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BACKGROUND

- Robotic surgical systems (RSS) have become commonplace in several medical areas.¹
- RSS are used in laparoscopic procedures, spine and neurosurgery, orthopedics, and vascular surgeries.^{1, 2}
- In prostatectomy RSS are state of the art and paved the way for other robotic urological procedures.²
- Diversification and technological advances may spur the application of RSS in different medical areas.^{1, 2}
- Under §17b of the KFG (Krankenhausfinanzierungsgesetz/Hospital Financing Act), German hospitals have a uniform remuneration system for billing inpatient services. In accordance with §21 KHEntgG, the InEK (Institut für das Entgeltsystem im Krankenhaus/Institute for the Hospital Remuneration System) makes data on charges for inpatient services available.³

OBJECTIVES

- To investigate the utilization of robotic-assisted surgery (RAS) from 2005 to 2020 in Germany.
- To evaluate age and sex-specific trends in the utilization of RAS.
- To evaluate indications and medical specialties associated with RAS and associated trends throughout the years.

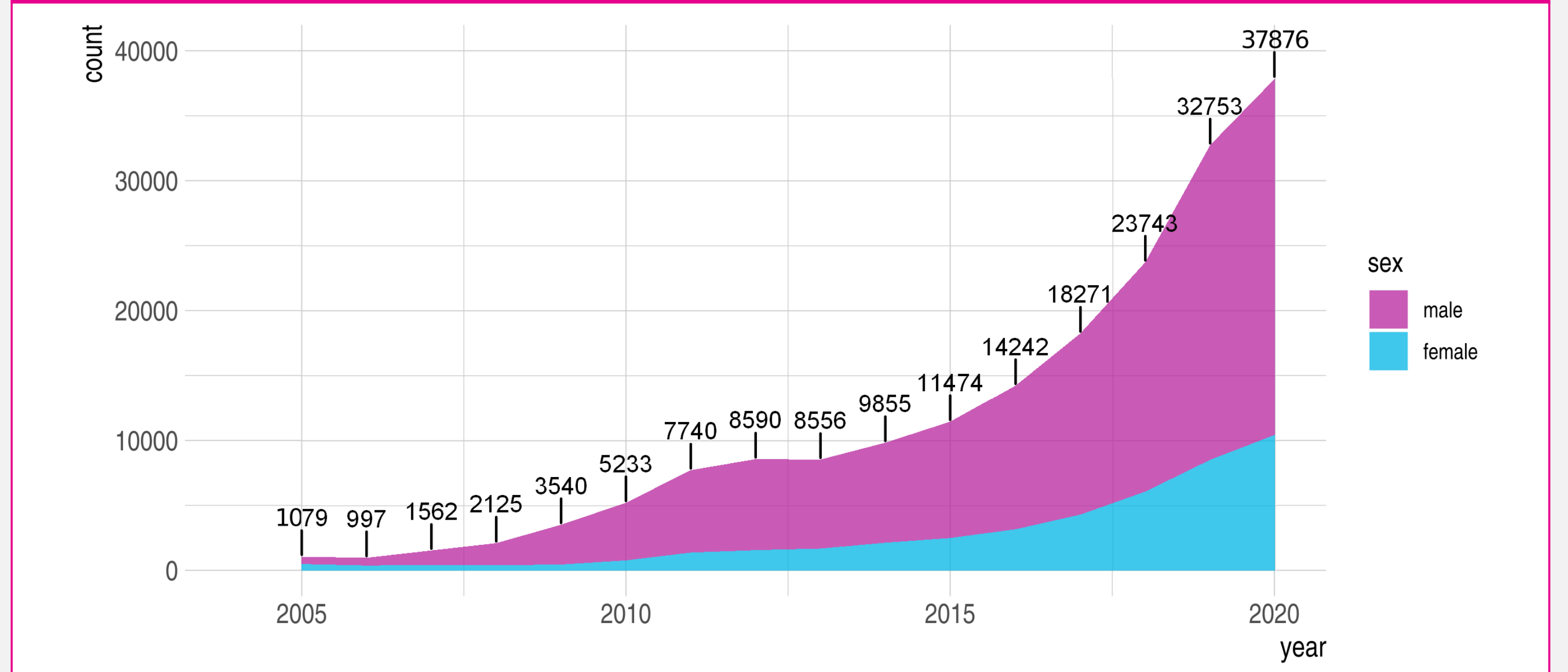
METHODS

- We conducted a retrospective data analysis using German §21 KHEntgG hospital data of the Federal Statistical Office of Germany (DESTATIS) and the InEK.^{3, 4}
- RAS was identified by OPS codes 5-987.0, 5-987.1, 5-987.x from 2005 to 2020.
- Age and sex-specific trends in RAS were investigate using compound annual growth rates (CAGR) and sex-ratios.
- Predominant indications, German Diagnosis Related Groups (G-DRG), and medical specialties associated with RAS were identified by DRG and ICD-10-GM codes. Results are presented as numbers and percentages.

RESULTS

- 1079 (561 male, 518 female) RAS were performed in 2005 in German hospitals. By 2020, the number had increased to 37,876 (27,415 male, 10,461 female), resulting in a CAGR of 26.8% (29.6% male, 22.2% female) (see **Figure 1**).

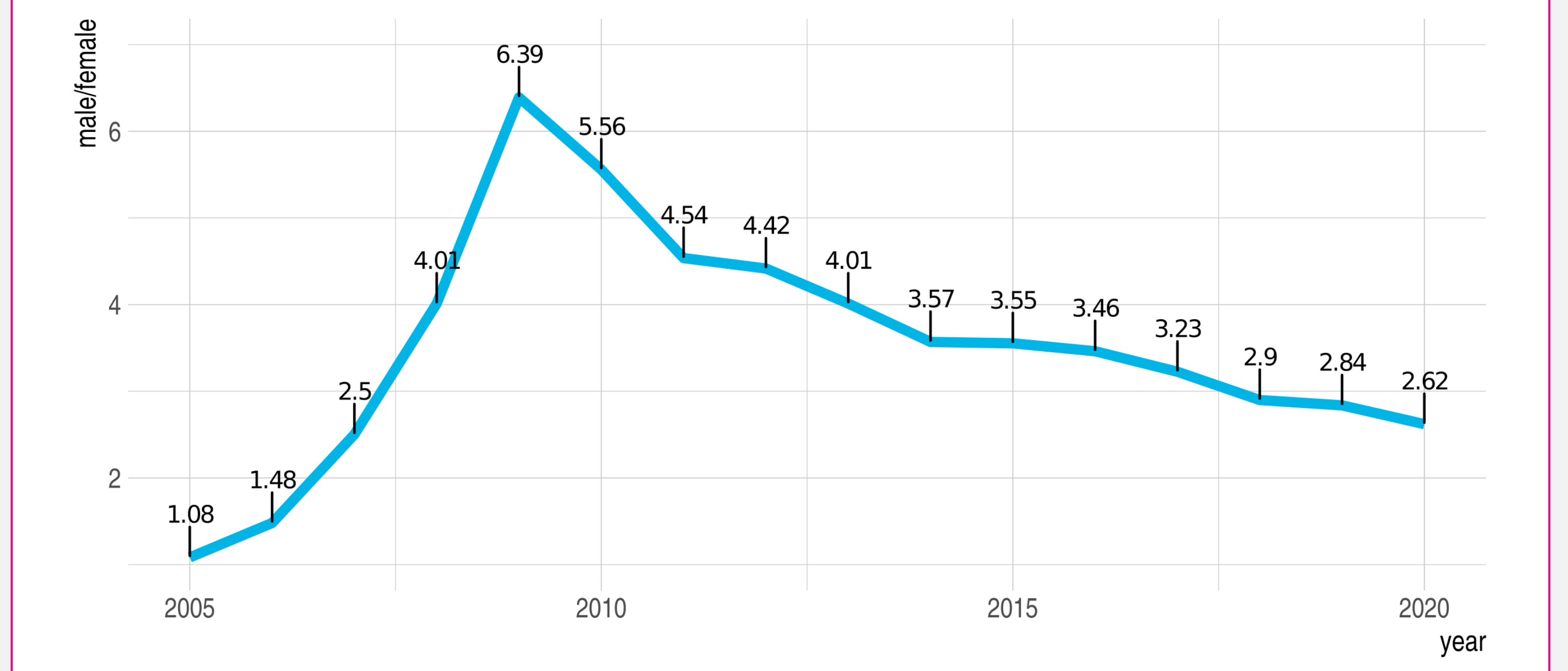
Figure 1. Number of robot-assisted surgeries (5-987.-) in Germany from 2005 to 2020



Year	Male	Female	Total
2005	561	518	1079
2006	597	542	1139
2007	1562	1125	2687
2008	2125	1540	3665
2009	5233	7740	12973
2010	8590	8556	17146
2011	9855	11474	21329
2012	14242	18271	32513
2013	23743	32753	56496
2014	37876	10461	48337

- With a sex ratio of 1.08:1, RAS was performed with similar frequency in males and females in 2005. Differences steeply increased until 2009 (sex ratio: 6.39:1), before steadily declining to a sex ratio of 2.62:1 by 2020 (see **Figure 2**).

Figure 2. Sex-ratio in robot-assisted surgeries (5-987.-) in Germany from 2005 to 2020

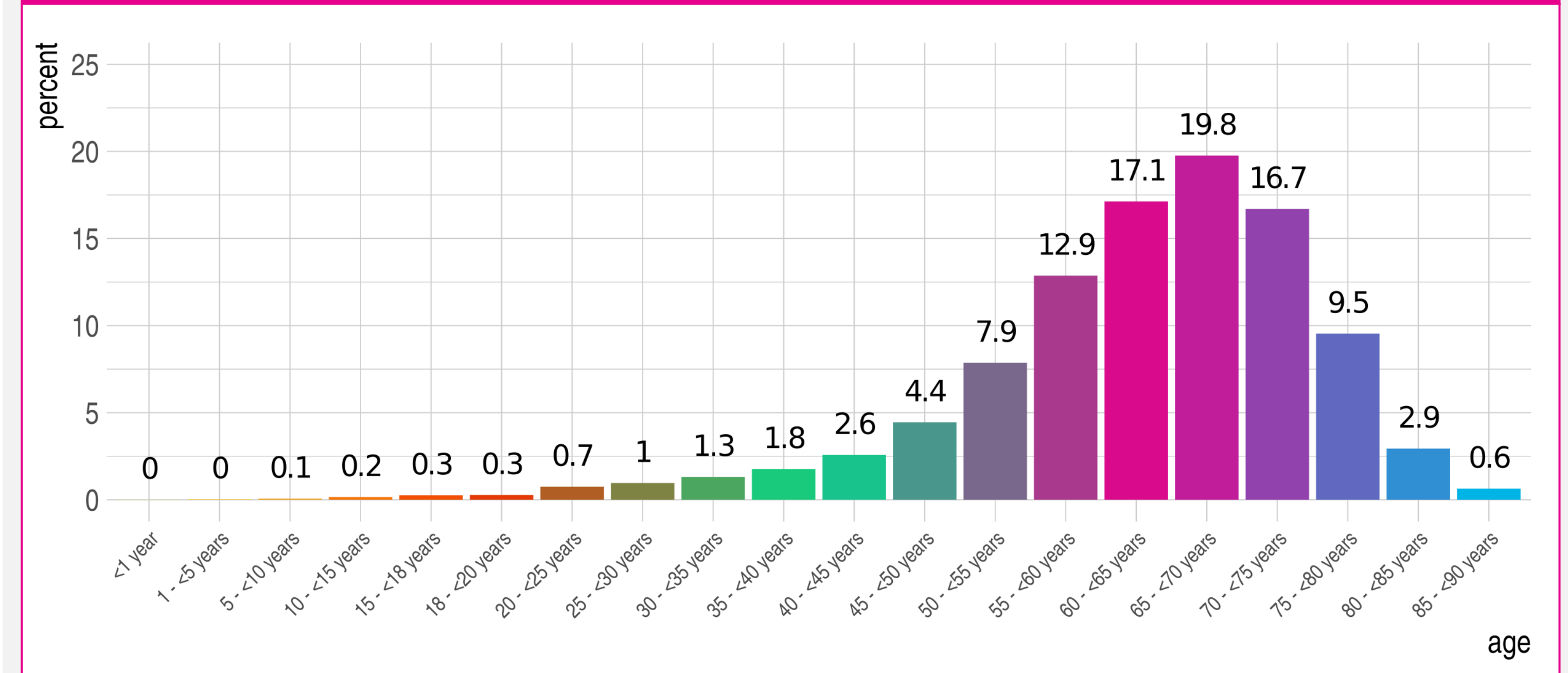


Year	Male/Female Ratio
2005	1.08
2006	1.48
2007	2.5
2008	4.01
2009	6.39
2010	5.56
2011	4.54
2012	4.42
2013	4.01
2014	3.57
2015	3.55
2016	3.46
2017	3.23
2018	2.9
2019	2.84
2020	2.62

- Across all evaluated years, RAS was performed most frequently on individuals between 65 to 70 years of age (19.8%) (see **Figure 3**).
- 87.4% of RAS were performed on individuals 50 years or older.
- Few RAS take place among men under the age of 50. They show a peak between 65 to 70.
- Females show higher age variability in the use of RAS. They also peaked around 65 to 70 years (12.21%) in 2020 but showed highest values at around 45 to 50 years in previous years (13.18% in 2009) (see **Figure 4**).
- In 2020, the medical specialty in which RAS was conducted most often was urology (66.7%), with the most common indication being malignant prostate neoplasms (41.8% of all indications). Other relevant specialties were gastroenterology (10.1%), orthopedics (9.2%), and gynecology (6.0%). 74.6% of robot-assisted surgeries were performed in connection with tumor indications (malignant neoplasms: 69.7%, benignant neoplasms: 4.9%).

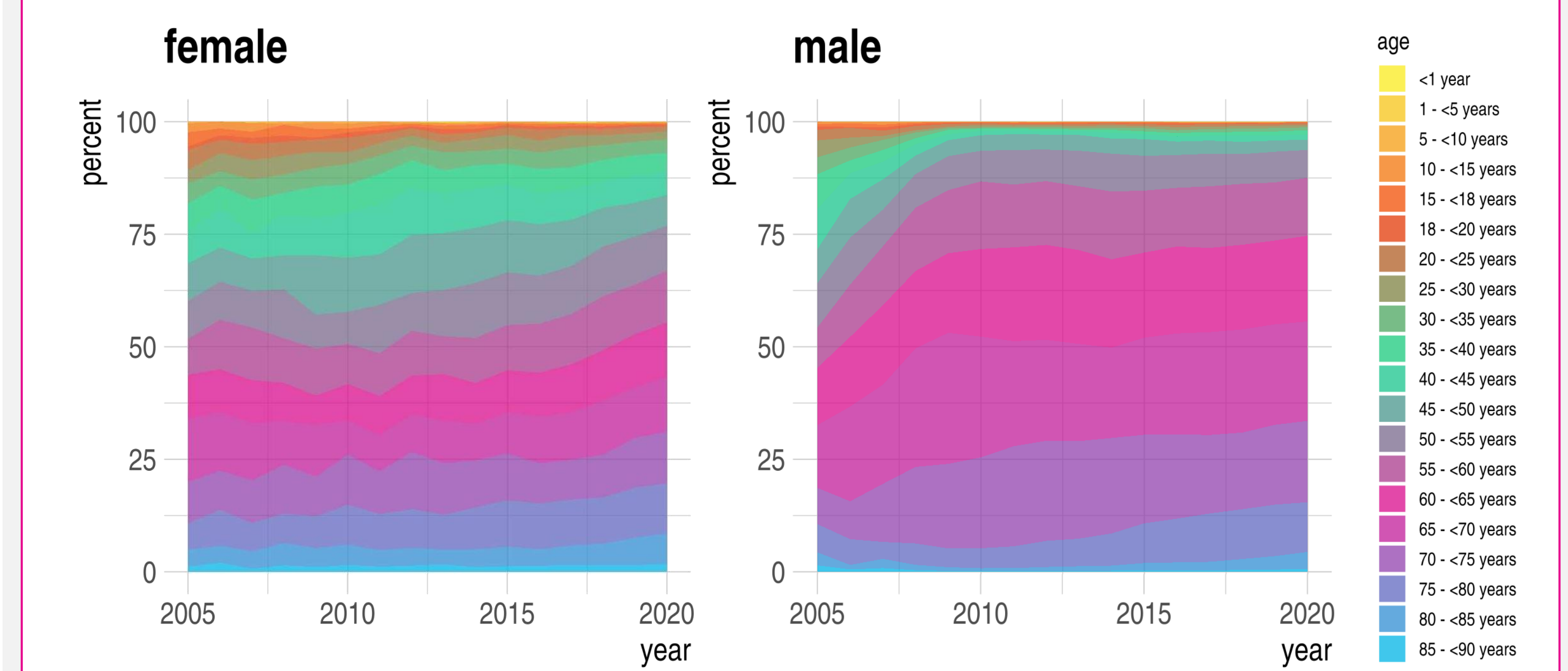
RESULTS (CONTINUED)

Figure 3. Percent of robot-assisted surgeries (5-987.-) in Germany by age



Age Group	Percent
<1 year	0
1 - <5 years	0
5 - <10 years	0.1
10 - <15 years	0.2
15 - <18 years	0.3
18 - <20 years	0.3
20 - <25 years	0.7
25 - <30 years	1
30 - <35 years	1.3
35 - <40 years	1.8
40 - <45 years	2.6
45 - <50 years	4.4
50 - <55 years	7.9
55 - <60 years	12.9
60 - <65 years	17.1
65 - <70 years	19.8
70 - <75 years	16.7
75 - <80 years	9.5
80 - <85 years	2.9
85 - <90 years	0.6

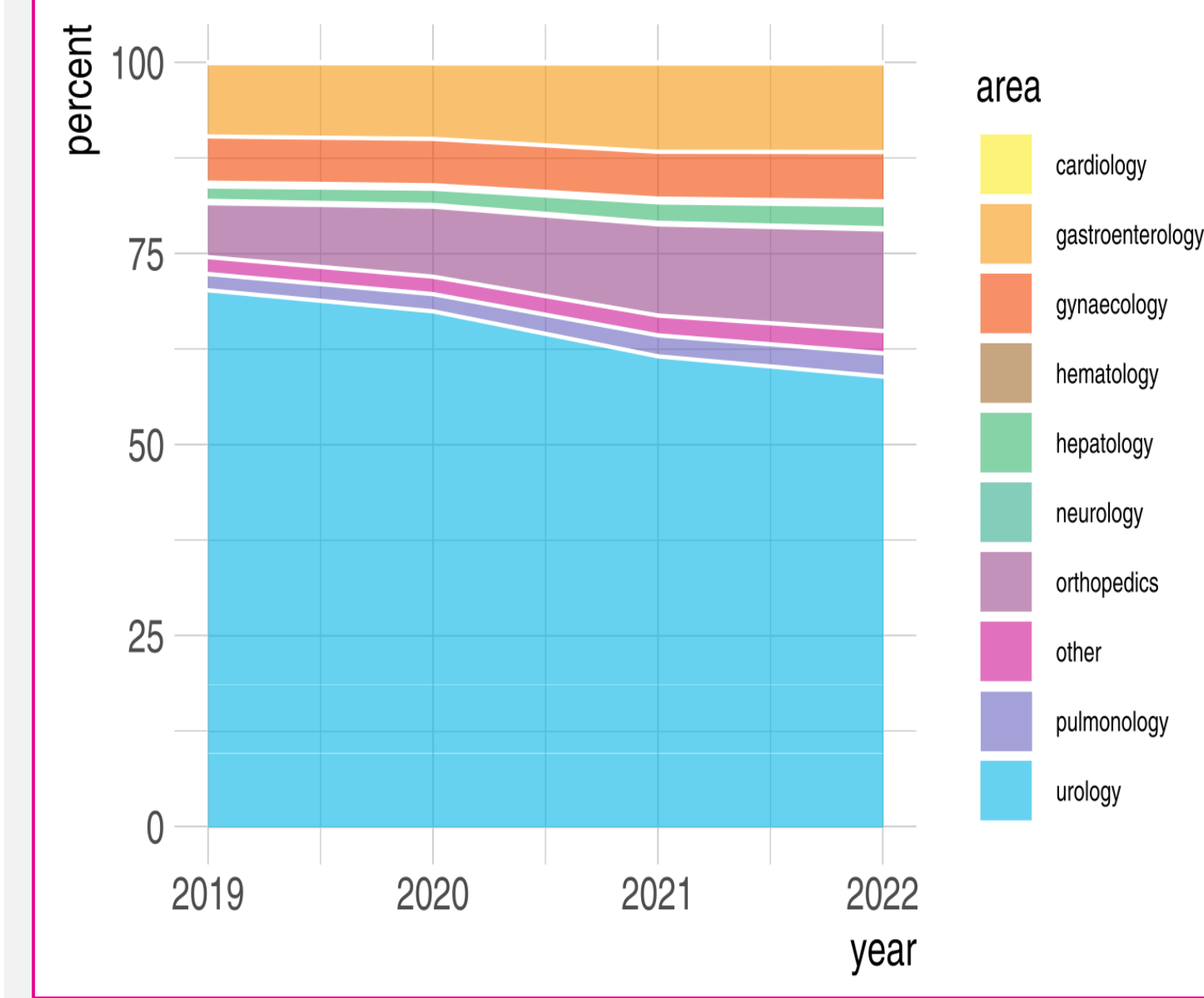
Figure 4. Percent of robot-assisted surgeries (5-987.-) in Germany from 2005 to 2020 by age



Sex	Age Group	2005	2010	2015	2020
female	<1 year	0	0	0	0
	1 - <5 years	0	0	0	0
	5 - <10 years	0	0	0	0
	10 - <15 years	0	0	0	0
	15 - <18 years	0	0	0	0
	18 - <20 years	0	0	0	0
	20 - <25 years	0	0	0	0
	25 - <30 years	0	0	0	0
	30 - <35 years	0	0	0	0
	35 - <40 years	0	0	0	0
male	<1 year	0	0	0	0
	1 - <5 years	0	0	0	0
	5 - <10 years	0	0	0	0
	10 - <15 years	0	0	0	0
	15 - <18 years	0	0	0	0
	18 - <20 years	0	0	0	0
	20 - <25 years	0	0	0	0
	25 - <30 years	0	0	0	0
	30 - <35 years	0	0	0	0
	35 - <40 years	0	0	0	0

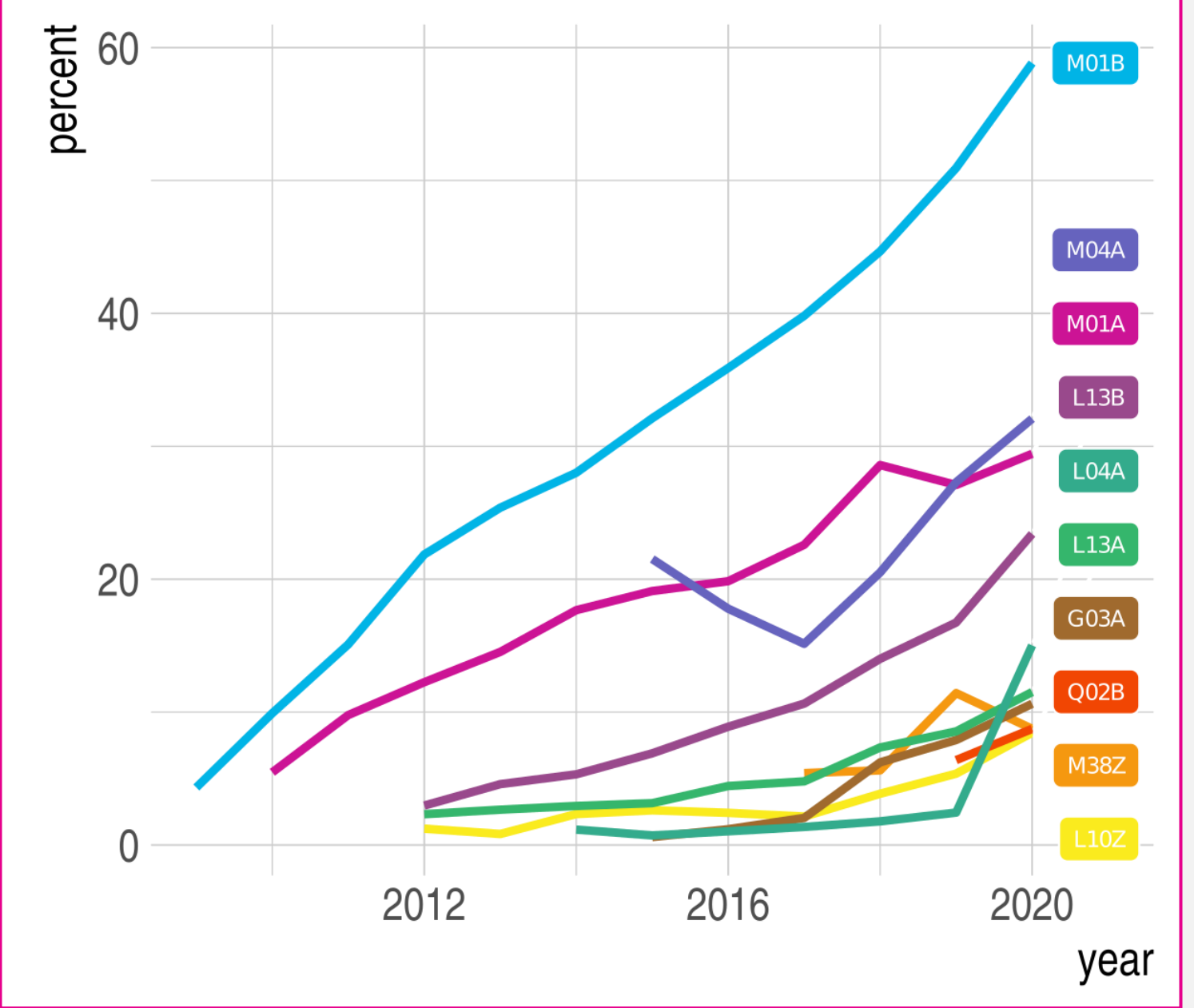
- Increasing diversification of the areas of application can be observed. The proportion of urology indications among performed RAS fell continuously between 2019 and 2022 from 70.2% to 58.9%, but increased for indications of other specialties, e.g., from 7.1% to 13.3% in orthopedics (see **Figure 5**).
- The proportion of RAS increased for most common DRG-classifications, e.g., from 4.3% in 2009 to 56.8% in 2020 for M01B (major surgery on the pelvic organs in men) and from 3.0% in 2012 to 22.4% in 2020 for L13B (kidney, ureter and large bladder surgery for neoplasms) (see **Figure 6**).

Figure 5. Percent of robot-assisted surgeries (5-987.-) in Germany from 2019 to 2022 by medical specialties



Specialty	2019	2020	2021	2022
cardiology	0	0	0	0
gastroenterology	0	0	0	0
gynaecology	0	0	0	0
hematology	0	0	0	0
hepatology	0	0	0	0
neurology	0	0	0	0
orthopedics	0	0	0	0
other	0	0	0	0
pulmonology	0	0	0	0
urology	70.2	58.9	58.9	58.9

Figure 6. Percent of robot-assisted surgeries (5-987.-) in Germany from 2005 to 2020 within DRG



DRG	2005	2010	2015	2020
M01B	4.3	56.8	56.8	56.8
M04A	0	0	0	0
M01A	0	0	0	0
L13B	3.0	22.4	22.4	22.4
L04A	0	0	0	0
L13A	0	0	0	0
G03A	0	0	0	0
Q02B	0	0	0	0
H3B2	0	0	0	0
L102	0	0	0	0

- Mainly complex robotic systems were used (5-987.0: 87.3%), as compared to robotic arms (5-987.1: 10.0%), or other systems (5-987.x: 2.8%).

CONCLUSIONS

- Use of RSS has proliferated over the past 15 years and is integrated in several medical specialties.
- We currently see clear differences in the use between sexes, potentially due to the common application of RAS in diseases of sex organs.
- RAS is most prevalent in urology and malignant prostate neoplasms, but also becomes more relevant in other medical specialties such as orthopedics or gastroenterology.
- We expect further growth in the use of robotic systems in the future, as well as continued diversification in application areas.

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