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A Cost-Consequence Analysis Comparing Vasectomy and Fertility Treatment with Oral Contraceptives

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Abstract

This thesis performs a cost-consequence and a cost-effectiveness analysis comparing vasectomy with cryopreservation of sperm and IUI to use of combined oral contraceptives (COCs). It limits itself to normally fertile males and normally fertile females aged 20-45, and does not attempt to estimate costs relating to contraceptive failure or environmental impact. Results indicate that COCs are cheaper for shorter periods of contraception. For longer periods of contraception, which method is more expensive varies depending on the cost of cryopreservation of sperm and the duration for which sperm is cryopreserved. COCs have a higher risk of unplanned pregnancies, while couples needing IUI to conceive manage to have children less often than average couples. Costs relating to estrogen being released into the environment are briefly touched upon in the discussion, and decision makers should be aware of these as they may be quite significant.

Keywords: contraception, cost-consequence analysis, vasectomy, IUI, combined oral contraception

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1 Purpose

This thesis puts forward an economic evaluation of different contraceptive methods, comparing a combination of vasectomy, cryopreservation of semen, and fertility treatment with combined oral contraceptives (COCs)¹. It does this in the context of the Swedish healthcare system, and in the hope of being usable as a basis for decision-making in said context. The comparison with COCs is not meant to evaluate which one of the treatments is better for all couples – the treatments are not mutually exclusive, and with issues as personal as contraception a variety of options is likely to have a value in itself – but to give a context to the numbers. The evaluation seeks to explore and compare the costs and consequences of the contraceptive methods.

Currently the contraceptive measures available to males in Sweden are limited to condoms or vasectomy. Vasectomy is communicated as a contraceptive measure to be used only by males that do not want additional children (see e.g. RFSU 2015; 1177 Vårdguiden 2015). Meanwhile, more than 26% of the female population aged 15-44 are using some form of hormonal contraception (The Swedish National Board of Health and Welfare 2015a)². Exploring the costs associated with vasectomy combined with cryopreservation of sperm and fertility treatment is interesting as the method may be an alternative for males seeking to avoid unplanned pregnancies, but without the finality of only a vasectomy. Fertility treatment is included in the analysis so as to make the outcomes of the vasectomy method and COCs comparable.

COCs have undoubtedly been important for society in general and for women's liberation in particular. This is not to say that COCs are without problems: it is well documented that COC leads to an increased risk of venous thromboembolism (see e.g. Solymoss 2011). It has also been shown that COC-use may lead to increased levels of certain hormones in nature as these hormones are not removed by water treatment plants (Johnson et al. 2007). This in turn may affect fish populations (Zeilinger et al. 2009).

In addition to this we live in a society in which women take a large part of the responsibility for the reproductive health of themselves and their partners – women know more than men about sexual and reproductive health (Makenzius et al. 2009), to a greater extent get tested for sexually transmitted infections such as chlamydia (Smittskyddsinstitutet 2013, p. 28), and females get sterilized more often than males in spite of the procedure being more costly and complex (Thunell and Kopp Kallner 2014). Further, women also take a large part of the responsibility for the care of the children, e.g. by taking 75% of the parental leave and more than 60% of the days at home with sick children (Statistics Sweden 2014, p. 42).

The choice to use COC as a comparison is based on COC being the most common form of contraception used by females in Sweden today (Lindh 2014). It is also subsidized by the counties. If these methods of contraception are similar in cost and consequences, and if COC is more heavily subsidized than vasectomy and cryopreservation of sperm, one may be tempted to ask if this is a desirable state of things. Is this reinforcement of traditional ideas about who takes responsibility for the reproductive health of the couple something that we want to continue with?

With this in mind, offering additional contraceptive measures for males seems like a good idea. Coupling a vasectomy with cryopreservation of semen, and intrauterine insemination (IUI) gives couples the option of not worrying about contraception once the procedure has been performed. It also gives the couple more explicit control over when to become parents, and by necessity involves both parties in the decision. In the long run one could hope that allowing men to take greater responsibility when it comes to reproductive health may make parenting less gendered.

¹Please see appendix A for a glossary of terms and abbreviations.

²Searching the database for pharmaceuticals belonging to ATC-group G03A (Hormonal contraceptives for systemic use), looking at the usage in Sweden as a whole for women aged 15-44, and taking into account data from 2006 to 2014.

2 Background and Previous Research

This section briefly presents some previous health economic analyses, one way of measuring healthcare costs, as well as vasectomy, cryopreservation of sperm, IUI, COCs and the side effects associated with each of these. It also mentions the environmental impact of COCs. Presenting the cost of the procedures and their side effects is what this thesis is about.

2.1 Previous Healtheconomic Analyses on Contraception

Others (see e.g. Sonnenberg et al. 2004; Trussell et al. 2009) have looked at the cost-effectiveness of contraceptives and compared vasectomy with COCs. In general vasectomy is considered a lot more cost-effective for longer periods, driven in part by its very low failure rate. We have found no studies comparing vasectomy with cryopreservation of semen and IUI with COCs.

2.2 Diagnosis Related Groups and DRG Weights

Costs based on diagnosis related groups (DRG) will be used to estimate the costs of the different contraceptive methods.

DRG is a patient classification system that groups patients into groups with other patients with similar diagnoses and resource use. Since several different diagnoses end up in the same DRG it gives a less detailed but more graspable picture of what goes on in e.g. a hospital. In counties where hospitals are payed based on their performance DRG forms the basis of remuneration (The Swedish National Board of Health and Welfare 2014, p. 7).

DRG weights are based on the average cost of all cases in a database, and this cost is assigned a DRG weight of 1.0. The weight of different DRGs is calculated by dividing the average cost of the group with the cost corresponding to a DRG weight of 1.0. The Swedish National Board of Health and Welfare provides lists of DRG weights as well as the calculated cost of DRG weight 1.0 (The Swedish National Board of Health and Welfare 2015b).

For example, a hospital has a given cost of running for one year. All patients that enter the hospital are classified into groups based on receiving similar treatments and requiring similar use of resources. These groups are called DRG. DRG weight is a relative measure of cost of treating different groups of patients. The average cost of an episode of care is given a DRG weight of 1.0. The cost of an average care episode in a given DRG is divided by the average of all care episodes to give the weight of the DRG. Having access to DRG weights and the value of DRG weight 1.0 thus allows us to calculate the cost of treating patients within a given DRG.

2.3 Vasectomy

Information regarding the vasectomy procedure is taken primarily from Dohle et al. (2012) and Michielsen and Beerthuis (2010) as these are the sources cited on vasectomy in Thunell and Kopp Kallner (2014). Thunell and Kopp Kallner (2014) is one part of the background information to the guidelines on contraception provided by the Swedish Medical Products Agency in “Antikonception – behandlingsrekommendation” (2014).

A vasectomy is a medical procedure with the aim of hindering sperm from passing through the vasa deferentia, in order to render the male sterile. A common way of doing this is by making a puncture in the scrotum, exposing the vasa deferentia, cutting and sealing them, and then allowing the puncture to heal by itself. It is often performed as an outpatient procedure. 3 months after the procedure the patient’s semen is analyzed to confirm that they are sterile.

Sharlip et al. (2012) and Dohle et al. (2012) recommend one session of pre-operative counseling, and at least one post-vasectomy semen analysis to confirm sterility. Dohle et al. (2012) recommends that the patient abstain from work the day after the vasectomy.

Approximate incidence of vasectomy side effects may be found in table 1. A number of sources (see e.g. Dohle et al. 2012; Thunell and Kopp Kallner 2014; Michielsen and Beerthuizen 2010; Sharlip et al. 2012) cite more or less the same side effects of vasectomy. The unabridged version of Sharlip et al. (2012) mentions hematoma, infection, chronic scrotal pain, epididymitis and need for repeat vasectomy. Costs of side effects will be estimated by looking at the cost of curing the side effect, adjusted for the probability of the side effect occurring.

Table 1: Probability of experiencing side effects for the different contraceptive methods. Vasectomy side effects taken from the unabridged version of Sharlip et al. (2012). COC side effects taken from Dinger, Bardenheuer, and Heinemann (2014).

Method	Hematoma	Infection	Chronic scrotal pain	Need for repeat vasec- tomy	Epididymitis	VTE
Vasectomy	0.015	0.015	0.015	0.01	0.03	
COCs						0.0006

2.4 Cryopreservation of Sperm

Freezing sperm has been around for a long time, and is used to preserve fertility or ensure availability of sperm. There are a number of ways in which to preserve sperm. The most common method currently in use is storage in liquid nitrogen (LN₂). Common to all methods of cryopreservation is reduced sperm quality (Sharma et al. 2015). Reduced sperm quality does not mean increased risk of birth defects, but does mean that sperm motility is reduced (E. Nieschlag, Behre, and S. Nieschlag 2010, p. 517). Reduced sperm quality is accounted for by storing sufficient amounts of sperm.

2.5 Intrauterine Insemination

IUI in its most basic form is the introduction of sperm into the uterine cavity using a thin flexible catheter (Beckmann and American College of Obstetricians and Gynecologists 2010, pp. 344-345), but may also include timing or triggering of ovulation. IUI is used to treat mild male factor infertility, amongst other conditions. The idea when used in treating mild male factor infertility is to maximize the chance of pregnancy by putting sperm close to the egg cell (Akanji Tijani and Siladitya Bhattacharya 2010).

Brucker et al. (2009) gives a delivery rate per cycle of 14%, and crude and expected cumulative delivery rates³ of 56% and 77% respectively for normally fertile females undergoing natural cycle IUI with cryopreserved donor sperm containing at least one million progressively motile spermatozoa⁴. Oats, Abraham, and Llewellyn-Jones (2010, p. 251) do not cite live birth rates for average

³Expected cumulative delivery rate accounts for drop-out rate, while crude does not. Thus, the crude cumulative delivery rate may understate the actual potential outcome of the method.

⁴Progressively motile meaning that the sperm are capable of moving towards an egg, as opposed to non-progressively motile sperm only capable of moving in a circle or immotile sperm not moving at all.

couples, but indicate that 10-15% of couples fail to achieve pregnancy in spite of having regular unprotected intercourse for 12 months, and that they are therefore considered infertile. The systematic review by Chachamovich et al. (2010) indicates that inability to have children may lead to a significant reduction of quality of life for women, whereas results for men are inconclusive.

S. Bhattacharya et al. (2008) indicate that spontaneous cycle IUI comes with no additional side effects compared to a pregnancy resulting from expectant management, and Brucker et al. (2009) did not record any complications related to infertility treatment or artificial insemination. This lack of additional side effects is the reason for looking at natural cycle IUI rather than looking at other fertility treatments that may have a higher live birth rate per cycle but that also come with a higher incidence of complications without adding to the cumulative live birth rate (see e.g. Goverde et al. 2000).

It may be worth noting that some couples will choose to go through e.g. IVF rather than only IUI. Due to the limitations imposed on this thesis and the complexity involved in calculating costs of IVF, this has not been attempted here.

2.6 Combined Oral Contraceptives

COCs lower female fertility by preventing ovulation (Oats, Abraham, and Llewellyn-Jones 2010, p. 243). In Sweden they require prescription and a yearly renewal (Vårdgivarguiden Stockholms Läns Landsting 2014). This requirement is in part due to the major side effect of COCs being an increased risk of venous thromboembolism (VTE) (see e.g. “Antikonception – behandlingsrekommendation” 2014; Dragoman 2014). Yearly check-ups are a part of VTE prevention. It has also been shown that COCs increase the relative risk of breast cancer, while lowering the risk of colorectal cancer and endometrial cancer (Gierisch et al. 2013). As the absolute risks of these cancers are low in the population considered we choose to not take these into account in our calculations. In Trussell et al. (2009) which evaluates the cost-effectiveness of different contraceptives the same choice is made.

Other reported side effects include adverse mood symptoms (Sundström Poromaa and Segeblad 2012) and different sexual side effects (Burrows, Basha, and Goldstein 2012). Regarding mood symptoms Sundström Poromaa and Segeblad (2012) report that there is a lack of good placebo-controlled studies, that many experience improved mood while using COCs, but that some report deteriorated emotional well-being. Burrows, Basha, and Goldstein (2012) mention decreased lubrication, vestibular pain, anatomical changes and affected sexual desire as the main possible negative sexual side effects of COCs. Pastor, Holla, and Chmel (2013) found no significant effect on sexual desire for COCs containing 20-35 µg ethinylestradiol: amongst the two most common types of COCs available in Sweden – ethinylestradiol combined with levonorgestrel and drospirenone respectively – all have at least 20 µg of ethinylestradiol (The Swedish National Board of Health and Welfare 2015a; The Swedish Medical Products Agency 2015)⁵. The evidence cited by Burrows, Basha, and Goldstein (2012) on decreased lubrication was McCoy and Matyas (1996) and Sabatini and Cagiano (2006). The former study did find a significant decrease of vaginal lubrication in COC-users, but pill users were no more likely than nonusers to report insufficient lubrication during sexual intercourse. Sabatini and Cagiano (2006) reported differences in vaginal dryness between different contraceptive methods, but lacked a control group and compared COCs that are not available in Sweden. Burrows, Basha, and Goldstein (2012) cite different findings on vestibular pain as a side effect of COC-use. There seems to be no consensus as to whether COCs are associated with vestibular pain. Results regarding anatomical changes were fetched from a

⁵Data on commonly prescribed COCs are taken from The Swedish National Board of Health and Welfare (2015a). Ethinylestradiol content of the COCs available may be found by searching The Swedish Medical Products Agency (2015) for ATC-groups G03AA07 and G03AA12.

single pilot study of 22 females and as such should be interpreted cautiously (Battaglia et al. 2012).

Since these side effects are hard to quantify both in terms of how many of them are actually caused by COCs and in terms of effect on quality of life, we will account for these by adding in the cost of changing the prescription in the proportion of females reporting discontinuation of COCs as a result of physical or mental side effects. Trussell (2011) estimated that 33% have abandoned COCs for method-related reasons after using it for one year or less. The Swedish study by Lindh et al. (2009) did not specifically state what proportion of COC-users that discontinued pill use, but amongst the 19-year olds participating in the study in 2001 the discontinuation of COCs was a result of either menstrual bleeding disturbances or mental side effects in 40% of the cases. A relatively small study by Sanders et al. (2001) reported that 47% of participants had discontinued COC use by the end of the 12 months, and 37% of those that discontinued did so at least in part due to physical side effects. In the cost-effectiveness analyses mentioned previously these side effects are not accounted for at all. Accounting for the cost of changing the prescription – in line with how costs of other side effects are accounted for by using the cost of amending the side effect – may be a significant understatement of the costs, as many females quit COCs altogether due to the side effects.

2.7 Unplanned Pregnancy

Putting a single number as society's cost of an unplanned pregnancy is somewhat problematic. Some pregnancies that occur while contraception is used will be mistimed rather than unwanted. Sonnenberg et al. (2004) and Trussell et al. (2009) account for mistimed pregnancies by only taking into account the costs of births that were unwanted but adjusting for the timing of the mistimed births. Both papers also account for costs related to ectopic pregnancy, spontaneous abortion and elective abortion. A concern that may be raised with this approach is the decision to stop the calculation with the costs of birth. One could argue that costs relating to e.g. postpartum absence from work should also be accounted for, but in such a case should one not also include costs of parents working part time in order to take care of their children, and any change to their future earnings? Also, a new person will be the result of this process, and should not the benefits produced by this new person also be a part of our calculation? If the entire duration of the 'condition' should be accounted for we may find ourselves in a situation in which the costs of contraceptive failure are negative, which is problematic in an attempt at evaluating contraceptive methods. We have been unable to find QALY-measures or equivalent for unplanned pregnancy in Sweden. Globally, the measures available seem to be quite poor (Mavranzezouli 2009).

Typical and perfect use pregnancy rates for first year of use for both methods of contraception are presented in table 2. Worth noting is that these figures are from Trussell (2011). No similar survey has been performed in Sweden (Thunell and Kopp Kallner 2014).

2.8 COCs and the Environment

Use of hormonal contraceptives increase the concentrations of estrogens in wastewaters. This may in turn affect fish populations living in areas affected by this increase, and may even lead a collapse of the fish population. The problem may be exacerbated by there being different kinds of estrogens released, with similar effects on fish. Recent measurements show that estrogen concentrations in Swedish waters are at harmful levels (Salin and Andersson 2014).

Table 2: Typical use and perfect use pregnancy rate for first year of use. Adapted from Trussell (2011). No similar survey has been performed in Sweden.

Method	Perfect use (%)	Typical use (%)
Vasectomy ^a	0.10	0.15
COCs	0.3	9

^a Perfect use of vasectomy assumes no unprotected intercourse taking place before the vasectomy has been confirmed to be successful through semen analysis.

3 Limitations of Scope

The stated purpose of this thesis is to put forward an economic evaluation of two contraceptive methods. It limits itself to looking at normally fertile males with a post-thaw progressively motile sperm count of at least one million spermatozoa, and normally fertile females aged 20-45. Patients with contraindications to the methods of contraception – e.g. females with increased risk of VTE – are not covered by the findings of this thesis. Further, costs related to unplanned pregnancies or to the environmental impact of COCs are not estimated, but these effects are accounted for as well as possible. We choose to not calculate these costs as the result would be highly uncertain and, at least in the case of contraceptive failure, to some degree arbitrary. It is likely better that decision makers are informed of these risks so that they in turn may seek better estimates than this thesis is capable of providing.

4 Method

4.1 Economic Evaluations in Healthcare

As this thesis is written in the hopes of it serving as a basis for decision-making in the Swedish public sector the economic evaluation will be based on the guidelines presented in SBU (2013). As SBU is the government agency responsible for health economic evaluations following their guidelines seems reasonable to fill the intended purpose. Chapter 11 of SBU (2013) is of special interest as it is concerned with health economic evaluations.

SBU (2013) mentions five forms of health economic analyses, the purpose and suitability of which are described in table 3.

Due to the nature of the question posed in this thesis CMA may be ruled unsuitable. CUA does not seem like a suitable candidate either: quality-adjusted life years (QALYs) is not the optimal yardstick for comparing contraceptive methods, in part since contraceptive failure may lead to a new person being born and in part since it is both hard to measure and a non-intuitive measure to be used to compare contraceptive methods. SBU (2013) states that CBA is methodologically difficult to use in health economics (p. 140).

CEA or CCA seem to be the tools best suited for the job, with the disaggregation of the CCA making it most suitable for decision making. Basing a CEA on the results of the CCA is done by presenting cost per year of contraception. It should however be noted that this measure will not be relevant to all decision makers since it will include costs that are not of significance to them. As we know that COC is already being used and subsidized by the counties we will use this as a

Table 3: Different forms of health economic analyses and their purpose. Adapted from SBU (2013).

Evaluation type	Purpose
Cost-Minimization Analysis (CMA)	Evaluate costs for treatments with identical effects and side effects.
Cost-Effectiveness Analysis (CEA)	Evaluate alternative methods not affecting quality of life.
Cost-Utility Analysis (CUA)	Evaluate therapies for non-life-threatening conditions requiring weighing in the effects on quality of life.
Cost-Benefit Analysis (CBA)	Evaluate effects in monetary terms rather than additional – in case of CUA, quality-adjusted – life years.
Cost-Consequence Analysis (CCA)	Present costs and effects without adding them up, in order to allow decision makers to draw their own conclusions based on the data most relevant to them.

reference point to compare the costs of the methods. Therefore, ratios of the costs of the different methods are presented.

4.1.1 Cost-Consequence and Cost-Effectiveness Analysis

CCA is a form of health economic analysis aimed at presenting costs and effects of a treatment in a disaggregated form, so as to allow decision makers to draw their own conclusions based on the data most relevant to them. This may be contrasted with the cost-effectiveness ratios often presented in other forms of analyses (Mauskopf et al. 1998). In this thesis CCA is used in order to evaluate the contraceptive options mentioned above. The basis of the CCA mentioned in SBU (2013) is Mauskopf et al. (1998). The article gives three major categories of outcomes resulting from treatment, and states that the CCA should try to capture as much information as possible about these outcomes. The major categories are listed below.

1. Direct medical care and other resource use and costs including physician visits, hospital days, drug treatment and paid caregiver time.
2. Indirect resource use and costs including patient and family caregiver lost productivity, work loss time and costs.
3. Clinical or symptom impact including life expectancy and quality of life.

These should all be accounted for. The estimates should be made keeping the entire length of the condition in mind.

The CEA presents a measure of effect which is not adjusted for quality of life. In this thesis this is done by presenting cost per year of contraception, based on the costs found through the CCA.

4.2 Data on Health Outcomes and Costs

Data on health outcomes are taken from relevant studies on treatments and their outcomes. Cost data are primarily fetched from the databases of the Swedish National Board of Health and Welfare, supplemented with cost-of-illness surveys. Costs of production losses are estimated with data from Eurostat's database on labor cost levels. This is in line with the recommendations of both Mauskopf et al. (1998) and SBU (2013). Costs of health outcomes are calculated as the cost of the procedure added to the cost of removing the side effects multiplied by the risk of the side effect occurring.

A discount rate of 3% is used when needed, in accordance with Bernfort (2009, p. 41). Sensitivity analyses are performed on factors having a large impact on final result as well as on the discount rate.

5 Results

Table 4 shows the cost of vasectomy and its side effects, table 5 presents the costs of COCs and their side effects, and table 6 presents the cost of a child conceived using IUI after 5, 10 and 20 years of sperm cryopreservation. Worth noting is that side effects are unlikely to be independent of each other, making actual costs likely to be somewhat lower than those stated. Considering that the estimated cost of side effects associated with both vasectomy and COCs is less than 500 SEK this should not have any large impact on the final result. Perhaps more pressing is the large uncertainty regarding the actual cost of cryopreservation of sperm. 2,500 SEK per year is an attempt at a mid-range estimate from the prices available from mostly private clinics, but it is hard to tell how this price relates to society's actual cost of sperm cryopreservation.

Table 7 gives an overview of the costs of both vasectomy with cryopreservation and IUI, and COCs. For five years of contraception only, vasectomy with cryopreservation costs almost twice as much as COCs. At 20 years of contraception without any attempt at children vasectomy with cryopreservation of semen costs 1.14 times the cost of COCs. Cost per year of contraceptions is presented in table 8. Worth noting is that the higher contraceptive efficiency of vasectomy is not accounted for in these costs, with typical use pregnancy rate during the first year of contraceptive use is 9% for COCs and 0.15% for vasectomy.

Looking instead at costs including those of a live birth at the end of 5, 10 or 20 years, vasectomy and IUI is almost 3 times more costly than COCs at 5 years, close to double the cost at 10 years, and 1.35 times the cost at 20 years. Added to this is also the fact that 56-77% of couples going through the procedure become parents, in comparison to 85-90% of couples in general.

Worth noting is that costs associated with vasectomy and cryopreservation are significantly reduced if cryopreservation is discontinued. Table 9 illustrates this. The incidence of this will depend on how long after vasectomy males choose to have or not have children.

Table 4: Probabilities of different vasectomy effects and their probability-adjusted costs. DRG weights and value of DRG weight 1.0 taken from the 2014 reference weight lists available through The Swedish National Board of Health and Welfare (2015b). Probability-adjusted cost is the cost of amending the side effect multiplied with the probability of the side effect occurring. As incidence of side effects are unlikely to be independent of each other, actual cost of these may be somewhat lower than stated below.

Effect	Probability	Probability-adjusted cost (SEK)
Pre-operative counseling ^a	1	2,596
Surgery ^b	1	9,152
Semen analysis ^c	1	2,907
Lost work time ^d	1	2,721
Hematoma ^e	0.015	92
Infection ^f	0.015	40
Chronic scrotal pain ^g	0.015	63
Need for repeat vasectomy ^h	0.01	149
Epididymitis ^f	0.03	79
Total costs		17,799

^a DRG W99O

^b DRG N21O

^c DRG N99O

^d Based on data from Eurostat's database on labor cost levels. Assumes 8 hour work day.

^e DRG J39O

^f DRG S99O

^g DRG W98O

^h Accounting for surgery, semen analysis and lost work time.

Table 5: Probabilities of different COC effects and their probability-adjusted costs. A discount rate of 3% was used to calculate present values. DRG weights and value of DRG weight 1.0 taken from the 2014 reference weight lists available through The Swedish National Board of Health and Welfare (2015b). Probability-adjusted cost is the cost of amending the side effect multiplied with the probability of the side effect occurring. As incidence of side effects are unlikely to be independent of each other, actual cost of these may be somewhat lower than stated below.

Effect	Probability	Probability-adjusted cost of n year(s) of COCs (SEK)			
		$n = 1$	$n = 5$	$n = 10$	$n = 20$
Appointment to renew prescription ^a	1	2,596	11,890	22,147	38,626
Cost of contraception ^b	1	548	2,510	4,675	8,153
VTE ^c	0.0006	84	385	717	1,250
Additional appointment due to side effects ^d	0.132	343	343	343	343
Total costs		3,571	15,127	27,881	48,371

^a DRG W99O

^b Based on pharmacy sales prices.

^c Based on the cost-of-illness calculations found in The Swedish Council on Technology Assessment in Health Care (2002). Adjusted to 2014 prices using healthcare component of CPI. The probability is given per year as in Dinger, Bardenheuer, and Heinemann (2014).

^d Based on Trussell (2011) and Lindh et al. (2009). Out of the 33% that gave up COCs for method-related reasons, 40% did so due to menstrual bleeding disturbances or mental side effects. Sanders et al. (2001) gives a number that is slightly higher, with 37% of the 47% discontinuing use citing physical side effects.

Table 6: Estimated cost of a child using natural cycle IUI and cryopreserved sperm. We assume a yearly cost of storing sperm of 2,500 SEK, that each cycle of IUI costs 2,567 SEK and that 7.14 cycles are needed for one live birth. The discount rate is set to 3%. Costs related to pregnancy and child-birth are not accounted for as these are similar to the costs of pregnancy achieved without the use of artificial insemination.

	Cost of a child after...		
	5 years (SEK)	10 years (SEK)	20 years (SEK)
Storage of sperm ^a	11,449	21,326	37,194
IUI ^b	15,816	13,643	10,152
Total	27,265	34,969	47,345

^a The price of the cryopreservation of sperm at private fertility clinics in Sweden ranges from 4,000 SEK for five years (*IVF-behandling – IVF-kliniken Stockholm* 2015) to 7,000 SEK per year (*Malmöpriser – Nordic IVF Center* 2015). In the base case analysis we choose to estimate the cost to 2,500 SEK per year.

^b DRG O76O

Table 7: Summary of total costs for 1, 5, 10 and 20 years of contraception, as well as total costs of contraception for 5, 10 and 20 years and a child at the end of that period for both methods. Also, the risk of unintended pregnancy during the first year of typical use, the percentage of couples that manage to give birth to a child, and the environmental impact of the methods.

		Vasectomy, cryopres- ervation and IUI	COCs	
Total cost of n years of contraception	$n =$	1	20,299	3,571
		5	29,248	15,127
		10	39,125	27,881
		20	54,993	48,371
Total cost of n years of contraception including cost of a live birth at year n	$n =$	5	45,064	15,127
		10	52,768	27,881
		20	65,144	48,371
Percentage of couples that become parents		56-77%	85-90%	
Risk of unintended pregnancy during first year of typical use		0.15%	9%	
Environmental impact		Negligible	Uncertain, but possibly quite significant	

Table 8: Cost in SEK per year of contraception for 5, 10 and 20 years of COC, vasectomy with cryopreservation of sperm, and vasectomy with cryopreservation of sperm and fertility treatment.

Years of contraception	COC (SEK/year)	Vasectomy	
		Without child (SEK/year)	With child at final year (SEK/year)
5	3,025	5,850	9,013
10	2,788	3,912	5,277
20	2,419	2,750	3,257

Table 9: Costs of the different methods for a given number of years of contraception with a child born at a given time during that period. It is assumed that sperm cryopreservation is discontinued after attempt at IUI.

			Contraception for n years		
n			5	10	20
Child after n years	5	Vasectomy	45,064	45,064	45,064
		COCs	15,127	27,881	48,371
	10	Vasectomy	-	52,768	52,768
		COCs	-	27,881	48,371
	20	Vasectomy	-	-	65,144
		COCs	-	-	48,371

6 Sensitivity Analysis

As seen in table 6 the cost of vasectomy, cryopreservation of sperm and IUI is largely driven by the costs associated with the cryopreservation of sperm. As the cost estimate is based on widely differing prices from different private clinics offering sperm cryopreservation, a sensitivity analysis is appropriate. This is shown in table 10. If the yearly cost of keeping sperm cryopreserved is 800 SEK it is less expensive than COCs for longer periods of protection, even if the couples decide to have children. For a yearly cost of 7,000 SEK vasectomy with cryopreservation of sperm will nearly always be more expensive than COCs.

Table 10: Summary of total costs for 1, 5, 10 and 20 years of contraception, as well as total costs of contraception for 5, 10 and 20 years and a child at the end of that period for both methods. Yearly cost of cryopreservation of sperm is 800 SEK/year or 7000 SEK/year.

		Vasectomy, cryopreservation and IUI		COCs
		800 SEK/year	7000 SEK/year	
Total cost of n years of contraception	$n =$	1	18,599	24,799
		5	21,463	49,857
		10	24,623	77,510
		20	29,701	121,941
Total cost of n years of contraception including cost of a live birth at year n	$n =$	5	37,279	65,673
		10	38,266	91,153
		20	39,853	132,093

The results of looking at a discount rate of 2% and 4% are found in table 11. The changes do not lead to any major differences from the base case analysis.

Table 11: Summary of total costs for 1, 5, 10 and 20 years of contraception, as well as total costs of contraception for 5, 10 and 20 years and a child at the end of that period for both methods. Discount rates set to 2% or 4%.

			2% discount rate		4% discount rate	
			Vasectomy, cryop- reserva- tion and IUI	COCs	Vasectomy, cryop- reserva- tion and IUI	COCs
Total cost of n years of contraception	$n =$	1	20,299	3,571	20,299	3,571
		5	29,583	15,583	28,929	14,714
		10	40,255	29,426	38,076	26,527
		20	58,678	53,436	51,775	44,216
Total cost of n years of contraception including cost of a live birth at year n	$n =$	5	46,189	15,583	43,999	14,714
		10	55,297	29,426	50,463	26,527
		20	71,017	53,436	60,143	44,216

7 Discussion

Which method of contraception is more expensive depends on the specifics of the method. If sperm is cryopreserved for the entire duration, COCs are always cheaper than vasectomy in the base case analysis, as shown in table 7. If cryopreservation is discontinued, as in table 9, or if yearly costs of sperm cryopreservation is lower than in the base case analysis, as in table 10, vasectomy may be cheaper than COCs after 10-20 years of contraceptive use. The discount rate has no major impact on the relative costs of the different contraceptive methods, as seen in table 11. No sensitivity analysis on the impact of the cost of side effects is done in spite of some downwards uncertainty, as these costs are very small to begin with. None of the above takes contraceptive failure or involuntary childlessness resulting from failed IUI into account.

As costs of the method involving vasectomy is largely driven by the cost of cryopreservation of semen and as this cost is highly uncertain it is difficult to draw any absolute conclusions based on this analysis. We have contacted the Karolinska University Hospital to get access to their internal price list, but unfortunately we have not received it as of submitting this thesis. Worth noting with regards to the cost of cryopreservation is that recent developments in sperm cryopreservation technology may allow for long term storage of sperm at -86°C rather than -196°C , allowing for a drastic decrease in cost (Sharma et al. 2015). If and when this is introduced in Sweden is not known, but it may in the future make cryopreservation significantly cheaper than it is today.

Considering that the overall costs of these methods may be quite similar, and considering that society currently subsidizes the use of COCs by taking the larger part of the cost related to the yearly renewal of the prescription, one could be tempted to ask why the same is not done for the yearly cost of sperm storage or the cost of the vasectomy procedure. As of 2014, two out of 21 Swedish counties did not offer vasectomy at all, in spite of the law stating that counties are obliged to offer sterilization to people older than 25 years of age. Two other counties charge close to 10,000 SEK for a vasectomy. Nine counties only charge the regular patient fee for vasectomy, with the remaining counties charging somewhere in between (Frisk 2014). Neither RFSU nor 1177 Healthcare Information mention any possibility of freezing sperm before undergoing a vasectomy.

Subsidizing the price of vasectomy might have some effect on the number of males undergoing the procedure, but in many cases price is likely not the main factor for males choosing to not undergo vasectomy. Offering and informing about the possibility to cryopreserve sperm may make vasectomy an option for males that would otherwise not feel certain enough about the decision – knowing that there is some chance of having children after the procedure may make vasectomy a more compelling alternative.

Another aspect of subsidies is the problem of making COC cheaper relative to vasectomy. This could be sound if there are positive externalities to use of COCs that are not present for vasectomy, justifying the subsidization of one but not the other. Although there are undoubtedly some positive externalities to the use of contraception in general, this thesis gives few clues as to why COC warrants subsidization while vasectomy does not.

According to Trussell (2011) 33% of females have quit using COCs within one year of starting. This is not accounted for as a cost in this thesis, but may be well worth mentioning as it is likely that many of these females switch to a less efficient method of contraception. This does not happen with vasectomy. As touched upon in the background the method used to estimate the costs of some of the side effects of COC may in fact understate the actual costs of these. All in all these estimated costs may thus be too low for COCs.

Vasectomy has a lower risk of unexpected pregnancy, but a higher risk of involuntary childlessness. Valuation of these states is not done in this thesis, but the risks of ending up in either situation is presented for both methods of contraception in table 7. Even if the impact of these are small on the level of society they may be very significant to the people involved, and anyone considering either method should be informed about these and other risks.

The cost of a live birth using cryopreserved semen and IUI is quite significant, as is shown in table 6. Needless to say, couples intending to have multiple children are likely better off using a more reversible form of contraception than vasectomy.

Valuation of the ecosystem services provided by estrogen-free waters may be done using several methods, with the most suitable possibly being the factor income method or the replacement cost method (Söderqvist, Hammer, and Gren 2004, pp. 149-159). This thesis does not attempt such a valuation, but does point out the potentially large costs associated with the collapse of fish populations or the upgrades to existing sewage treatment plants necessary to prevent such collapse. Decision makers should know that these costs exist and that they may be very substantial.

8 Summary

The purpose of this thesis is to make an economic evaluation of vasectomy with cryopreservation of sperm and IUI, and to compare this with COCs. It does this, but limits itself to looking at normally fertile males with a post-thaw progressively motile sperm count of at least one million spermatozoa, and normally fertile females aged 20-45, and not concerning itself with costs related to the environmental impact of COCs or with costs related to contraceptive failure. Information is presented on the different contraceptive methods, cryopreservation of sperm, and IUI, as well as some previous research done on the cost-effectiveness of different contraceptive methods. Different health economic evaluations are presented, the choice of cost-consequence and cost-efficiency analysis is motivated, and CCA and CEA are presented in some more detail. Results indicate that COCs are cheaper for shorter periods of contraception. For longer periods of contraception which method is more expensive varies depending on the cost of cryopreservation of sperm and the duration for which sperm is cryopreserved. COCs have a higher risk of unplanned pregnancies, while fewer couples undergoing IUI manage to have children, with risks of ending up in either state being presented without any other measures of quality of life. Costs re-

lating to estrogen being released into the environment are briefly touched upon in the discussion, and decision makers should be aware of these costs as they may be quite significant.

References

- 1177 Vårdguiden (2015). *Sterilisering*.
- Akanji Tijani, Hammed and Siladitya Bhattacharya (2010). "The role of intrauterine insemination in male infertility." In: *Human Fertility* 13.4, pp. 226–232.
- "Antikonception – behandlingsrekommendation" (2014). In: *Information från Läke-medelsverket* 25.2, pp. 14–28.
- Battaglia, Cesare et al. (2012). "Sexual Behavior and Oral Contraception: A Pilot Study: Pill and Sexuality." In: *Journal of Sexual Medicine* 9.2, pp. 550–557.
- Beckmann, Charles R. B. and American College of Obstetricians and Gynecologists, eds. (2010). *Obstetrics and gynecology*. 6th ed. Baltimore, MD: Lippincott Williams & Wilkins. 497 pp.
- Bernfort, Lars (2009). *Hälsoekonomiska utvärderingar: Vad menas och hur gör man?* Linköping University Electronic Press.
- Bhattacharya, S. et al. (2008). "Clomifene citrate or unstimulated intrauterine insemination compared with expectant management for unexplained infertility: pragmatic randomised controlled trial." In: *BMJ (Clinical research ed.)* 337, a716.
- Brucker, Michaël De et al. (2009). "Cumulative delivery rates in different age groups after artificial insemination with donor sperm." In: *Human Reproduction* 24.8, pp. 1891–1899.
- Burrows, Lara J., Maureen Basha, and Andrew T. Goldstein (2012). "The Effects of Hormonal Contraceptives on Female Sexuality: A Review." In: *Journal of Sexual Medicine* 9.9, pp. 2213–2223.
- Chachamovich, Juliana Rigol et al. (2010). "Investigating quality of life and health-related quality of life in infertility: a systematic review." In: *Journal of Psychosomatic Obstetrics and Gynaecology* 31.2, pp. 101–110.
- Dinger, Jürgen, Kristina Bardenheuer, and Klaas Heinemann (2014). "Cardiovascular and general safety of a 24-day regimen of drospirenone-containing combined oral contraceptives: final results from the International Active Surveillance Study of Women Taking Oral Contraceptives." In: *Contraception* 89.4, pp. 253–263.
- Dohle, Gert R. et al. (2012). "European Association of Urology Guidelines on Vasectomy." In: *European Urology* 61.1, pp. 159–163.
- Dragoman, Monica V. (2014). "The combined oral contraceptive pill- recent developments, risks and benefits." In: *Best Practice & Research Clinical Obstetrics & Gynaecology* 28.6, pp. 825–834.
- Frisk, Ingrid, ed. (2014). *RFSU:s Sverigebarometer 2014*.
- Gierisch, Jennifer M. et al. (2013). "Oral Contraceptive Use and Risk of Breast, Cervical, Colorectal, and Endometrial Cancers: A Systematic Review." In: *Cancer Epidemiology Biomarkers & Prevention* 22.11, pp. 1931–1943.
- Goverde, Angelique J et al. (2000). "Intrauterine insemination or in-vitro fertilisation in idiopathic subfertility and male subfertility: a randomised trial and cost-effectiveness analysis." In: *The Lancet* 355.9197, pp. 13–18.
- IVF-behandling – IVF-kliniken Stockholm* (2015).
- Johnson, Andrew C. et al. (2007). "What difference might sewage treatment performance make to endocrine disruption in rivers?" In: *Environmental Pollution (Barking, Essex: 1987)* 147.1, pp. 194–202.
- Lindh, Ingela (2014). "Preventivmedelsanvändning i Sverige." In: *Information från Läke-medelsverket* 25.2, pp. 32–36.

- Lindh, Ingela et al. (2009). "Contraceptive use and pregnancy outcome in three generations of Swedish female teenagers from the same urban population." In: *Contraception* 80.2, pp. 163–169.
- Makenzius, Marlene et al. (2009). "Male students' behaviour, knowledge, attitudes, and needs in sexual and reproductive health matters." In: *European journal of contraception & reproductive health care : the official journal of the European Society of Contraception* 14.4, pp. 268–76.
- Malmöpriser – Nordic IVF Center (2015).
- Mauskopf, Josephine A. et al. (1998). "The Role of Cost-Consequence Analysis in Healthcare Decision-Making." in: *Pharmacoeconomics* 13.3, pp. 277–288.
- Mavranzouli, Ifigeneia (2009). "Health economics of contraception." In: *Best Practice & Research Clinical Obstetrics & Gynaecology* 23.2, pp. 187–198.
- McCoy, Norma L. and Joseph R. Matyas (1996). "Oral contraceptives and sexuality in university women." In: *Archives of Sexual Behavior* 25.1, pp. 73–90.
- Michielsen, Dirk and Rob Beerthuisen (2010). "State-of-the art of non-hormonal methods of contraception: VI. Male sterilisation." In: *European Journal of Contraception and Reproductive Health Care* 15.2, pp. 136–149.
- Nieschlag, Eberhard, Hermann M. Behre, and Susan Nieschlag, eds. (2010). *Andrology*. Berlin, Heidelberg: Springer Berlin Heidelberg.
- Oats, Jeremy, Suzanne Abraham, and Derek Llewellyn-Jones, eds. (2010). *Llewellyn-Jones fundamentals of obstetrics and gynaecology*. 9th ed. Edinburgh ; New York: Mosby. 354 pp.
- Pastor, Zlatko, Katerina Holla, and Roman Chmel (2013). "The influence of combined oral contraceptives on female sexual desire: A systematic review." In: *European Journal of Contraception and Reproductive Health Care* 18.1, pp. 27–43.
- RFSU (2015). *Sterilisering*.
- Sabatini, Rosa and Raffaele Cagiano (2006). "Comparison profiles of cycle control, side effects and sexual satisfaction of three hormonal contraceptives." In: *Contraception* 74.3, pp. 220–223.
- Salin, Kia and Alicja Andersson (2014). "Hormonella preventivmedels påverkan på miljön." In: *Information från Läkemedelsverket* 25.2, pp. 79–80.
- Sanders, Stephanie A et al. (2001). "A prospective study of the effects of oral contraceptives on sexuality and well-being and their relationship to discontinuation." In: *Contraception* 64.1, pp. 51–58.
- SBU (2013). *Utvärdering av metoder i hälso- och sjukvården: En handbok*. Stockholm: Statens beredning för medicinsk utvärdering (SBU).
- Sharlip, Ira D. et al. (2012). "Vasectomy: AUA Guideline." In: *Journal of Urology* 188.6, pp. 2482–2491.
- Sharma, Rakesh et al. (2015). "Effect of sperm storage and selection techniques on sperm parameters." In: *Systems Biology in Reproductive Medicine* 61.1, pp. 1–12.
- Smittskyddsinstitutet (2013). *Epidemiologisk årsrapport 2012*. Solna.
- Söderqvist, Tore, Monica Hammer, and Ing-Marie Gren (2004). *Samverkan för människa och natur: en introduktion till ekologisk ekonomi*. Lund: Studentlitteratur.
- Solymoss, Susan (2011). "Risk of venous thromboembolism with oral contraceptives." In: *CMAJ : Canadian Medical Association Journal* 183.18, E1278–E1279.
- Sonnenberg, Frank A. et al. (2004). "Costs and net health effects of contraceptive methods." In: *Contraception* 69.6, pp. 447–459.
- Statistics Sweden (2014). *Women and men in Sweden 2014*.
- Sundström Poromaa, Inger and Birgitta Segeblad (2012). "Adverse mood symptoms with oral contraceptives." In: *Acta Obstetrica et Gynecologica Scandinavica* 91.4, pp. 420–427.
- The Swedish Council on Technology Assessment in Health Care (2002). *Blodpropp - förebyggande, diagnostik och behandling av venös tromboembolism*. Yellow 158.

- The Swedish Medical Products Agency (2015). *Läkemedelsfakta*.
- The Swedish National Board of Health and Welfare (2015a). *The Swedish Prescribed Drug Register*.
- (2015b). *Vikter*.
- (2014). *Vägledning till NordDRG: Svensk version 2015*. 2014-12-20.
- Thunell, Louise and Helena Kopp Kallner (2014). “Preventivmetoders effektivitet – sterilisering samt preventivmedel efter abort, förlossning och under amning.” In: *Information från Läkemedelsverket* 25.2, pp. 37–41.
- Trussell, James (2011). “Contraceptive failure in the United States.” In: *Contraception* 83.5, pp. 397–404.
- Trussell, James et al. (2009). “Cost effectiveness of contraceptives in the United States.” In: *Contraception* 79.1, pp. 5–14.
- Vårdgivarguiden Stockholms Läns Landsting (2014). *Riktlinjer Antikonception Barnmorskemottagning/ Ungdomsmottagning i Sll*.
- Zeilinger, Jana et al. (2009). “Effects of synthetic gestagens on fish reproduction.” In: *Environmental toxicology and chemistry / SETAC* 28.12, pp. 2663–2670.

A Glossary of Terms and Abbreviations

Combined oral contraception (COC)	A form of female contraception, "the Pill."
Cost-consequence analysis (CCA)	A form of health economic analysis that lists costs of different treatments and their respective outcomes in a structured and transparent way.
Diagnosis related group (DRG)	A patient classification system.
Epididymitis	Inflammation of the epididymis. The epididymides are found by the testicles.
Estrogen	Female sex hormones.
Expectant management	Not doing anything about a medical condition, but instead choosing to wait and see what happens. In the case of infertility this means not attempting any treatment but instead allowing the couple to continue trying for a child before attempting a fertility treatment.
Intrauterine insemination (IUI)	A form of artificial insemination.
Vasectomy	Male sterilization.
Vas deferens	A 'tube' transporting sperm during ejaculation.
Venous thromboembolism (VTE)	A blood clot formed in a vein.