





## ORIGINAL ARTICLE

# Changes in the incidence and uptake of reproductive surgery versus *in vitro* fertilisation in Australia between 2001 and 2015: A population-based study

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**Capsule:** Was the prediction that IVF would lead to the death of fertility surgery accurate?

The Australian experience from 2001 to 2015.

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**Objective:** Improvements in success rates of assisted reproduction led to predictions that infertility surgery in both women and men would become extinct in developed countries. We sought to identify the changes in reproductive surgery that occurred between 2001 and 2015 to determine whether these predictions have been accurate.

**Design:** The Australian Institute of Health and Welfare (AIHW) national procedural dataset and the Australian Medicare Benefits Scheme (MBS) claims database were searched for procedure data for male and female reproductive surgery and assisted reproduction from January 2001 to December 2015. The denominators were based on annual point estimates of the total population aged 25–44 years (female) and 25–55 years (male) from the Australian Bureau of Statistics (ABS). This dataset provides procedures undertaken but not their indications.

**Results:** Over the study period the incidence of tubal surgery fell by 66%, vasectomy reversal by 33%, and surgical varicocelectomy by 50%. In contrast, the rate of hysteroscopic myomectomy increased by 48%, hysteroscopic septoplasty by 125%, and laparoscopy for severe endometriosis increased by 84%. *In vitro* fertilisation oocyte retrievals increased by 90%. The rate of abdominal myomectomy was unchanged.

**Conclusion:** Fertility surgery is not dead but has evolved.

## KEYWORDS

assisted reproductive treatment, fertility surgery, IVF, tubal surgery

## BACKGROUND

In 2008, Feinberg, Levens and de Cherney predicted that 'infertility surgery is dead: only the obituary remains.'<sup>1</sup> The authors made their prediction on the basis of three premises: that the results of assisted reproductive treatment (ART) continued to improve; that the time from treatment to pregnancy is much quicker with ART; and that ART carries less risk than that

associated with prolonged surgery and anaesthesia. Over the last decade, advances in the methods and scope of ART procedures and treatments have been associated with increased uptake. In 2015, 4.3% (13 344) of the 308 887 babies born in Australia, were conceived via ART.<sup>1,2</sup>

The role of surgery in female factor infertility lies in the establishment of an aetiology, the treatment of abnormalities, and, potentially, the optimisation for ART. These aims are

addressed by hysteroscopic procedures (such as polypectomy, myomectomy, septoplasty and division of adhesions), laparoscopic procedures (including salpingostomy for hydrosalpinx, fimbrioplasty, tubal anastomosis, myomectomy, and laparoscopic treatment of endometriosis and endometrioma), and open surgery (including myomectomy and tubal surgery). In men, the canon of reproductive surgery (excluding invasive procedures to obtain sperm for ART) encompasses vasectomy reversal and varicocelectomy. We used Australian data to identify changes and trends in the incidence and uptake of reproductive surgery between 2000 and 2015 to confirm or refute Feinberg and colleagues' prediction.

## MATERIALS AND METHODS

Data were extracted from two mandated Australian national data collections, the Australian Institute of Health and Welfare (AIHW) national procedural dataset and the Australian Medicare Benefits Scheme (MBS) claims database, from January 2001 to December 2015. For procedural data regarding inpatient fallopian tube surgery, laparoscopic and open myomectomy, anastomosis of the vas deferens and epididymis, and varicocelectomy, the source was the AIHW national procedural dataset.<sup>3</sup> These data are collected under the auspice of the Australian Health Ministers' Advisory Council (AHMAC) through the National Health Information Agreement. The data are collected as specified in the National Minimum Data Sets relating to hospitals and day procedure facilities and are compiled by pooling data supplied by all Australian state and territory health authorities. All procedures performed in Australian facilities are coded according to the agreed national standard, the *Australian Classification of Health Interventions* (ACHI),<sup>4</sup> which is based around the Australian National MBS. We selected procedures coded according to the International Classification of Diseases-10-AM/ACHI guidelines, as detailed in Box 1. Validation studies of the AIHW dataset have reported 99.5% agreement with 'true' morbidity (kappa 0.86).<sup>5</sup>

To quantify the uptake of *in vitro* fertilisation (IVF) procedures and rate of laparoscopic resection of endometriosis, we used the Australian MBS claims database. Surgery for less severe endometriosis (levels I–III) was not included as the database was unable to provide sufficiently accurate data for these procedures. Medicare data include services performed by a registered provider for services that qualify for a benefit, and for which a claim has been processed. As this is the basis of remuneration for all procedures, this database is subject to audit by the Australian National Audit Office and the Professional Services Review (PSR) scheme. The dataset has been audited and found to be extremely accurate.<sup>6</sup> The PSR audit and recoup costs from fraudulent claims.<sup>7</sup> This database does not include services provided by hospital doctors to public patients in public hospitals, or services that qualify for a benefit under the Department of Veterans' Affairs (DVA) National Treatment Account.

### BOX 1

#### Male procedures

ICD procedure codes

30635-00 Repair of varicocele

37616-00 Microsurgical vasovasostomy, unilateral

37616-01 Microsurgical vasovasostomy, bilateral

37616-02 Microsurgical vaso-epididymostomy, unilateral

37616-03 Microsurgical vaso-epididymostomy, bilateral

37619-00 Vasovasostomy, unilateral

37619-01 Vasovasostomy, bilateral

37619-03 Vasoepididymostomy, bilateral

#### Female procedures

35694-00 Laparoscopic salpingoplasty

35694-01 Laparoscopic anastomosis of fallopian tube

35694-04 Salpingoplasty

35694-05 Anastomosis of fallopian tube

35697-00 Microsurgical salpingoplasty

35623-00 Uterine myomectomy via hysteroscopy

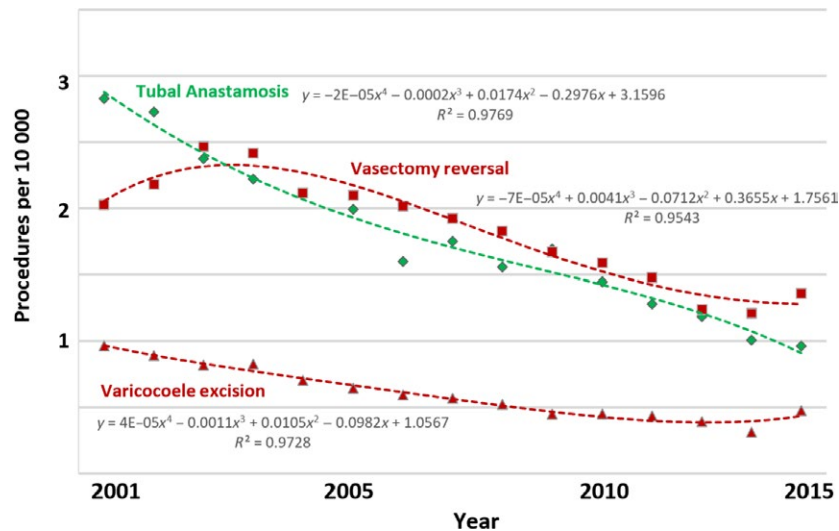
35634-00 Division of uterine septum via hysteroscopy

#### MBS item number

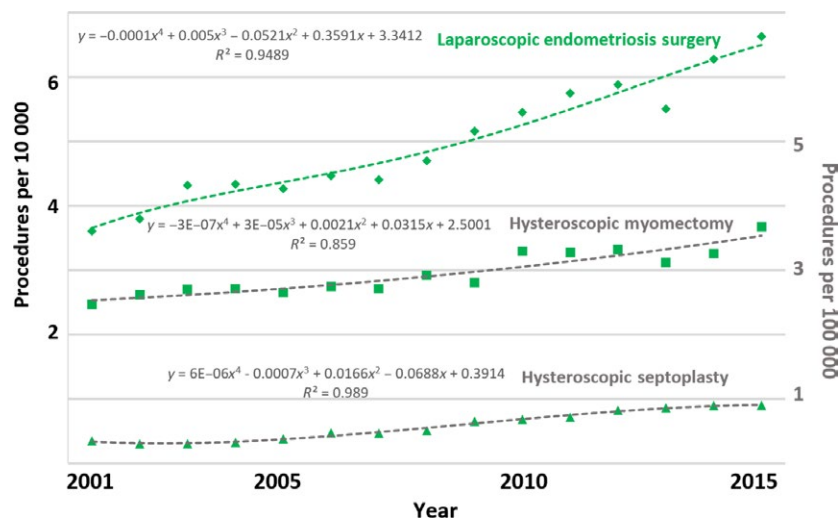
35641 Endometriosis level four or five, laparoscopic resection of, involving any two of the following procedures: resection of the pelvic side wall including dissection of endometriosis or scar tissue from the ureter, resection of the pouch of Douglas, resection of an ovarian endometrioma greater than 2 cm in diameter, dissection of bowel from uterus from the level of the endocervical junction or above: where the operating time exceeds 90 min.

The 'reproductive age group, denominator' we used was 25–44 years inclusive for women and 25–55 years for men. Annual point estimates for the total Australian female population aged 25–44 years and men 24–55 years inclusive, were obtained from the Australian Bureau of Statistics (ABS).<sup>8</sup>

Data were analysed in Excel™ (Microsoft, 2017 Redmond, WA, USA). Datasets were subject to parametric and nonparametric analysis as applicable. Simple linear regression was performed in Excel using the least squares method. Trends generally say little about changes of uptakes of the procedures related to each other. To have a more comprehensive view of the change of the various reproductive-assisted procedures, we considered IVF oocyte retrieval as a reference and performed regressions on the ratios of given procedures relative to IVF oocyte retrieval. Investigation on the ratios reveals the relative changes of the fertility surgery to the rise of the assisted reproductive treatment, ie, do the fertility surgeries change proportional to the increasing popularity of the IVF? The study received prospective approval from the Human Research Ethics Committee of the Australian National University (protocol 2015/347).



**FIGURE 1** Age-stratified incidence rates (procedures per 10 000) of fallopian tubal anastomosis (◆) in women aged 25–44 years and vasectomy reversal (■) and varicocoele excision (▲) in men aged 25–54 years for the period 2001–2015.



**FIGURE 2** Age-stratified incidence rates (procedures per 10 000 women aged 25–44 years) of laparoscopic surgery for levels four and five endometriosis (◆), and for hysteroscopic myomectomy (□) and septoplasty (▲) (procedures per 100 000 women) for the period 2001–2015.

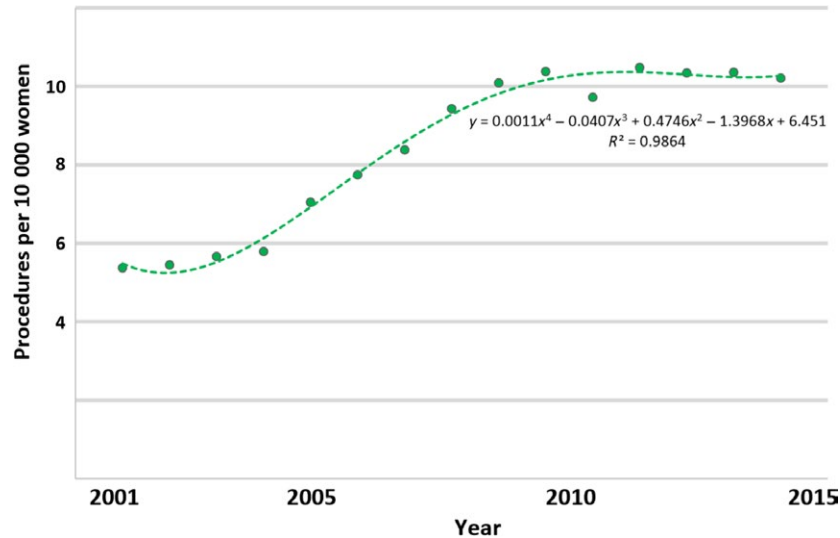
## RESULTS

Over the study period the incidence of tubal reconstructive surgery, vasectomy reversal, and varicocoelectomy declined significantly (Fig. 1). In contrast, the rates of hysteroscopic myomectomy, septoplasty, laparoscopic endometriosis surgery (Fig. 2) and IVF oocyte retrieval (Fig. 3) increased. While the overall rate of myomectomy has remained stable, the rate of open myomectomy decreased and laparoscopic myomectomy increased (Fig. 4).

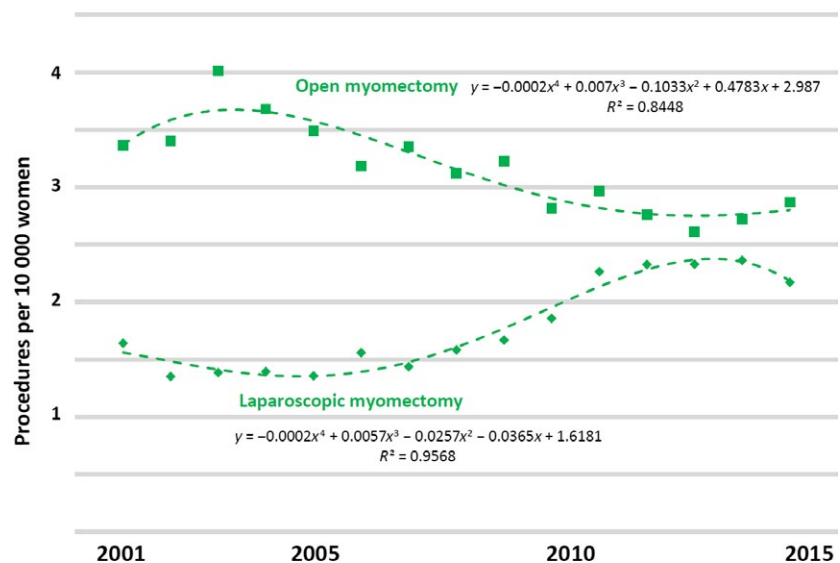
The incidence of tubal surgery fell by 66% (from 2.83 to 0.96/10 000/year), vasectomy reversal by 33% (from 2.03 to 1.36/10 000/year), for surgical varicocoelectomy by 50% (from 0.96 to 0.48/10 000/year). In contrast, the rate of hysteroscopic myomectomy increased by 48% (from 0.25 to 0.37/10 000/year)

hysteroscopic septoplasty by 125% (from 0.04 to 0.09/10 000/year). Similarly, the rate of laparoscopy for severe endometriosis increased by 84% (from 3.61 to 6.63/10 000/year). IVF oocyte retrievals increased over the study by 90% (from 5.37 to 10.21/10 000/year); however, the significant change occurred only between 2000 and 2008, with no significant change from 2009 to 2015. The overall rate of open and laparoscopic myomectomy was 2.5/10 000/year. This remained stable throughout the period with the contribution of both procedures changing over time.

We found that tubal reconstruction, vasectomy reversal and surgical varicocoelectomy were negatively correlated with IVF, (Figs 1 and 3), consistent with the large positive coefficient in Table 1. Laparoscopic endometriosis surgery gained popularity over this time frame, similar to IVF oocyte retrievals, with non-significant difference in the trend ( $P = 0.069$ ).



**FIGURE 3** Age-stratified incidence rate of *in vitro* fertilisation (IVF) oocyte retrieval procedures in women aged 25–44 years in Australia (procedures per 10 000 women), 2001–2015. Age-stratified incidence rates (procedures per 10 000 women aged 25–44 years) of laparoscopic surgery for levels four and five endometriosis, for hysteroscopic myomectomy, and septoplasty.



**FIGURE 4** Age-stratified incidence rate of open (■) and laparoscopic (◆) myomectomy in women aged 25–44, 2001–2015

## DISCUSSION

This study has shown that, at a national level, some reproductive surgery procedures in women and men – notably tubal and vas surgery – have become much less common as Feinberg and colleagues predicted ten years ago. However, procedures such as the treatment of endometriosis and hysteroscopic procedures, have become more common.

The landscape of fertility surgery has shifted significantly in the new millennium. Before the era of ART, tubal surgery was the only option for fertility in a couple with tubal factor infertility and vasectomy reversal for men wishing additional pregnancies. However, between 2001 and 2015 the number of oocyte retrievals increased to 90%. This was associated with an increase in the

live delivery rate obtained with ART. In 2015 in Australia, 18% of all cycles started ended in a live delivery up from just over 16% in 2002.<sup>9</sup>

### Tubal reconstruction surgery

The rate of spontaneous conception after tubal reconstructive surgery and vasectomy reversal can be high. For tubal reconstructive surgery, rates of spontaneous conception range from 69% in women with mild disease to 9% in women with severe tubal disease.<sup>10</sup> For vasectomy reversal, the likelihood of sperm in the ejaculate and pregnancy rate depends on the time since vasectomy. Success rates are higher than 70% for sperm in the ejaculate and 30% for conception in a year, even 15 years after

**TABLE 1** Result of coefficients and *P*-values for ratio of surgical procedure to *in vitro* fertilisation oocyte retrieval

	Response	Coefficient	SE	<i>P</i> -value
Female	Ratio for tubal reconstruction	0.644	0.031	<0.001*
	Ratio for laparoscopic endometriosis	0.024	0.012	0.069
Male	Ratio for vasectomy reversal	0.556	0.04	<0.001*
	Ratio for surgical varicocelectomy	1.431	0.141	<0.001*

\*indicates a significant difference at 5% level in historical changes between *in vitro* fertilisation, oocyte retrieval and a given procedure.

the initial vasectomy.<sup>11</sup> The prevalence of vasectomy among married and coupled adults was stable during the period in question (13.7% in 2001 and 14.0% in 2015).<sup>12</sup>

## Varicocelectomy

Varicocelectomy to improve male subfertility is controversial. A 2012 Cochrane review found that the evidence that varicocele decreases male fertility is poor and that no studies on treatment reported live birth as an outcome. Surgical correction, therefore, is similarly contentious and sperm optimisation, intracytoplasmic sperm injection (ICSI) and surgical sperm retrieval have decreased the need for varicocelectomy.<sup>13</sup>

## Changing pattern of Infertility

During the same period the improvement in fertility outcomes, both spontaneous and ART, due to treatment of endometriosis and submucosal fibroids, polyps or septa has been reaffirmed.<sup>14,15</sup>

An aging maternal population has increasingly complex fertility issues, and surgery to improve fertility needs to adapt to this changing environment. Increasing maternal age effects fecundity as well as sees an increase in coexistent maternal disease, including tubal factor infertility, endometriosis and leiomyoma.<sup>15</sup> The mean age of mothers in Australia has increased over the time period from 29.0 in 1999 to 30.3 in 2015.<sup>16,17</sup> The mean age for women undertaking IVF was 35.5 in 2005<sup>9</sup> and 35.9 in 2015.<sup>2</sup>

In a population with decreasing fecundity, the option of immediate ART rather than tubal reconstruction unassisted pregnancy may be more expedient.

Over the study period the reported incidence of *Chlamydia trachomatis* infection in Australia increased more than threefold, with notifications increasing from 125 to 435 per 100 000 between 2001 and 2011.<sup>18</sup> Estimates of the attributable fraction of tubal factor infertility due to chlamydia vary widely: with estimates ranging between 11 and 15% to as high as 45%.<sup>19,20</sup>

The increased uptake of bilateral salpingectomy for sterilisation, with its concomitant reduction in risk of ovarian cancer, creates a cohort of women for whom tubal reconstruction surgery is not possible. There has also been an overall decrease in the rate of tubal sterilisation procedures. In 2001 15.9% of women

utilised tubal sterilisation procedures which decreased to, on average, 5.3% between 2005 and 2015.<sup>12</sup> The uptake of intrauterine device (IUD) usage also influences the requirement for and rate of reconstructive surgery. The rate of IUD use in Australia during this period was 1.3% of all contraceptive users,<sup>21</sup> suggesting this has not had a dramatic impact on the rate of tubal reversal procedures. The level of these effects was unable to be determined in this study.<sup>22</sup>

## Leiomyoma

Leiomyoma increases in prevalence and size as women age; the incidence in women aged 40 to 44 years is five times that of women aged 25–29 years.<sup>23</sup> The presence of submucosal fibroids and polyps<sup>24</sup> is associated with decreased fertility and their excision improves both spontaneous and ART fertility outcomes.<sup>25</sup> The same is true of congenital uterine septum, the excision of which reduces the risk of spontaneous pregnancy loss and improves both spontaneous and ART pregnancy outcomes by up to fourfold.<sup>26,27</sup> The overall effect of myomectomy for subfertility is unknown. The heterogeneity of the disease has led to multiple trials finding no benefit in laparoscopic myomectomy. There is likely to be a subset of women with intramural fibroids who would benefit from myomectomy to improve spontaneous fertility.<sup>23</sup> Our finding of a fixed rate of myomectomy (open and laparoscopic) over the period supports the lack of a clearly identifiable group of women who benefit from the procedure. The increasing rate of hysteroscopic myomectomy (48%) and hysteroscopic septoplasty (125%) between 2000 and 2015 supports a shift in fertility surgery as well as more robust evidence regarding its efficacy.

We also found a significant increase in the rate of laparoscopy for 'severe' endometriosis. Endometriosis is thought to affect fertility by several mechanisms although there is no clear correlation between the clinical stage of endometriosis, symptoms and infertility. These effects include distorted pelvic anatomy due to adhesions, elevated inflammatory cytokines in the pelvis that might have adverse effects on oogenesis,<sup>28,29</sup> fertilisation and tubal function, and impaired implantation.<sup>30</sup> The optimal surgical and medical management of endometriosis for fertility remains debatable. The increase in surgery for stages III and IV endometriosis is line with the current recommendations from the American Society for Reproductive Medicine.<sup>31</sup>

## Endometriosis

The increased effectiveness and accessibility of ART, especially ICSI and surgical or transcuteaneous sperm retrieval, have meant that large numbers of quality sperm are no longer required for fertility. As these procedures can be performed in the fertility clinic with little to no surgical recovery or significant complications, they are, as our data indicate, replacing conventional vasectomy reversal and varicocelelectomy. The male partner also does not require ongoing contraception post-conception.

The strengths of this study relate to the long period utilising accurate national statistics. However, the dataset does not allow identification of multiple procedures on an individual. The dataset also does not describe the indications for surgery and some procedures, for example myomectomy and endometriosis surgery, are performed for non-fertility indications. We were also unable to test confounders. Similarly, the small percentage of IVF procedures undertaken in public hospitals was not able to be determined. As only three of the 85 fertility clinics Australia-wide that contribute to the compulsory data set are named as public hospitals (3.5%), the overall contribution of public hospital-based IVF procedures is likely to be very small.<sup>2</sup>

Our data support the evolution, rather than the death, of fertility surgery. Higher success rates and faster conception times with ART are likely contributing factors in the reduction in the rate of surgery for both male and female tubal factor infertility. This shift in practice may lead to the extinction of these procedures as urologists and gynaecologists will not have sufficient surgical volume for training and skill maintenance. Conversely as the cohort of patients seeking fertility ages the number of procedures undertaken to assist them in spontaneous or assisted conception will continue to increase.

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