In Europe, other manufacturers, such as Medtronic, J&J and Globus are also well regarded. There is a potential unmet need in community based activities and smart thinking

Ipsos-Sermo PULSE survey Q2: Please rate your level of experience with each of the following manufacturers of robotics? Q3: For each of the following attributes – please select the one manufacturer that you believe leads/you most strongly associate with that attribute. Base US, n=73 EU, n=170 mix of urologists, OBGYN, general and GI surgeons performing robotic surgery

Future of the Operating Room: Six drivers of use

01 The aging population, global burden of disease and subsequent general hospital bed shortages are highly motivating reasons to use robotics, as in many cases patient recovery time is reduced

02 Introduction of less expensive systems and the launch of systems that do not require use of disposable instruments is bringing down the per procedure cost, meaning more can afford robotics

03 Technological advances in robotic systems are enabling more widespread use; e.g., haptic feedback, modular components increasing versatility, as well as the availability of portable devices that allow transfer between operating rooms and create suitability in ambulatory surgery centres

04 Increased emphasis on physician and operating room safety drives use of robotics, as they have the potential to significantly reduce and potentially eliminate the need for intraoperative fluoroscopy

05 Integration of robotic training into medical residency programs will further drive the adoption of robotics within each surgical specialty

06 Regulatory approvals of robotic systems for additional clinical indications and in new geographic markets has lead to procedure volume growth

Key benefits of robotics: Category #1 – General

It is generally accepted that robotic surgical systems offer similar benefits to those offered by minimally invasive surgery (MIS), including shorter recovery time, less scarring and reduced healthcare costs, due to shorter hospital stays driving uptake over open methods. The jury is still out on whether the additional cost of robotics over traditional laparoscopic procedures carries sufficient additional benefits. Key benefits and how they are measured by hospitals to justify investment, fall into three categories:

Category #1: General benefits of robotics

Experts found it easier to train on robotics than anticipated:

Despite some controversy about how well trained surgeons are, the expectation was that it could take up to 100 cases to be proficient, with some KOLs finding they were confident after just 20 cases, citing that the visualisation system makes it easy to educate doctors. This does seem to vary by platform used and specialty.

1. A study published by the British Journal of Urology found that when utilizing a four-arm da Vinci robotic system prostatectomy, blood loss significantly dropped after 50 procedures and complication rate after 150 cases.
2. However, when using the less complex MAKO robot, physicians at the American Academy of Orthopaedic Surgeons 2017 annual meeting reported a learning curve of 10 cases.
3. There is anecdotal evidence of a steeper learning curve amongst newer indications, such as cardiology, with 6-12 months of training required.

Robotics is an 'easier' option for surgeons who have not yet been trained in minimally invasive techniques – particularly in the US.

The use of robotics in all general surgery increased from 2% to 15% from 2012 to 2018.

Whilst hospitals that launched robotic surgery programs had a broad and immediate increase in the use of robotic surgery, there was an associated decrease in traditional laparoscopic minimally invasive surgery. However, there will still be a need for laparoscopic methods in the near future, where robots or trained surgeons are not available.

Higher patient case loads are made possible due to:

Shorter procedure and recovery time

1. Better access to patients by using telecommunications
2. Increased patient attraction, through enhanced hospital brand and competitive advantage by offering the more 'innovative and advanced' robotic technology.
3. One orthopaedic surgeon noted that since he began using the MAKO for partial-knee replacements in 2006, procedure volumes for total joint replacements at his facility had increased by 20% by 2018.

https://www.medicaldevice-network.com/features/da-vinci-surgical-robot-competitors/
Ou et al., 2011
Informa Pharma – Robotically Assisted Surgical Devices_Dec 2019

Key benefits of robotics: Category #2 – During surgery

Category #2: Benefits of robotics during surgery

Robotics are seen as an enabling technology, improving an average surgeons' performance by reducing surgical complexity and through superior imaging, which helps the surgeon see more clearly and to be more precise. Others caution that training is still required to make good robotic surgeons, and some may lose the skills to adequately perform traditional laparoscopic procedures. Robotics is seen by some more experienced surgeons as a benefit and a crutch to less experienced surgeons, who have less confidence.

> *"I think that's the value of technology. It is always an enabler, it's a tool. It enables people who are good to be really great and average people to be decent. For me the journey has always been about technology improving access."*
>
> OBGYN, Singapore

Improved precision is a key benefit over laparoscopic methods, which use straight instruments, whereas robotics have more angulated tools. Robotics have wrists with greater flexibility than human wrists and increased visibility within the operating field.

> *"You can see & handle things better and surgery is more precise because the fine monoport tip, it's sharp and doesn't grab too much tissue so there is less chance of collateral damage."*
>
> Colorectal, EU

Improved ergonomics, through the use of independent three-arm system, frees up the surgeons' hands and reduces dependence on an assistant to hold the camera. This means robotic surgeries are less straining and fatiguing than open and minimally invasive procedures. This, in turn, can lead to fewer complications, higher case load, and extension of the surgeons' professional life.

> *"You did have surgeons in the past that had all sorts of contortions and back issues & it really limited some people's careers because you were hunched over a table for 8 hours…now you are able to operate more comfortably."*
>
> Uro, USA

Robotics allow surgeons to perform otherwise challenging or impossible surgeries, for example, obese or difficult body shapes that are too problematic for traditional laparoscopic methods. The greater flexibility of the robotic wrist assists with complex tasks in confined areas of the body, normally inaccessible to human hands. For example, endometrial suturing in a myomectomy – the increased access in the pelvis area causes less trauma to the patient, leading to faster recovery.

> *"Before robotics I used to do laparoscopic surgery and it was quite challenging and I don't expect I can do the same complex stuff I do with a robot these days if I didn't have the robot."*
>
> Uro, UK

Robotic surgeries enable more efficient use of the OR

1. Procedures are more reproducible and consistent, as all surgeons are trained in the same way and the robot brings consistency in skill and manoeuvrability, further enhanced by 3D planning software. This means that outcomes and duration are more accurate and standardised, which enables better planning and efficient use of the OR.
2. Robotic methods tend to have shorter operating times; therefore the number of operations performed increases, improving hospital efficiency. This has the benefit of being an easily measurable KPI.
3. Robotic methods are less likely than laparoscopic methods to be converted to an open surgery, which enables more efficient use of the operating room.

https://www.medicaldevice-network.com/features/da-vinci-surgical-robot-competitors/
Ou et al., 2011

Informa Pharma – Robotically Assisted Surgical Devices_Dec 2019

Key benefits of robotics: Category #3 – After surgery

Category #3: Benefits of robotics after surgery

Post-surgical complications are less frequent & complex, including bleeding, infections, bladder & sexual status (urological procedures, meaning less antibiotic use and bed occupancy

> *"An open prostate surgery normally keeps someone in a hospital for 2-3 days; they usually lose a very significant amount of blood, people would need blood transfusions… The convalescence, getting people back on their feet and back to work was much more delayed with open procedures … so the fact that we are able to do these surgeries and are almost send people home on the day of surgery has really improved the patient convalescence."*
>
> Urologist, America

Recovery time is reduced, which reduces length of hospital stay, bed occupancy and ward time, on average from 4 days to 1 day post-surgical hospitalisation. This has wider economic benefits, such as quicker return to work and less reliance on family members to look after patients or children whilst the patient recuperates

> *"The bed occupation rate is an issue at our hospital. We took our programme and this has to affect the bed occupancy in some way. So, we took our traditional 4-day hospital stay for open surgery and made it like a day surgery procedure, that was huge. That could be measured immediately."*
>
> OBGYN, Singapore

There are fewer 7-, 30- & 90-day readmissions with robotic surgery, due to reduced recurrence and complication rates. According to a retrospective analysis of a commercial claims database, lower all-cause readmission rates associated with MAKO partial-knee procedures translated to 40% lower readmission costs at 30 days and 66% lower readmission costs at 90 days, compared to manual partial-knee surgery, a saving per episode of $14,958 at 90 days

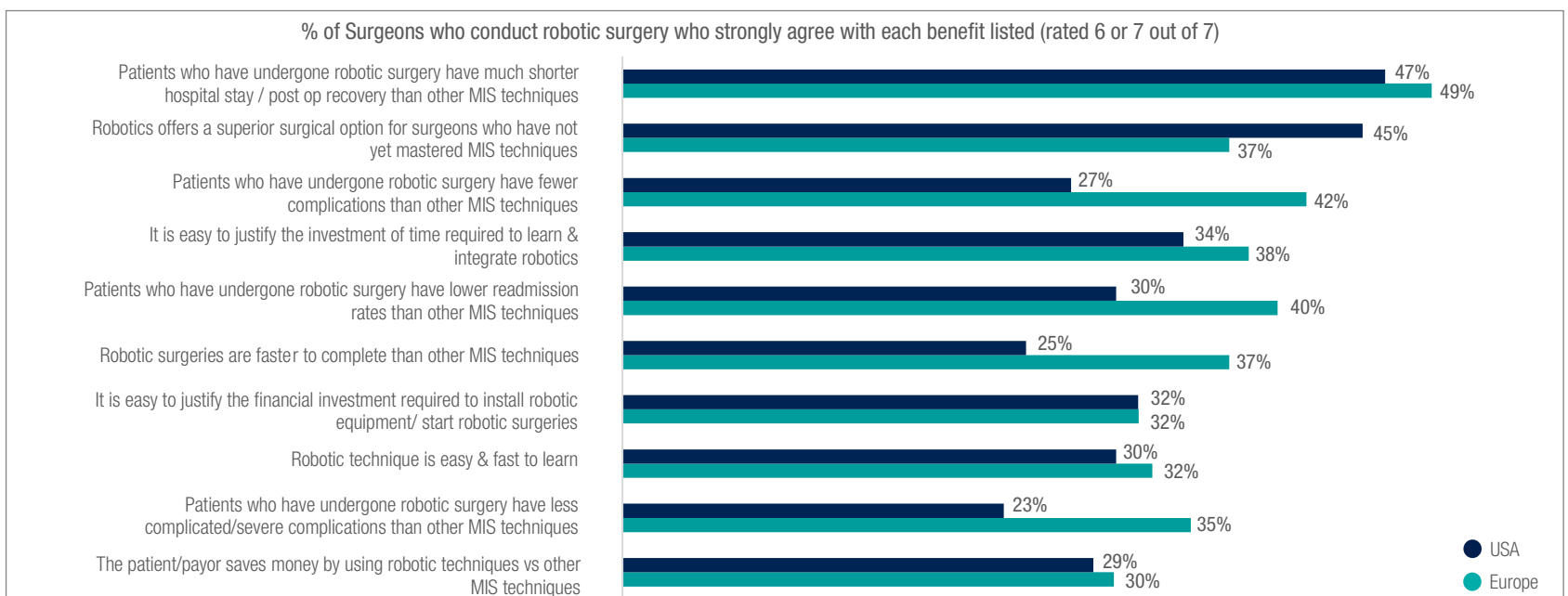
Pain and scarring post- operatively are reduced, although this is also true of other minimally invasive methods. The smaller wound means less scarring, which can be particularly important to women in OBGYN procedures (especially in Korea). The use of the mono port and sharp & accurate tools which pick up only a small amount of tissue means less damage to surrounding bodily structures especially in orthopaedics. This allows patients to ditch crutches and pain medication more quickly

> *"The more women you can get to have minimal invasive surgery, safely and high quality compared with open surgery, the less time they are going to take off work, the less time they are going to take off childcare, the less time that their partners have to take off for childcare and miss working days."*
>
> OBGYN, UK

Informa Pharma – Robotically Assisted Surgical Devices_Dec 2019
Baker Tilly, 2016

Key benefits of robotics: Global data

Reduced hospital stay is the main benefit of robotics. In the US, the ability to 'leapfrog' MIS techniques and ease of learning robotics are the next leading benefits. Meanwhile, in the EU, fewer complication rates and lower readmission rates are noted, likely due to the way funding is justified for robotics in public health systems



Ipsos-Sermo PULSE survey Q4. When thinking about robotics, how strongly do you agree/ disagree with each of the following statements? Please rate on a scale of 1-7 where 1 is strongly disagree and 7 is strongly agree. Base n=73 US, n=170 EU, mix of urologists, OBGYN, general and GI surgeons performing robotic surgery

Five key barriers to robotics

01 Insufficient clinical evidence

The main issue with robotics is that there is not enough clinical evidence of significantly superior outcomes, compared to conventional methods, to justify the vastly increased costs (up to twice the price of traditional laparoscopy).

Scientific literature gives mixed evidence, some showing equivalence between robotic, minimally invasive and open, while others showing improvements in convalescence and blood loss for robotic. There is even evidence of poorer clinical outcomes in cancer operation, where the surgeons are not fully qualified to perform those robotic procedures.

Some physicians are cynical, stating that certain robotic surgeries can take longer than minimally invasive methods and are not necessarily easier than laparoscopic methods.

This lack of sufficient evidence makes some surgeons reluctant to recommend it to patients.

> *"No robotic system has shown any benefit whatsoever over laparoscopic instrumentation except in a few rare cases and very selective situations. In essence there is no benefit to robotics other than marketing today. The problem is, when the surgeon can't offer you laparoscopic equivalent and has to say, I'm either opening you up or operating with a robot. That is beginning to occur in certain specialties simply because of capabilities of robotics, lack of training by the surgeons and the company's ability to really market aggressively."*
>
> OBGYN, US

> *"National health institutions are very wary about adopting new technologies, particularly if they are very expensive."*
>
> OBGYN, UK

02 Lack of competition means high costs

Perceived lack of competition means the cost of the machine, running costs, and infrastructure (as the Da Vinci requires a large OR) are prohibitively high, limiting uptake in many hospitals and countries. This high cost is not always seen as justified and disincentivises the hospital to invest in, as it becomes less profitable – especially when many economic benefits, such as a patient getting back to work sooner – are not realised by the hospital itself.

This means that robots tend to be focused in centres of excellence, for example in Shanghai, only 5-8 hospitals are using robotics, and can cause the equivalence of brain drain.

Cynics claim it would be better to train more surgeons on laparoscopy than spend on robotics.

Five key barriers to robotics

03 Lack of (adequate) government reimbursement

Due in part to lack of convincing clinical evidence, this limits uptake of robotic methods, especially in China, Korea and EU. The limited out-of-pocket affordability means suitable patients choose other more affordable, reimbursed methods. The European healthcare model particularly is prohibitive towards increased uptake of robotics; for example, NHS funding in the UK is hospital specific, so smaller hospitals are unlikely to spend high amounts on robotics. In the US and Korea, robotics is covered by private insurers under 'minimally invasive' codes but it increases insurance premiums for everyone. Where reimbursement exists, the challenge is that the healthcare reimbursement system is outdated:

1. It has not caught up with improvements in patient recovery times so patients are being forced to stay in hospital for two days to get their reimbursement, despite being able to leave the same day. This obviously has an impact on bed occupancy rates.
2. Coding has not caught up with the new robotic indications, making it difficult to claim for innovative operations. For example, urology was one of the first indications, so a lot of operations have dedicated CPT codes, but there are no CPT codes for robotic cystectomy or advanced reconstruction procedures

> *"Fortunately, most of the private supplementary health insurance products cover robotic surgery costs in Korea. Therefore, private supplementary insurance has become the major payer for robotic surgeries in Korea."*
>
> OBGYN, Korea

04 Access to /availability of robotic platforms or trained surgeons

Not having enough fully trained surgeons and scrub teams to meet the demand, especially in Europe, can put providers in a catch-22 situation: Surgeons do not get enough case load, due to lack of training/experience, which then does not justify the time and cost investment required for training. Training for the whole team is seen as essential for robotics and experienced teams are in demand, so retaining them can be a challenge.

Most markets agree they do not have enough robotic platforms to meet demand, due to the high investment cost. Even if more surgical teams were trained in robotics, they might not have enough platforms to meet demand; already in some hospitals in Europe and particularly the US, booking available robots can be challenging, as multiple specialties may use the same system.

The lengthy regulatory marketing approval process and sales cycle, which can be as long as two years in countries such as Japan and China, also limits availability of robotic surgical systems.

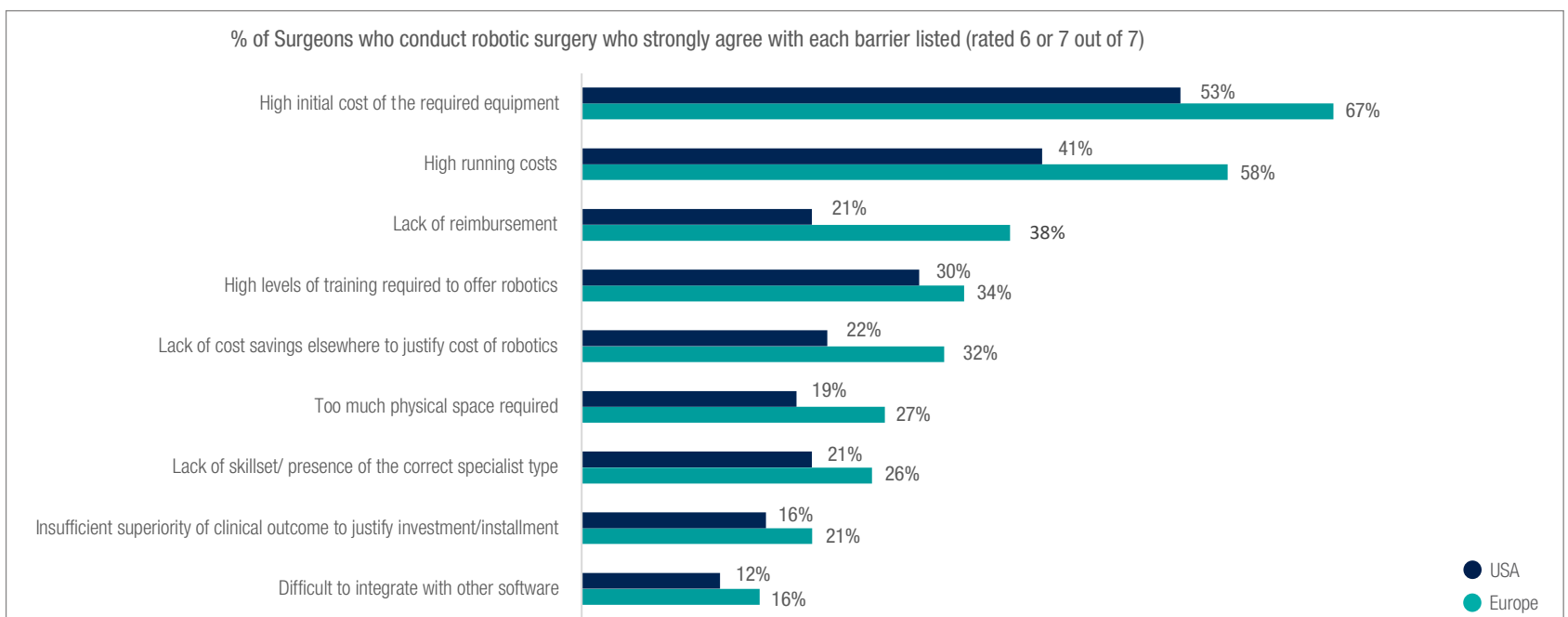
> *"A robot is not a thing that makes you a better surgeon itself. It takes the same amount of training and team training and introduction as other surgical methods. It is not a shortcut to doing good surgery, that's a misinterpretation. But once you have it up and running and learned the system you can do complex procedures"*
>
> OBGYN, Sweden

Five key barriers to robotics

05 Patient acceptance & demand can also limit use of robotics. On one hand, some patients may not be willing to let robots perform surgeries, and physicians may not be sufficiently convinced to wholeheartedly recommend robotics to patients, as we see happening in Korea. On the other hand, patients in the US may see robotic surgery advertised and want that method, even if they are not eligible for that condition.

Key barriers to robotics: Global data

High initial costs and running costs are by far the largest barriers – particularly in Europe, where lack of reimbursement is also an issue. High levels of training required also ranks highly. All barriers are more strongly felt in EU, explaining the lower uptake of robotics in the region



Ipsos-Sermo PULSE survey Q5. What are the main barriers to using (more) robotics in surgeries? Please rate your level of (dis)agreement with each of the following potential barriers?
Base n=73 US, n=170 EU, mix of urologists, OBGYN, general and GI surgeons performing robotic surgery

Support needed to increase uptake of robotics

Training, education and reducing costs are the main support needed to enhance robotics uptake; value-added services, such as case building for funding and maintenance contracts/remote monitoring of systems, would also give a boost

Subsidised training and education for surgeons is required to increase use of robots. Using virtual/augmented reality and simulation training as per the aeronautical model, as well as increased use of semi-automated sequences during surgery, are seen as ways to reduce the time and cost of training by as much as 50-60% and could lead to better results. KOL-led education, remote training via video & simulation, and hands-on in-clinic training are all mentioned, along with training for the nursing/OR staff.

% of surgeons who spontaneously mentioned training in the survey:

51%	53%	54%
63%	63%	80%

Better integration with other systems in the OR and with enhanced imaging options.

More system upgrades, for both software and technical improvements to make robots more precise, smaller and easier to use.

Reduce the cost burden

Increasing competition is expected to bring costs down, making robotic systems accessible to medium- and small-sized hospitals. Lower costs will free up funds for doctor training programs and increase reimbursement coverage. Updated/more comprehensive reimbursement is key in reimbursed markets such as Korea, China and EU.

% of surgeons who spontaneously mentioned costs in the survey:

12%	13%	21%
8%	16%	17%

Value-added services and maintenance, including start-up support, support in building a case for funding for initial purchase or per-cost usage for continued funding, more contract options, lower cost and/or faster maintenance, real-time remote troubleshooting, remote monitoring and maintenance.

Ipsos-Sermo PULSE survey Q9: What additional support should manufacturers of robotics provide to healthcare professionals?. Base n=73 US, n=170 EU,China mix of urologists, OBGYN, general and GI surgeons performing robotic surgery

Ideal world innovations may take longer to reach the OR

Artificial intelligence & automation may become standard in 10-15 years

Performing a robotic procedure today can look a bit like playing a video game, but as the technology progresses, some futurists think we will reach a day when surgeons will not need to be in the operating room at all during a procedure.

AI is already breathing new life into robotic-assisted devices, making it easier for surgeons to navigate small incisions and limit strains on joints. In the future, surgeons are expected to move into a supervisory role of deciding how and where to treat the disease and leave the robot to do the fine precision work. Advanced AI will allow robots to 'explore' the patient's body and give the surgeon several courses of action to choose from. Once an action is selected, the robot could execute the fine precision work while the surgeon supervises.

> *"If you record the same procedure 1000 times there are going to be elements of that procedure that are going to be fairly straightforward just like driving… it's just like self-parking cars that have a parking assistant. There are parts of surgery that a robot can do perfectly safely on its own. So, you can make that already fairly efficient… I'll be watching you the robot do it on its own and I can get started on the next case…The robots are going to develop into a surgical assistant."*
>
> OBGYN, Singapore

Physicians are comfortable with around 20% of the procedures being automated this way and expect the robot to point out omissions or anomalies during a procedure. Most see automation as a way to perform procedures that they may not be able to otherwise perform – especially for less experienced surgeons.

However, some physicians believe patients will take a long time to come to terms with AI performing surgeries and that this kind of technology

% of surgeons who spontaneously mentioned AI & Automation in the survey:

15%	13%	29%
-%	6%	3%

> *"I think AI has the ability to augment critical decision making…like figuring out who we should operate on or even deciding what to do on a move by move basis in the OR ... what's been shown in AI and machine learning is that the computer algorithms can pick up more minute trends than the human brain can at least initially. So, I think it's got the potential to impact decision making by being able to recognize trends and things that would have otherwise not been discovered or seen and large data too. There's only so much a human can remember and process but there's very little limit of large data sets especially when it comes to genomics data."*
>
> Urologist, America

https://www.marketwatch.com/story/these-companies-are-investing-billions-so-robots-can-perform-surgery-without-a-doctor-in-the-room-2020-02-19

Ideal world innovations may take longer to reach the OR

Improved connectivity and remote control robotics

Faster data speeds mean a shorter lag time between command execution and actual play, bringing this closer to the type of reaction you get when the surgeon is physically present.

In addition, the OR of the future will likely see one surgeon overseeing many operations in multiple hospitals and countries, without having to leave his or her position, due to having greater 5G connectivity.

This could improve access to specialised care in smaller non-specialised hospitals, where they may not have the specialist present – as long as they can afford the robotic platform.

The improved connectivity will allow greater efficiency and case load, as one surgeon can 'travel' from one OR to the next to perform the next surgery without waiting for OR turnaround time.

> *"In terms of the physical hospital, hospitals are going to get smaller. So, specialist centres, like the national University Hospital… it's going to need less space because you are not providing all that care in one physical campus any more. There'll be healthcare clusters with 5 different hospitals ... in our healthcare group, all that care will be centralised so there will be less of a need to staff and build a big hospital ... so it's just a question of how well you build your network; it will be network-based care rather than centre based care."*
>
> OBGYN, Singapore

This is not expected to lead to a reduction in staff needed, but rather a redistribution of staff away from centres of excellence into the ORs where operations are being performed. This model will establish a more decentralised, network-based care with surgeons overseeing procedures from their centres of excellence while procedures are taking place out in the larger community.

% of surgeons who spontaneously mentioned telehealth in survey:

	10%		-%		4%
	10%		-%		3%

> *"The other big thing in technology is going to be connectivity. With 5G you're going to be able to have one human master surgeon operating with 5 assistants more or less simultaneously… you don't have to get up and go to a different OR, you have the same master control which is connected to 5 different robots. The concept has already started in China."*
>
> OBGYN, Singapore

Ipsos-Sermo PULSE Q6: What do you expect to be the future trends in robotics?. Base US, DE n=40, ES n=35, FR n=32, UK n=23, IT n=40) mix of urologists, OBGYN, general & GI performing robotic surgery

Most realistic changes likely to happen in 2-3 years

Increased competition, price reduction and improved access

The field is about to get more crowded in the coming years with Medtronic, Johnson & Johnson, and others stepping up efforts in the space.

The emergence of new players would break Intuitive's monopoly and could bring down prices for robotic devices, to the point of replacing other minimally invasive procedures and opening the market to small-medium hospitals in developed countries and larger hospitals in emerging markets.

Increased competition and lower costs are expected to increase reimbursement and training programs, making robotic platforms more accessible to surgeons on a global basis and increasing access for patients.

Rising investment in the sector will boost awareness of the technology and the numbers of surgeons trained on the platforms.

% of surgeons who spontaneously mentioned increased competition:	14%	8%	-%
	-%	13%	3%
% of surgeons who spontaneously mentioned price reduction in survey:	15%	5%	21%
	15%	25%	14%
% of surgeons who spontaneously mentioned increased usage in survey:	27%	25%	33%
	63 %	34%	63%

> *"Increase in competition will lower prices and this will lead to an increase in doctor training programmes as well as increase HIRA's reimbursement for surgical robots… More robots will be made. Some made in Korea which will become available to small and medium hospitals as will cost less than Da Vinci."*
>
> OBGYN, Korea

> *"It would be nice if there was some real competition in the markets. When you have competitors, you end up with the same price for equipment"*
>
> OBGYN, Sweden

Increasing indications for robotics

Operating rooms of the future will see an increase in use of robots for more indications, as robotics is easier to learn than laparoscopic techniques and robotics can learn to perform actions that surgeons cannot do.

Smaller next-generation robots with enhanced vision systems will further expand the range of possible procedures and open new indications. Increased accuracy and reduction in operation difficulty are expected to enable robots to perform more complex surgery with smaller wound sites.

% of surgeons who spontaneously mentioned increased indications:	6%	3%	33%
	43%	3%	26%

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Most realistic changes likely to happen in 2-3 years

Digital imaging

This technology is already being used to alert surgeons to things they cannot see, to avoid tissue damage as they operate, by showing real-time blood flow using wavelength reflection to detect where veins, vessels and arteries are without the use of traditional dyes.

In neurosurgery, molecular image-guided surgeries are performed by injecting a tracer, which turns tumours a different colour that can be seen through specialised goggles.

Even with recent improvements, such as 4K and firefly, which uses an infrared screen and has enabled surgeons to see and zoom in clearly to images, this technology is expected to get even more sophisticated.

> *"The number one area is lighting arrangements. So, you score somebody with ICG, so you can see where the ICG lights up… they're coming up with other dyes, other fluorescent imaging sources so you can see blood vessels or ... whatever organ you want to get to. That's called Augmented Reality where you can see more than with your own two beady little eyes"*
>
> OBGYN, America

Ultrasound, CT, and MRI are expected to play a greater role in making surgeries even more precise by giving doctors a better real-time portrait of the body, even as matter shifts during the surgery. MRI can be superimposed on the site being operated on. In nephrectomy, for example, this can give the surgeon a better view of a deeply buried tumour overlaid clearly on the patient. Other systems are creating 3D models by converting CT scans or by fusing perioperative and intraoperative ultrasound scans with fluorescent vision systems.

Augmented reality is also expected to be used to see more than just visible light.

% of surgeons who spontaneously mentioned enhanced imaging in survey:

15%	3%	13%
3%	6%	11%

% of surgeons who spontaneously mentioned AR/VR in survey:

3%	10%	-%
3%	6%	3%

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Most realistic changes likely to happen in 2-3 years

Miniaturization and migration out of the OR.

As machines get smaller, more portable, easier to use, and cheaper, they could move away from OR to in-office for certain procedures, such as hysteroscopies.

% of surgeons who spontaneously mentioned miniaturization in survey:			
	16%	-%	13%
	5%	3%	3%

Increased use of data/smart systems are expected to make improvements to surgical technique and therefore outcomes. For example, data analytics can be fed back to the surgeon in real-time to advise on the best instrument to use in a specific situation.

> *"One of the key things that's interesting about surgical robotics is that the next evolution is going to be analytics of data to optimize use of the equipment within the healthcare ecosystem. Intuitive being in the business for this long has had time to realise their systems and are generating a lot of data that they are really not touching at all. That's one of the things that is rapidly emerging in robotics."*
>
> OBGYN, Singapore

> *"So I think machine aligned systems are going to shorten that loop to the point it's going to be in real time so before you pick an instrument up or you open a package, that computer is going to be able to say 'you use this instead of that, this is going to be more efficient for the patient' Over the past five years data has been collected but not really analysed. Intuitive will be processing this data."*
>
> OBGYN, US

Peripheral technology is expected to become more widespread. The OR of the future is expected to become wireless with novel ways of presenting and collecting patient information; e.g., scannable wristbands, video programs that film the surgery and write reports/take notes.

New/updated innovations that continue to make the robotic platforms easier to use, more ergonomic and precise.

% of surgeons who spontaneously mentioned innovations in survey:			
	27%	18%	25%
	20%	28%	23%

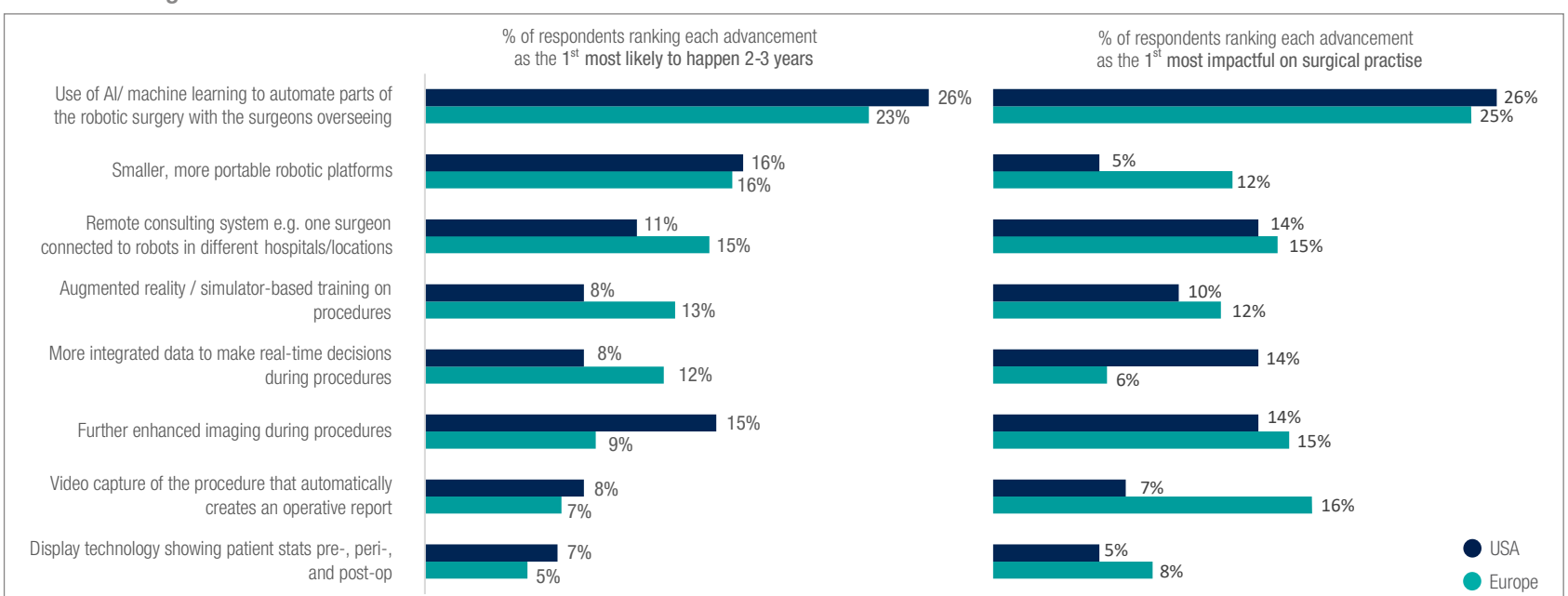
Single-port systems are particularly mentioned as a future trend.

% of surgeons who spontaneously mentioned single ports in survey:			
	12%	8%	4%
	3%	9%	3%

Ipsos-Sermo PULSE Q6: What do you expect to be the future trends in robotics?. Base US, DE n=40, ES n=35, FR n=32, UK n=23, IT n=40) mix of urologists, OBGYN, general & GI performing robotic surgery

Most likely & most impactful trends: Global data

Use of AI to automate parts of robotic surgery is ranked as the most likely to happen in the next 2-3 years and most likely to have a significant impact. Smaller robots are highly likely to happen in the short term but impact is limited. The US particularly expects further enhanced images to come soon.



Ipsos-Sermo PULSE survey Q7. Out of the following future trends please rank the top three that you believe are most likely to be implemented in the next 2-3 years? Q8. Out of the following future trends please rank the top three that you think will have the most positive impact on your surgical practice? Base n=73 US, n=170 EU, mix of urologists, OBGYN, general and GI surgeons performing robotic surgery

Impact of COVID-19 & Conclusion

The biggest impact of COVID-19 is a drastic reduction in caseload as elective surgeries are being postponed – Germany & France are least affected. New protocols are in place around patient selection, testing for COVID and infection control

Reduction in procedure volume, as only urgent/emergency cases are being conducted and elective procedures are postponed, leading to a drop in 50-60% of volume in EU , ~80-95% drop in the US and 100% drop in practices that are elective only. Prostrate and bariatric procedures are most affected, cancer cases that can wait 60 days are also postponed. Germany seems to be the least affected European country with only 50% of respondents stating they have seen a reduction in cases & 45% seeing no changes.

Funding for new platforms is expected to decrease or be delayed as a result of COVID-19 related costs on the system. Reimbursement is largely not expected to be affected.

New Protocols are being introduced:

1. Patient selection criteria are becoming more stringent with each case being presented to a surgical committee for approval
2. Patient preparation & screening to include COVID-19 tests in some cases
3. Infection control during the surgery is stepped up with airseal devices, negative pressure ORs & more complex biocleaning

Positive/ Increase in use: A minority report an increase in use and awareness as robotic surgery has less contact, so is seen as safer; especially so in Spain where 17% of respondents make this claim.

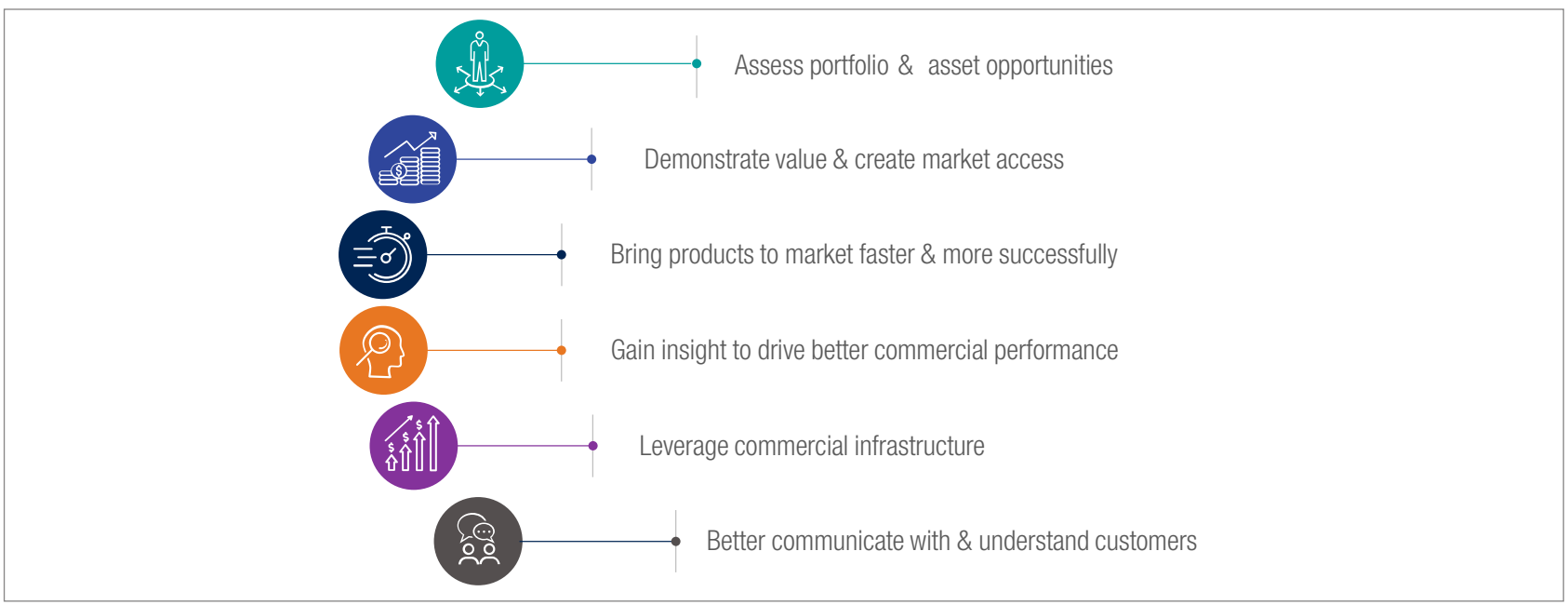
Conclusion: As the market becomes increasingly crowded, manufacturers will need to invest in the right strategy to differentiate their solutions. Leveraging a connected digital ecosystem, gathering and using data to drive better outcomes, and establishing outcomes-driven payment models will pave the way of the future. Winning strategies will use deep learning algorithms to complement surgical expertise by enhancing real-time decision making during complex surgeries. Ultimately, while surgical robotic platforms represent a key new technology, their interoperability with connected operating rooms of the future will be equally important for their long-term prospects.

Ipsos-Sermo PULSE survey Q10. How has robotic surgery been affected by COVID-19? Base n=73 US, n=170 EU, mix of urologists, OBGYN, general and GI surgeons performing robotic surgery

FUTURE OF THE OPERATING ROOM: ROBOTICS FULL REPORT

Ipsos' healthcare team partners with pharmaceutical, biotech, medical device and technology organisations to inspire better healthcare

From strategic research & consulting through commercial execution



For more information on MD&D market research and data from this survey, please contact us at: medtech@ipsos.com

Visit our Interactive brochure Ipsos Medtech Capabilities

FUTURE OF THE OPERATING ROOM: ROBOTICS FULL REPORT

Operating in over 50 countries, our 1000+ healthcare experts support key business decisions for our clients throughout the commercial lifecycle – from early-stage strategy, through to product launch and performance optimisation. We do this through a uniquely integrated combination of therapeutic, market, analytical and commercial expertise, as well as gold standard, proprietary real-world evidence.

Earlydevelopment

Market mapping/ landscaping

- Assessment of unmet needs
- Regulatory environment
- Competitor landscape
- Current practice
- Patient pathways

Opportunity assessment & Identification

- Market sizing & forecasting
- Market segmentation

Late development

New product design & development

- Innovation workshops with R&D, marketing & customers to generate new ideas
- Fine-tuning existing concepts

Concept testing

- Pricing & value assessment
- Human factors/ usability testing
- Conjoint analysis of best features/ value per feature

Launch

Launch strategy

- Message/positioning testing
- Price optimisation
- Value proposition /story refinement
- Engagement strategies
- Preferred marketing channels
- Target identification

Post-launch

Brand health tracking

- Advertising and messaging effectiveness
- Brand equity
- Sales force effectiveness
- Awareness & usage

Customer experience/ satisfaction

- Customer loyalty
- Value optimisation strategies

Portfolio management

Next-gen/upgrade strategies

- Assessment ofunmet needs
- Identification of gaps in a portfolio

Portfolio (merger) management

- Optimisation of existing portfolio
- Risk of cannibalisation of new product design or merging of two company portfolios
- Rebranding effect in case of company mergers

SERMO RealTime (a digital HCP-only rapid research tool) provides a valuable add-on to traditional research methods to gather almost instant and affordable insights in today's fast-paced environment.

SERMO RealTime can be used for multiple purposes, including:

- refining an upcoming study design
- supporting ongoing business decisions
- checking on brand messaging and/or visuals
- tracking market trends
- analysing general sentiment pre- and post-campaign
- supporting a workshop discussion

How does it work?

- Questionnaires can be scripted & launched in 24-48 hours
- Depending on the target sample respondent & size, surveys can be in field for 1-5 days **76% of all pulse surveys complete in under 5 hours.**
- Questions are fielded online to a global panel of 1.8 million HCPs, covering 40+ specialities from 30 countries,
- Target lists can also be uploaded and panel matched.
- Raw data is provided instantly in Excel, and in one to three days in PowerPoint.
- Surveys can have up to **10 questions** with two optional screener questions.

GAME CHANGERS

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Ipsos' Healthcare Service Line partners with pharmaceutical, biotech and medical device manufacturers to inspire better healthcare. Operating in 50+ markets, our 1,000+ experts support key business decisions for our clients throughout the commercial lifecycle, from early-stage strategy, to launch, to performance optimization. We do this through a uniquely integrated combination of therapeutic and market expertise, gold standard real-world evidence and market-leading custom research approaches—all underpinned by a global footprint and unprecedented access to today's healthcare stakeholders.