# Assisted reproductive technology treatment costs of a live birth: an age-stratified cost–outcome study of treatment in Australia

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## ABSTRACT

**Objectives:** To calculate the cost of assisted reproductive technology (ART) treatment cycles and resultant live-birth events.

**Design:** Cost-outcome study based on a decision analysis model of significant clinical and economic outcomes of ART.

**Setting and participants:** All non-donor ART treatments initiated in Australia in 2002. Treatment cycles, maternal age and birth outcome data were obtained from the Australian and New Zealand Assisted Reproduction Database. Direct health care costs were obtained from fertility centres, and included government, private insurer and patient costs.

**Main outcome measures:** Average health care cost of non-donor, fresh and frozen embryo ART treatment cycles. Average and age-specific costs per live-birth event following ART treatment.

**Results:** Average health care cost per non-donor ART live-birth event was $32 903 (range, $24 809 for women < 30 years to $97 884 for women ⩾ 40 years). The cost per live birth for women aged ⩾ 42 years was $182 794. The average treatment cost of a fresh cycle was $6940, compared with $1937 for a frozen embryo transfer cycle.

**Conclusions:** Debate regarding funding for ART services has been hindered by a lack of economic studies of ART treatments and outcomes in Australia. This is the most comprehensive costing study of ART services to date in terms of resources consumed during ART treatment. It confirms that ART treatment is less cost-effective in older women. Alongside economic considerations of ART, community values, ethical judgements and clinical factors should influence policy decision-making.


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Assisted reproductive technologies (ART), such as in-vitro fertilisation (IVF) in which a woman's egg is retrieved and fertilised and the resultant fresh (or thawed frozen embryo) is implanted into her uterus, are now widely accepted as effective and acceptable treatments for infertility. However, the question of how ART should be funded and who should have access to treatment is generating considerable debate in Australia, Europe and the United States.[1-5] Before the May 2005 federal Australian budget, there was much speculation that the number of publicly funded ART treatment cycles would be capped, based on a woman's age and the number of treatment cycles offered. Hindering this debate, and ultimately causing the issue to be referred to an independent review committee,[6] is the complete lack of economic studies evaluating the costs and outcomes of ART treatment in Australia.

During 2002, 32 958 ART treatment cycles (including donor insemination) were initiated in Australia, resulting in 5953 live-born babies.[7] This equates to a utilisation rate of about 1600 cycles per million population, which is similar to rates found in Europe.[8-10] Despite this, a review of the literature over the past decade found no economic studies that used Australian data or that could be usefully applied to the unique Australian health funding environment.

Currently, all treatment cycles undertaken in Australia attract a rebate through the Medicare Benefits Scheme (MBS). More than half of the estimated $6000–9000 direct treatment costs are covered by the MBS or the Pharmaceutical Benefit Scheme (PBS). The most significant change to funding of ART in the past decade has been the introduction of the Medicare Plus Safety Net in January 2004 — this pays 80% of the out-of-pocket expenses for medical services provided outside of a hospital once an individual's or family's threshold is reached. This policy has effectively reduced patient expenses for ART services by up to half, and resulted in a 57% increase in MBS benefits paid for ART services in 2004 (to $79 million).[11]

It is not just the absolute amount spent on ART services by government, insurers and patients that is important; the return on that expenditure in terms of ART outcomes must also be considered. This measure of cost-effectiveness is most commonly expressed in economic evaluations of ART by the cost per birth of at least one live-born baby (a live-birth event). The aims of this cost–outcome study were to calculate the average cost of an ART treatment cycle, and the average and age-specific cost per live birth for all ART treatment cycles conducted in Australia in 2002. Direct costs borne by government, private insurers and patients were included to provide a societal perspective of total health care resources consumed by ART services.

## METHODS

### Study design

A decision analysis model was developed representing each clinically and economically significant stage of ART treatment for both fresh and frozen embryo transfer cycles. The model was constructed to represent each possible outcome from an initiated treatment cycle, including cycles discontinued before oocyte retrieval or embryo transfer. Additional procedures, such as surgical sperm collection, intracytoplasmic sperm injection (ICSI), assisted hatching, blastocyst culture and cryopreservation of embryos, were also included. The model

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was populated with the number of initiated ART cycles undertaken in Australia in 2002 reaching each stage of the ART decision analysis model.

Five age-specific models were constructed for women: < 30 years, 30–34 years, 35–39 years, ⩾ 40 years, and all ages. A subanalysis of cycles conducted in women aged ⩾ 42 years was also undertaken. The number of cycles reaching each stage of the decision analysis model was multiplied by the corresponding average cost for each type of partial and complete cycle, and summed to provide the total age-specific ART cost.

## Use of ART services

The Australian Institute of Health and Welfare National Perinatal Statistics Unit maintains the Australian and New Zealand Assisted Reproduction Database (ANZARD), which records information about all ART treatment cycles conducted in Australia and New Zealand and the resulting pregnancies and births. For this study, ART refers to all procedures that involve the in-vitro handling of human oocytes, embryos and sperm to establish a pregnancy. It excludes artificial insemination using partner or donor sperm. Information about non-donor oocyte and embryo treatment cycles conducted in Australia in 2002 was requested for this study.

In 2002, fresh ART cycles discontinued after fewer than 9 days of stimulation, and the use of hormonal support in frozen embryo transfer cycles, were variably reported to ANZARD. To adjust for this, a 5% early cancellation rate was applied across all age groups as an estimate of cycles discontinued after fewer than 9 days of ovarian stimulation. This brought the percentage of cycles cancelled before oocyte retrieval in line with US registry data.[12] Costs associated with hormonal support were applied to 25% of frozen cycles (5% of which were discontinued before embryo transfer).

Twenty-six fresh cycles and six frozen embryo transfer cycles, and the four associated live births, were excluded from the study because the women's ages were not recorded in ANZARD.

## Direct health care costs of ART services

Baseline costs for each type of partial and complete ART cycle were calculated from a review of 2002 charging practices from a survey of Australian fertility clinics. Costs included benefits paid by the MBS for assisted reproductive services (medical procedures, counselling, ultrasound, scientific services, pathology), average benefits paid by the PBS for medications, average private insurance benefits paid for theatre, hospital accommodation and anaesthetist charges, and other published out-of-pocket expenses borne by patients according to clinic fee schedules.

To take account of variations in clinic charges across Australia, the baseline costs were adjusted for differences in average fees for out-of-pocket expenses between states and territories, and then weighted according to the percentage of ART services conducted in each state and territory in 2002.

Only direct health care treatment costs associated with the ART procedure were included. Costs represent resources consumed in 2002, and are expressed in 2005 Australian dollars. Costs were not discounted because benefits (the birth of a live-born baby) were achieved within 1 year of expenditure.

## Live births from ART treatment cycles

The number of live births from non-donor ART cycles by age group was obtained from

**1 Live-birth events from non-donor ART cycles, Australia 2002**

| | Number per age group (years) | | | | |
|---|---|---|---|---|---|
| Cycle type | All ages | < 30 | 30–34 | 35–39 | ⩾ 40* |
| Fresh cycles | 3177 | 564 | 1329 | 1070 | 214 |
| Frozen embryo cycles | 1435 | 230 | 625 | 472 | 108 |
| Total of all cycles | 4612 | 794 | 1954 | 1542 | 322 |

*All ages combined within age groupings. ◆

**2 Cost of treatment, and number of ART cycles and additional procedures, Australia 2002**

| | | Number per age group (years) | | | | |
|---|---|---|---|---|---|---|
| Cycle type | Cost* | All ages | < 30 | 30–34 | 35–39 | ⩾ 40† |
| **Fresh cycles** | | | | | | |
| Discontinued < 9 days of ovulation stimulation | 1 508 | 928 | 119 | 285 | 317 | 207 |
| Discontinued ⩾ 9 days of ovulation stimulation | 3 118 | 1 786 | 162 | 408 | 658 | 558 |
| Failed oocyte retrieval | 5 699 | 293 | 25 | 56 | 89 | 123 |
| Failed fertilisation | 6 861 | 637 | 50 | 159 | 206 | 222 |
| Fertilisation, no embryo transfer | 6 861 | 1 057 | 171 | 326 | 323 | 237 |
| Completed IVF cycle | 7 117 | 5 758 | 642 | 1 878 | 1 996 | 1 242 |
| Completed ICSI or mixed ICSI / IVF cycle | 7 708 | 8 174 | 1 177 | 2 611 | 2 783 | 1 603 |
| Completed mixed fresh/frozen cycle | 7 708 | 48 | 4 | 10 | 15 | 19 |
| Completed GIFT cycle | 7 117 | 189 | 18 | 44 | 64 | 63 |
| *Total initiated fresh cycles* | | *18 870* | *2 368* | *5 777* | *6 451* | *4 274* |
| Surgical sperm collection | 517 | 1 325 | 206 | 403 | 479 | 237 |
| Intracytoplasmic sperm injection | 591 | 881 | 116 | 241 | 281 | 243 |
| Assisted hatching | 261 | 774 | 31 | 144 | 289 | 310 |
| Blastocyst culture | 640 | 2 718 | 285 | 831 | 1 056 | 546 |
| Cryopreservation | 222 | 8 293 | 1 370 | 3 189 | 2 724 | 1 010 |
| **Frozen embryo cycles** | | | | | | |
| Cycles supported by hormones discontinued before embryo thaw | 203 | 140 | 19 | 52 | 49 | 20 |
| Failed thaw | 515 | 801 | 78 | 237 | 307 | 179 |
| Completed frozen embryo cycle | 2 078 | 9 797 | 1 367 | 3 693 | 3 385 | 1 352 |
| *Total initiated frozen embryo cycles* | | *10 738* | *1 464* | *3 982* | *3 741* | *1 551* |

*Cost is expressed in 2005 Australian dollars. †All ages combined within age groupings. IVF = in-vitro fertilisation. ICSI = intracytoplasmic sperm injection. GIFT = gamete intrafallopian transfer. ◆

the ANZARD 2002 Australian cohort (Box 1). A live birth was defined as the birth of at least one live-born baby beyond 20 weeks' gestational age who survived for at least 28 days. Live births were counted as birth events (ie, a twin or triplet live birth was counted as one live-birth event). There were 5474 live-born babies delivered as a result of these births.

### Cost–outcome analysis

The average cost of an ART cycle was calculated by dividing the total cost of ART services involving fresh or frozen embryos by the number of initiated cycles involving fresh or frozen embryos, respectively. The average and age-specific cost per live birth was calculated by dividing the total ART cycle costs by the number of live births associated with each age group.

### Ethics approval

This study was approved by the Social/Health Research Human Research Ethics Advisory Panel I, University of New South Wales.

## RESULTS

A total of 29 608 ART cycles were initiated in Australia in 2002: 18 870 fresh cycles and 10 738 frozen embryo cycles (Box 2).

The total direct health care cost of ART cycles undertaken in 2002 was $151.7 million ($130.9 million for fresh cycles; $20.8 million for frozen embryo cycles). The average cost of a fresh cycle was $6940 for all initiated cycles. The average cost of a frozen embryo cycle was $1937. Average treatment costs were up to 6.1% more expensive in the younger age groups because they included a larger proportion of completed cycles, and were more likely to include cryopreservation.

The average cost per live birth for all non-donor ART cycles was $32 903 (Box 3). The cost per live birth varied from $12 491 for frozen embryo cycles in women aged 30–34 years to $133 705 for fresh embryo cycles in women aged 40 years and older. The average cost of the 5474 live-born babies conceived following non-donor ART treatment was $27 722.

The most health care resources were consumed by the 35–39 years age group (34%) and the 30–34 years age group (32%). The ⩾ 40 years age group consumed 21% of resources, despite having the highest cost per live birth (Box 4).

A subanalysis of cycles undertaken by women aged ⩾ 42 years is presented in Box 5. This older age grouping resulted in a cost per live delivery of $182 794 and consumed 9% of ART health care resources.

**3 Cost* per live birth from non-donor ART cycles, Australia 2002**

| Type of ART cycle | Cost per age group (years) | | | | |
|---|---|---|---|---|---|
| | All ages | < 30 | 30–34 | 35–39 | ⩾ 40† |
| Fresh cycles | 41 218 | 29 811 | 30 744 | 41 742 | 133 705 |
| Frozen embryo cycles | 14 494 | 12 542 | 12 491 | 15 259 | 26 905 |
| Total all cycles | 32 903 | 24 809 | 24 905 | 33 636 | 97 884 |

* Cost is expressed in 2005 Australian dollars. † All ages combined within age groupings. ◆

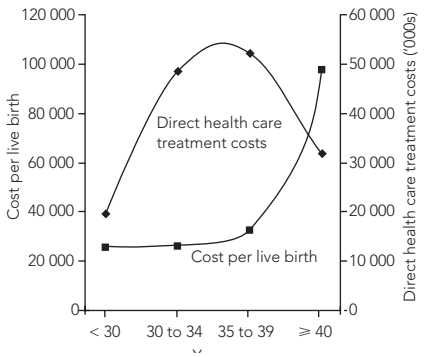
## DISCUSSION

This is the most comprehensive population-based costing study of resources consumed during ART treatment. The strength of this study lies in the use of ANZARD, which is a national registry of all ART cycles initiated in Australia. Use of detailed data from the 25 Australian fertility clinics eliminated the need to use a single estimate for the proportion of cycles abandoned before embryo transfer. Furthermore, this study reflected total health care costs by including government, private insurance and patient out-of-pocket expenses, rather than relying solely on fertility clinic charges. The costs were also nationally adjusted to account for differences in fertility clinic fees, which vary by up to 20% between states. However, the costs were not adjusted for differential age-related medication consumption and early cycle cancellation, or for complications arising from ART treatment that required hospitalisation (0.7% of cycles[7]). The ART success rates were based on the most recently available national data, which are at least 3 years old. Given the continuing advances in ART treatment and success rates, our findings need to be considered in this context.

The average cost of a fresh cycle in Australia was $6940, and for a frozen embryo transfer cycle, $1937. It is difficult to compare these estimates with results from other studies because of differences in study design, health care setting, and definitions of cost. However, our figures are substantially less than US estimates for ART cycle costs, and similar to cost estimates from the United Kingdom and other European countries. To aid comparison with other countries, the following estimates have been inflated to March 2005 using the Australian Health Services Consumer Price Index[13] and converted to Australian dollars using September 2005 foreign exchange rates. In a 2002 survey, the estimated average cost of an IVF cycle in the US was US$9547 ($15 017), and the average cost from 25 other countries, excluding Australia, was US$3518 ($5534).[8] The UK National Institute for Clinical Excellence (NICE) estimated the average cost in England for an IVF cycle as £2771 ($6961), for an ICSI cycle as £2936 ($7376), and for a frozen embryo transfer cycle as £1000 ($2512).[9] A recent study estimated the cost of a complete IVF cycle undertaken in Finland as €3291 ($5582).[14]

Funding of ART services differs between countries, and often within countries. Australia is unique in its unrestricted approach to public funding of ART services, and cannot be easily compared with funding arrange-

**4 Total non-donor ART treatment costs* and cost per live birth, Australia 2002**




* Cost is expressed in 2005 Australian dollars. ◆

**5 Cost* per live-birth event from non-donor ART cycles, for women aged ⩾ 42 years, Australia 2002**

| | Fresh cycles | Frozen cycles |
|---|---|---|
| Live-birth events | 42 | 35 |
| Initiated cycles | 1972 | 629 |
| ART treatment costs | $12 917 493 | $1 157 644 |
| Cost per live birth | $307 559 | $33 076 |

* Cost is expressed in 2005 Australian dollars. ◆

ments internationally.[2] For example, in the UK there is a wide variation in the public provision of ART services based on the area health authority. The NICE guidelines developed in 2004 recommend that couples be offered up to three cycles of IVF on the National Health Service (NHS) if the couple meet strict selection criteria.[9] From April 2005, all women with appropriate clinical need should have at least one cycle of treatment paid by the NHS.[15] Fertility treatment in other European countries is covered by a mix of restricted public and private sector financing.[2,16] In the US, financing of ART is primarily through third-party payer arrangements or directly by patients, and only 14 states are required to provide some level of insurance for infertility treatment.[17]

Although ART services are costly from an individual's perspective, they only account for a small proportion of national health care expenditure. ART services in Australia accounted for less than 1% ($79 million) of the $8.6 billion MBS benefits paid in 2004,[11] and, as we found, 0.2% ($151.7 million) of the $72.2 billion public and private expenditure on health care in 2002–03.[18] It will be difficult for the government to make significant savings by limiting funding in this area. Furthermore, because the cost of a live birth is a function of ART pregnancy rates, as the overall success of ART improves, so should its cost-effectiveness. Indicative of this is the increase in live births per embryo transfer cycle from 13% in 1993 to 21% in 2002.[7]

The age-specific cost per live birth has been investigated in a small number of studies, and although the absolute costs vary between studies, the relative change between age groups is similar, and is directly associated with the age-related decline in female fecundity.[9,19,20] For cycles recorded in ANZARD, women aged 40–44 years undergoing fresh non-donor ART in 2002 had a 6% chance per initiated cycle of achieving a live birth, compared with an 18% chance in women aged 35–39 years and a 25% chance in women younger than 35 years.[7] Success rates for women older than 40 years vary considerably with each successive year, and the use of donor eggs improves success rates with ART, particularly in older women.[12]

Our aim in this study was to look at the cost of ART treatment in terms of live births achieved; a second study will consider the downstream costs associated with ART treatment. Multiple births, which occur in 18%–22% of all deliveries following ART treatment in Australia, despite fewer embryos being transferred over the past decade,[7] remain the most significant challenge facing assisted reproduction. The practice of selective single embryo transfer in women at risk of twinning and the augmenting effect of cryopreservation of embryos to reduce the incidence of multiple births, requires further economic evaluation.[21,22] The goal of assisted reproduction must be the birth of a healthy baby, and any economic framework must consider the long-term economic and non-economic costs of multiple births following ART procedures.

We found ART to be three to four times less cost-effective in women aged ⩾ 40 years than in younger women, but age is not the sole determinant of potential success with ART treatment. Factors such as ovarian reserve, successful child-bearing, duration of infertility, number of previous unsuccessful attempts at treatment, and the use of donor eggs all influence success rates.[23,24] Furthermore, broader arguments relating to community values, ethical and responsible practice and equity of access, should be judged alongside economic considerations to inform public policy on ART provision.

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## COMPETING INTERESTS

The ANZARD data collection is maintained by the National Perinatal Statistics Unit and funded by the Fertility Society of Australia, which was not involved in study design, data analysis, interpretation or publication.

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