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2015

**Contraception: past, present, and future**

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*Boston University*
BOSTON UNIVERSITY
SCHOOL OF MEDICINE

Thesis

CONTRACEPTION: PAST, PRESENT, AND FUTURE

by

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B.S., Boston University, 2013

Submitted in partial fulfillment of the requirements for the degree of Master of Science 2015
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My heartfelt thanks.

God Bless
CONTRACEPTION: PAST, PRESENT, AND FUTURE

ESHERE GBARBEA

ABSTRACT

The most common method of birth control used since 3000 B.C., is the condom. It has been used continuously in the 21st century but several other forms have been added. Due to reformers like Marie Stopes, Margret Sanger, Katharine McCormick and Gregory Pincus contraceptive usage has become popularized in today’s society. New forms of contraceptive include but are not limited to intrauterine devices (IUDs), shots, pill, patch, and vaginal rings. These devices have been developed as both hormonal and non-hormonal products. Hormonal birth control delivers hormones such as estrogen and progestin, which affect the joining of the sperm and egg. Products that are non-hormonal are a viable alternative for women who cannot tolerate hormonal regulation.

Estrogen and progestin function as contraceptives by changing various areas in the vaginal tract by changes such as the thickening of cervical mucus, thinning the uterus lining, or increasing the vagina acidity. Researchers are also trying to develop other options such as a male contraceptive option to expand and reach a target population that is not currently reached.

There are also government policies currently in Congress that address the issue of the uninsured; thereby reaching those who may need contraceptives the most. The Affordable Care Act also known as Obama care is trying to provide Medicaid to people
who do not and would not ever be able to afford adequate health care, including contraceptives on their own. With the passing of the Affordable Care Act more women will be able to go to a medical provider to be informed and educated on the various contraceptive methods, enabling them to make an informed decision.
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LIST OF ABBREVIATIONS

ACA………………………………………………………………Affordable Care Act
BRDT………………………………………………………………Bromodomain
CI…………………………………………………………………Contraceptive Injection
DMPA………………………………………………Depo-Proverar
EC …………………………………………………………………Emergency Contraceptive
EE …………………………………………………………………Ethinyl estradiol
FDA………………………………………………Federal Drug Administration
FSH………………………………………………….Follicle stimulating hormone
GAPDS………………………………………………………..3-phosphate dehydrogenase-S
GnRH…………………………………………….Gonadotropin-releasing hormone
HIV …………………………………………………………………human immunodeficiency virus
IUD …………………………………………………………………Intrauterine device
IVF …………………………………………………………………in vitro fertilization
LH …………………………………………………………………luteinizing hormone
LNG …………………………………………………………………Levonorgestrel
MPA…………………………………………………………..Medroxy-Progesterone Acetate
NES ……………………………………………………………nestorone and estrogen ethyl estradiol
NETA ……………………………………………………………norethindrone acetate
NSAID …………………………………………………………non-steroidal anti-inflammatory drugs
SC………………………………………………………………….Subcuataneous
STD………………………………………………………………Sexual Transmitted Diseases

xi
STI.................................................................Sexual Transmitted Infections
TB ........................................................................................................ tuberculosis
TSS.................................................................................................Toxic Shock Syndrome
UP...............................................................................................Unintended Pregnancy
INTRODUCTION

History

Birth control methods have been around for many years. The earliest time period known to use birth control was around 3000 B.C. (Christin-Maitre, 2013). The most common method used by Egyptians was condoms. Egyptians developed vaginal pessaries as well as vaginal sponges. Pessaries were like a cotton tampon used to prevent pregnancies. They were made out of crocodile dung, honey, and sodium bicarbonate and were then soaked in fermented juice of acacia plants. Vaginal sponges were used as spermicides and were soaked in lemon juice or vinegar (Christin-Maitre, 2013).

After the Egyptian the next recorded record came from the Greeks (Christin-Maitre, 2013). Around the fourth century B.C., Aristotle wrote about anointing a woman with olive oil to prevent pregnancy and exerting pressure on their abdomen to expel semen from the vagina. Plants during this time period were also recorded to have certain properties to hinder a woman's ability to conceive and included plants such as pomegranate, pennyroyal, and pine. The Catholic Church in 1276 also offered ways to induce menstruation. Women in Sri Lanka were recorded to eat one papaya a day as it was thought that the enzyme papain contained within the papaya interacted and affected progesterone levels (Christin-Maitre, 2013).

The Chinese had their own ideas on how to prevent pregnancies. The women were instructed to drink lead and mercury to inhibit implantation (Christin-Maitre, 2013). But
the side effects of the chemicals far outweighed the benefits because they lead to sterility and. In the 16th century, Europeans used condoms made from fish or animal gut, to prevent syphilis and pregnancy. Fortunately, in 1944, Charles Goodyear invented the patented vulcanization of rubber which is now used in many condoms and diaphragms. Throughout these time periods several forms of birth control methods have come into being. Approaches such as abstinence, condoms, IUDs (intrauterine devices), breastfeeding, coitus (the pull out method), infrequent coitus (infrequent sexual intercourse), pills, and induced abortion were utilized (Christin-Maitre, 2013).

From the beginning of the 20th century there have been many improvements made. These changes/improvements can be credited to many men and women involved in researching and advocating for the use of birth control (Christin-Maitre, 2013). The major players in the development of birth control included Dr. Marie Stopes from Scotland (Christin-Maitre, 2013). She wrote the book called Wise Parenthood and opened her first birth control clinics in Holloway, north London, in 1921. The dawning of hormonal methods was conceived by Margaret Sanger, Katharine McCormick and Gregory Pincus (Stopes, 2006)

Due to the Comstock act of 1873 posed in US Supreme Court prohibiting advertisement, information and distribution of birth control, and allowing the postal service to confiscate birth control through the mail, it was really difficult for individuals to receive what was needed in the states (Christin-Maitre, 2013). This all changed in 1916 when Margaret Sanger founded the American Birth Control League and opened up
Planned Parenthood (Baker, 2011). She has said “No women can call herself free who does not own and control her body (About Education, n.d.). No women can call herself free until she can choose consciously whether she will or will not be a mother. Her movement was inspired by her mother’s experience with pregnancy. Her mother was pregnant 18 times and had birthed 11 children and died at the early age of 50 (Christin-Maitre, 2013).

A year after the opening of her clinic, Sanger was arrested and sent to jail for 30 days for the crime of maintaining a public nuisance. Once Sanger was released she reopened her clinic and suffered additional prosecution. In 1938, with the help of Sanger, the Comstock case was reversed, lifting the ban on birth control (Our Bodies Our Selves, n.d.). In the 1950s Sanger, along with her woman’s right partner Katharine McCormick helped to create the first human birth control pill (Christin-Maitre, 2013). Katharine McCormick was the wife of the person who invented the mechanical harvester. She helped fund Gregory Pincus research into developing the pill. Gregory Pincus was the creator of the first contraceptive pill (Christin-Maitre, 2013).

McCormick also funded the first clinical trial ran by Dr. John Rock who was the co-developer of the pill (Christin-Maitre, 2013). Along with the help of Sanger staff of Planned Parenthood, he wrote a book called “The Time Has Come: A Catholic Doctor Proposal to End the Battle over Birth Control” (Rock, 1963). Dr. Rock used Carl Djerassi’s a researcher on steroids, when developing the pill (Marks, 2001). Carl Djerassi had synthesized a progestin known as norethisterone which was found to be stronger than
the natural progesterone. So strong that doses over 5mg of progestin in a 21 day regimen led to the suppression of ovulation as well as caused an unacceptable amount of bleeding. To stop the bleeding it had to be combined with mestranol (Ravina, 2011).

Along with that discovery mestranol, its active metabolite, ethinyl estradiol (EE) and norethisterone were added to the contraceptive pill (Christin-Maître, 2013). These three ingredients made up the first pill Enovid, a combined oral contraceptive. It was approved by the FDA in 1957 and used treat menstrual disorders, but soon people started noticing that it helped to prevent pregnancy as well (The Embryo Project Encyclopedia, n.d.). With this discovery, in 1959 the pharmaceutical company Searle went to the FDA to approve the pill being marketed as an oral contraceptive (Our Bodies Our Selves, n.d.). The next year it was approved. In 1968, the use of IUDs was approved coming out with earlier versions such as the copper 7.

By 1972, birth control had become legalized for all American citizens, even those unmarried. Finally, by the 1990 and early 2000 methods we are now so familiar with more option that have been invented. Things like the first contraceptive implant, Depo-Provera an interjectable contraceptive, Fc1, the female condom, and lastly Plan- B the emergency contraceptive (Our Bodies Our Selves, n.d.).

The purpose of this thesis is to inform and educate women on the importance of awareness when choosing a birth control option. Additionally, current and future studies on the topic will be discussed, while reporting on their effectiveness and failure rates.
Methods of Birth Control

There are several methods of birth control in practice along with abstinence and breastfeeding. They can be separated into two groups. The first group is the reversible method and the second is the permanent method. In the reversible group are intrauterine contraceptives, the hormonal methods, barrier methods, and the fertility awareness-based methods. The permanent method includes sterilization (female and male) and vasectomies.

We have all been told that the safest and the most effective way to prevent pregnancy is through abstinence (“Birth Control Methods - Birth Co. Some, however, may be confused on just what that entitles. The correct way of abstinence is to abstain from all forms of sexual play. These include oral, anal, and vaginal activities (“Planned Parenthood,” n.d.).

Breastfeeding can help to prevent pregnancy because the constant act helps to change a woman’s hormone so that ovulation does not occur. Without ovulation there is no egg and without the release of an egg pregnancy cannot occur (Planned Parenthood, n.d.).

Long Acting Reversible Methods-Intrauterine Contraception

IUD’s are a small t-shaped device that can be inserted into the vagina by a health care provider and can last for up to 12 years (Planned Parenthood, n.d.). This method does not rely on the user adherence because once inserted they must consult with a healthcare provider to discontinue (Mestad et al., 2011). There are three types of IUDs
approved for use within the United States. The first is a copper based IUD also known as Paragard® created by the Teva Women’s Health, INC, Cincinnati, OH (Mestad et al., 2011). The second is a hormonal type called Levonorgestrel (Mestad et al., 2011). The brand on the market is known as Mirena® (5 yrs) or sometimes Skylar® (3 yrs) (“Planned Parenthood,” n.d.). The last one is the etonogestreal sub dermal implant also known as Implanon® (Mestad et al., 2011).

Paragard® can be used as an emergency contraception if inserted within five years (Planned Parenthood, n.d.). Upon insertion of the copper intrauterine device, the copper ions are slowly released into the uterine and tubal fluid where it has both a pre and post fertilization effect (Mestad et al., 2011). The copper IUD composition can be toxic to both the ovum and the sperm, thus leading to a major impact on the pre-fertilization stage (Koyama, Hagopian, & Linden, 2013). This can occur even after fertilization has taken place and before the embryo enters the uterus (Koyama et al., 2013). The resulting effect includes a toxic oocyte, impairment of sperm function (including motility, viability, acrosome reaction, fertilizing capacity, and influence on tubal motility) and the fertilization process (Mestad et al., 2011). If fertilization does occur then the IUD leads to a local inflammatory reaction in the endometrium that causes the release of cytokines and integrin’s which can inhibit implantation (Koyama et al., 2013).

The hormonal IUD releases a small amount of progestin (Planned Parenthood, n.d.). The difference with the Levonorgestrel (LNG) IUD is that it can be used while a mother is breastfeeding without impacting the infant (Mestad et al., 2011). The
mechanism of action for this devise relays on a paracrine action. LNG is held within the
cylinder of the plastic device that is coated by a membrane that can control the release
and the dosage of the drug (Mestad et al., 2011).

The drug Mirena® releases at a rate of the 20µg / day when first inserted, after
five years it decreases to a rate of 14 µg/day (Mestad et al., 2011). Skyla® releases at a
rate of 14 µg/day and slowly decreases to a rate of 5 µg/day after three years. Even
though the rates decrease, it still functions at a clinically effective rate. LNG acts similar
to the copper IUD in that they both help to hinder per fertilization (Mestad et al., 2011).

Reversible Methods- Hormonal Method

The first reversible method is the contraceptive implant. The implant is a thin,
flexible, plastic device that can be inserted underneath the skin of the upper arm (Planned
Parenthood, n.d.). It is tubular and approximately 40mm long (Choices, 2015). This then
constantly release small amounts of progestin ensuring prevention of pregnancy for up to
three years ((Planned Parenthood, n.d.). The mechanism that enables the implant to
effectively prevent pregnancies is through the hormonal release of progesterone that is
transported within the blood stream (Choices, 2015). The released synthetic progesterone
acts similar to the natural one. It then stops the release of the ovum from the ovaries,
thickens the cervical mucus and thins the womb lining. This results in the sperm’s
inability to move through the cervix and thus less likely to accept a fertilized egg. The
contraceptive implant has been proven to be 99% effective. Studies have shown that less
than 1 in 1000 women get pregnant in one year. It is easily removed, resulting in the return of the natural cycle Figure 3 (Choices, 2015).

The most common types on the market today are Nexplanon® and Implanon® (Planned Parenthood, n.d.). Implanon® was commonly used before October 2010 but became less installed after Nexplanon® was created (Choices, 2015). Both implants work in similar manners with the only difference being that Nexplanon® decreases the risk of insertion errors, is visible on X-rays and CT’s scans, and can be used until the age of menopause. The implant can be inserted at any time during the menstrual cycle. If inserted during the first five days of the cycle it can result in an immediate protection against pregnancy (Figure 1). If installed any time after it will take up to five days for the implant to become effective (Choices, 2015).

![Figure 1: IUD placement. Shown is the different IUDs and how they are inserted. Take from Loren, 2011.](image-url)
The installation of the contraceptive implant may cause a general infection at the application site which can be treated with basic antibiotics (Choices, 2015). The bodily effects include headaches, acne, nausea, breast tenderness, changes in mood, loss of sex drive, and weight gain. The implant can also have a chemical cross reaction with other prescriptions taken by the individual. Some examples include enzyme inducing drugs such as HIV (human immunodeficiency virus) and epilepsy medications, St. Johns Wart remedies, rifabutin (an antibiotic that treats tuberculosis (TB)), and rifampicin (antibiotic that treats TB and meningitis). If a patient is on these medications, it is recommended to use an additional, contraceptive (condoms/shot) during treatment and 28 days after treatment (Choices, 2015).

The second hormonal method is the contraceptive shot. It is an injection that contains the hormone progestin (“Planned Parenthood,” n.d.). It can prevent pregnancy for up to three months. Brand on the market known as Depo-Provera® or sometimes DMPA (Planned Parenthood, n.d.).

The shot can be given into the buttocks and upper arm and helps to prevent ovulation when it is taken on schedule with an effectiveness of 99% if applied on time (Carlson, Eisenstat, & Ziporyn, 2004). The hormone is also reversible and can easily be removed from the body. The shot is administered by a clinician four times a year. Once the shot is given the active ingredient medroxyprogesterone acetate or MPA is released. MPA is chemically similar to progesterone (Carlson et al., 2004).
The shot costs approximately 30 to 75 dollars excluding doctor’s visit (Carlson et al., 2004). In order to receive the first shot, a full physical examination is required. Once cleared by physical examination, the shot can be given the first five days following completion of the menstrual cycle. This is to ensure that the woman is not pregnant. It can also be given to mothers who just delivered and chose not to breast feed given within five days of child birth (Carlson et al., 2004).

There are many effects associated with the shot, such as an irregular vaginal bleeding and weight gain (Carlson et al., 2004). It was shown that one third of women get irregular bleeding for the first three months and eventually decreases overtime. With the increase in weight gain it was shown to be not as common as the pill. Researchers found that with an increase in years of usage there is an increase in weight. At two years usage there’s an eight pound gain (4 per year), four years usage has a fourteen pound gain (3.5 per year), and six year usage found a 16.5 gain (2.75 per year) (Carlson et al., 2004).

Other effects include a complete menstrual stop, depression, and osteoporosis (Carlson et al., 2004). Osteoporosis can lead to a decrease in bone density after five years and is only seen in women who smoked. Osteoporosis can be reversible but if it occurs in adolescents it can have long term effects. The shot is not recommended for those with a history of liver disease, major depression, as well as women who are pregnant and have unexplained bleeding where the origin cannot determined (Carlson et al., 2004).
If breast feeding, it is important for new mothers to wait six weeks after child birth for the first injection due to passage through the breast milk (Carlson et al., 2004). Researchers have not found any side effects in infants. If you want to conceive, stop receive the shot and within a year after last dosage. It was shown that 90 percent of women become pregnant within the first 18 months (Carlson et al., 2004).

MPA is insoluble in water so it must be formulated in an aqueous suspension that includes PEG and polysorbate 80, along with their preservatives methylparaben and popylparaben (Lee & Desai, 2007). Sodium chloride is also included to adjust the tonicity of the injection. When injected it forms deposits and has a long half-life due to slow absorption from the site. This in turn leads to slow dissolution of the drug. Within 24 hours of the shot the concentration is sufficiently high resulting in an immediate protection against pregnancies (Lee & Desai, 2007).

There are two types of the Depo-Provera® shots, Depo-sub Q Provera™ and Depo-Provera® CI that can be classified based on the application of the shot (Lee & Desai, 2007). The Depo-sub Q Provera™ shot is a subcutaneous (SC) progestin only injection that is available in prefilled syringes. The syringes need to be shaken well for a disbursement of the drug, once injected MPA is absorbed and reaches a steady state concentration after multiple injections into the abdomen or anterior thigh. The shot should be administer every 12 to 14 weeks with a dosage of 104mg of MPA per dose. At the injection site it’s slowly released resulting in a low blood concentration. This shot should be used given to women who cannot tolerate estrogen (Lee & Desai, 2007).
Depo-Provera® CI is a contraceptive injection that is inserted into the intermuscular (Lee & Desai, 2007). It is injected every twelve weeks into the deltoid or gluteal muscle. It comes in vials and prefilled syringes that need to be shaken to ensure a uniform suspension of the drug. The MPA in this shot has a half-life of 50 days and reaches a steady state concentration of 150mg per dose and reaches peek at three weeks. The dosage distribution includes 1-7 ng/ml at the peak, 1 ng/ml maintained at 3 months, 0.2 ng/ml at 5-6 months, at 6 months effectiveness is lowered and another shot is required (Lee & Desai, 2007).

**Combined Oral Contraceptives:** Often contraceptives are a combination of hormones that are taken daily and act as an oral contraceptive method (Planned Parenthood, n.d.). These can be made from having both estrogen and progestin or only progestin. The pill keeps the egg from leaving the ovaries and makes the cervical mucus thicker ensuring that sperm do not reach the egg.

**The Patch:** The patch is a thin, beige, plastic that can adhere to the skin (Planned Parenthood, n.d.). The design of the patch is specific to be water and sweet proof (Bell, n.d.). It can be adhered to the abdomen, buttocks, upper arm and torso. When applied it is important to never apply soap or skin products such as lotion or oil to the area due to it effecting the ability to stick (Bell, n.d.).

The patch is worn for 3 weeks in a row and then removed for the last remaining week. The patch must be worn for seven days and changed on the eighth day (Helms &
Mistakes as we know do occur, therefore if the patch falls off for less than 24 hours it can be easily reapplied without the need of using a backup birth control method. However, if it is more than 24 hours a new patch must be reapplied thus resetting to a new patch cycle (Helms & Quan, 2006). It is important to pick a specific day (such as Monday) where you can always ensure application (Bell, n.d.). This is to make sure seven days have passed before applying a new patch. On the market now is the Xulane® (Planned Parenthood, n.d.).

The patch releases both progestin and estrogen (Bell, n.d.). The chemicals released from the patch works by preventing ovulation, thickening the cervical mucosa, and thinning out the uterus to hinder attachment. If you are a first time user, it is important to use a backup contraceptive during the first seven days, just as a failsafe. Medical experts do not prescribe users to be over the age of 35 and if they had risk of blood clots chest pains, diabetes, high blood pressure, headaches, a known suspected tumor, hepatitis, heart disease, or if they are allergic. The patch may also have drug interactions with certain antibiotics that are used to treat seizures, migraines and tuberculosis (Bell, n.d.).

Smokers are advised not to use the patch due to an increase in blood clots, strokes, and heart attacks (Carlson et al., 2004). The patch is made by Orthoevra® in 2002 and can also be referred to as the transdermal patch. Another side effect occurs to contact wearers who experience an increase in blurry vision and the inability to wear
contacts. The patch cost approximately 30 to 35 dollars per month, this however does not include the medical examination fees (Carlson et al., 2004).

The patch is infused with a total concentration of 6.75mg of progestin norelgestromin and estrogen ethinyl estradiol (Helms & Quan, 2006). The daily dosage delivers 0.15mg per day for progestin norelgestromin and 20 µg per day for estrogen ethinyl estradiol. When the patch is adhered, chemicals travel transdermal through the skin. Once absorbed the norelgestromin is metabolized to active progestin norgestimate. It must be applied the first day of a woman’s menses or the Sunday following (to ensure consistence) (Helms & Quan, 2006).

The next side effect reported during clinical trials is a 9-20 percent chance of developing breast symptoms, headaches, allergic reactions, nausea, upper respiratory infections, menstrual cramps, ad abdominal pains (Helms & Quan, 2006).

The Vaginal Ring: There are many advantages to using the vaginal ring as a contraceptive method including the consistent and constant delivery of steroid hormones (Johansson & Sitruk-Ware, 2004). The hormone is absorbed through the epithelium in a rapid and constant rate. This method allows for the delivery of natural steroids. Another advantage of the ring is that it can be easily controlled by the user with accessible insertion and removal techniques. This allows for easy removability during sexual intercourse for up to 2 hours. This is compared to the IUD and other hormonal implants where a health care provider has to implant the devices (Johansson & Sitruk-Ware, 2004).
The hormone contained in the rings, first contained a low dose estradiol (Johansson & Sitruk-Ware, 2004). This was first developed by the pharmaceutical company Pharmacia for a local estrogen deficiency problem (Holmgren, Lindskog, & von Shoultz, 1989). It was then developed to include a estradiol ester (EE) ring for menopausal women by Galen Pharmaceutics (Johansson & Sitruk-Ware, 2004). Today, technology and formulations have been used to allow for a more efficient, safe, rational, and sleek design (Johansson & Sitruk-Ware, 2004).

The design of the ring is a small, flexible, ring that is inserted once a month to release small amounts of progestin and estrogen (Planned Parenthood, n.d.). Figure 2 shows the Population Council’s combination estrogen/progestin ring which contains the synthetic progestin Nestorone (16-methylene-17alpha-acetoxy-19-nor-pregn-4-ene-3, 20-dione) plus the synthetic estrogen, ethinyl estradiol (EE) (Johansson & Sitruk-Ware, 2004).
Figure 2: Diagram of the Nestrone / Ethinyl Estradiol Contraceptive Vaginal Ring. Abbreviations: Norestrong/ethinyl estradiol - NES/EE. (Johansson & Sitruk-Ware, 2004)
This vaginal ring can be left in place for three out of four weeks and removed for the remaining week (Planned Parenthood, n.d.). This helps to prevent. For women who are wanting to prevent pregnancy the use of a combination contraceptive ring is the best (Johansson & Sitruk-Ware, 2004). The use of estrogen and progestin as used in the oral formulation is widely considered the optimal hormonal contraceptive method (Johansson & Sitruk-Ware, 2004).

Recent FDA approval for vaginal rings contain etonogestrel/EE (Johansson & Sitruk-Ware, 2004). These are the Nuva® ring, Organon USA, Roseland, N.J, which is available to women in the US. The Population Council developed a ring to release a combo of progestin and estrogen, which contained norethindrone acetate (NETA) and EE. This was originally used for three months periods, but was reformulated to last for twelve months. However, due to a finding that it caused ovulation problems it was discontinued and another formula was made. The new formula contained a synthetic progestin Nestorone along with a synthetic estrogen ethyl estradiol (EE) known as NES. NES is a progestational agent that is derived from 19-norprogesterone which can be more potent than its counterpart levonorgestrel. With the NES and EE developed by the council it was made effective for 12 months (Johansson & Sitruk-Ware, 2004).

The hormones are implanted within the core of the ring and are released with the range of three weeks to one year (Johansson & Sitruk-Ware, 2004). It is taken up by the skin and the vaginal epithelial membrane easily (Alvarez-Sanchez, Brache, Jackanicz, & Faundes, 1992). The steroid in the ring is within two rods where one contains NES alone
and the other has both NES and EE (Alvarez-Sanchez et al., 1992). The Population Council is trying to identify a competitively priced, long term contraceptive method that will remain active for the longest duration which is extremely important for developing countries (Johansson & Sitruk-Ware, 2004).

There are other rings in development, including a progesterone-only ring, a steadily released progesterone that is intended for contraceptive use (Johansson & Sitruk-Ware, 2004). However, it cannot be used by women that are breast feeding because the use of steroids can lead to exposure of the newborn infant via breast milk (Johansson & Sitruk-Ware, 2004). This new ring can be as effective at preventing pregnancy as the copper T-shaped IUD (Zegers-Hochschild et al., 2000). It can also be used for progesterone therapy during in vitro fertilization (IVF) (Sivin et al., 1997).

Emergency Contraception Pills

Emergency contraception pills are used to prevent pregnancy for up to five days after unprotected sex (Planned Parenthood, n.d.). There are two types, the morning after pill and the Paragard® IUD insertion. There are also two types of pills. The first is the levonorgestrel (LNG) pill which is most commonly known as Plan B® and the ulipristal acetate pill, also known as the Ella®.

The LNG is a progestin-only pill that suppresses ovulation by delaying the luteinizing hormone (LH) surge (Figure 3) (Koyama et al., 2013). It must be taken before
the surge begins. When the pill is taken closer to the ovulation time it can be less effective (Koyama et al., 2013).

![Menstrual Cycle Diagram]

**Figure 3: Menstrual Cycle.** Shown is the progression of hormones and its affect in the uterus. (Koyama et al., 2013).

The Ella® pill keeps a woman’s ovary from releasing an egg for longer than usual (Planned Parenthood, n.d.). It is also known as Ulipristal® and is used after unprotected sexual intercourse occurs (“Ella (Emergency Contraceptive) - Drugs.com,” n.d.). It is not intended to be used as a regular form of birth control. Ella has been known to cause harm to an unborn baby or cause birth defects. With this information it is important to note when a woman’s menstrual period occurred to make sure that pregnancy has not been established (“Ella (Emergency Contraceptive) - Drugs.com,” n.d.).
Emergency contraceptives cause alterations in hormone levels and changes in menstrual bleeding (Table 2) (Koyama et al., 2013). The side effects from the dosage leads to a mild nausea, vomiting, and headaches. When comparing the Yuzpe® and the LNG pill methods, the Yuzpe® method had the highest incidence of side effects (including nausea and vomiting) while the LNG had absolute no contraindication (pregnancies). The LNG pill was shown to be well tolerated with nausea at 2% and vomiting in 5.6%. Less common side effects include fatigue, dizziness, headaches, mastalgia, and disruptions in the menstrual cycle (Koyama et al., 2013).

**Reversible Method- Barrier Method**

The **Sponge** is a soft, round, plastic foam that contains spermicides that are constantly released. The sponge can be infused with a spermicide called nonoxynol-9® which helps to maintain an inhospitable acidity within the vagina (Holmes, Hoskins, & Gross, 1980). The foam is made from polyurethane and has a nylon loop attached for easy removal (Vincent & Greenberger, 2012). It can be inserted before intercourse and keeps sperm from joining the egg by covering the cervix and blocking the uterus (“Planned Parenthood,” n.d.).

When inserting the sponge it is best to insert upside down with the loop facing towards the outside of the vagina for easily removal (Vincent & Greenberger, 2012). The sponge can be inserted before any sexual activity and remain in place for repeated activity for a 24 hour time period (must not be kept in for more than 30 hour after
insertion). Also, after activity must be removed a minimum time period of 6 hours after sex (Vincent & Greenberger, 2012).

For cleaning, the sponge can be washed repeatedly and reused. The washing solution can be a simple buffer salt solution (Holmes et al., 1980). There have been problem associated with usage of the sponge. The sponge does not protect against STDs and STIs (Vincent & Greenberger, 2012). It has been found to be 89-91% effective for certain women. However, in women who have had children it has been shown to be less effective (Vincent & Greenberger, 2012).

The advantages of using the sponge method as a birth control alternative is that it is easy to carry and use, can be inserted for 24 hours, is immediately effective, it doesn’t affect fertility, can’t be felt by the woman or partner once inserted, and lastly can be used by women breastfeeding (Hales, 2008). The disadvantage of the sponge includes difficulty to remove, less effective if they have had children, doesn’t protect against STDs and STIs, requires an advance planning in order to place causes irritations and toxic shock syndrome (Hales, 2008).

Some cases have had expulsion during bowel movement and the development of odors after intercourse or menstruation (Holmes et al., 1980). Side effects of using the sponge includes vaginal irrational, allergic reactions, and an increase risk in toxic shock syndrome (Hales, 2008). The sponge is available to the public without a doctor
prescription. To hold the sponge in place while in the vagina there are depression that hold onto the cervix (Hales, 2008).

The diaphragm is a shallow, dome-shaped cap with a flexible rim made from silicone or latex (“Planned Parenthood,” n.d.). Used by covering the cervix to block entrance of sperm into the uterus. This must be used along with a spermicide (“Planned Parenthood,” n.d.). The diaphragm has metal springs in the rims in order to exert pressure on the vaginal walls and urethra to stay in place (Hales, 2008). There are nine to ten sizes available for fitting at the doctor’s office (Benson, 1998). Size variations can depend on weight gain (20 plus/minus pound requires fitting), birth of baby, time of fitting. Can be worn for up to 24 hours but no more than that (Benson, 1998).

With the various sizes, there needs to be a proper fitting consultation with a professional medical advisor where women can be properly educated on how to insert and remove the diaphragm (Benson, 1998). This needs to be done because if done the improperly it could result in pregnancy. At the doctor’s visit they teach that the diaphragm is to be inserted one hour before intercourse along with the spermicide (Benson, 1998). Before insertion fill the diaphragm two-third full with spermicide jelly and smear some around the edges (Mucciolo, 2000). Then pick a comfortable position (either laying on back with knees up, squatting, or standing with one leg propped up) for easy insertion (Mucciolo, 2000).
If inserted more than one hour prior, additional spermicide may be required before intercourse is to occur (Benson, 1998). After intercourse, the diaphragm must be left in place six to eight hours and if intercourse occurs more than once each time requires additional use of the spermicide. If left out in the open for long periods it can dry out and crack (Benson, 1998).

Side effects include a puncture of the latex, vaginal abrasion, increase risk of urinary tract infections, and toxic shock syndromes (TSS) (Hales, 2008). Latex can cause allergic reactions and can be easily punctured by fingernails. It can also deteriorate quickly if exposed to petroleum products (lubricants, oils) and heat or light. Diaphragm usage needs special care and may cause odors (Hales, 2008).

Problems associated with the diaphragm can be a dislodgement with the movement of a large bowel movement (Benson, 1998). There are no serious health risks but allergic reactions and TSS can occur. The toxic shock syndrome is a bacterial illness that can occur in less than 10 women per 100,000 users. Women who decide to use the diaphragm need to be aware of the symptoms of TSS. These include a sunburn rash, fever, nausea, vomiting, and muscle aches. If two or more of these occur while using the diaphragm, immediately seek medical assistance (Benson, 1998). The advantage of using this method over the other is that sexual intercourse can occur during a woman’s menstrual cycle (Mucciolo, 2000). The diaphragm can block the menstrual flow and prevent it from spilling out of vagina. If women do choice to engage it is important to keep the device in for more than several hours (Mucciolo, 2000).
The Cervical Cap is a silicone cap shaped like a sailor’s hat. It is similar to the diaphragm in that it can be inserted to cover the cervix, thus, blocking access of sperm into the uterus. This must be used in conjunction with a spermicide. The market brad is known as Fem Cap® (“Planned Parenthood,” n.d.).

The Fem Cap® is a non-hormonal latex free devise that can conform to the anatomy of the cervix and vagina (Hales, 2008). The Fem Cap® requires a prescription and must be fitted by a health care provider to ensure a proper measurement (Unzeitig & Lunsen, 2000). It has to fitted by a physician due to variation of the cervix size, shape, and angle in comparison to the vagina (Unzeitig & Lunsen, 2000). It is available in three sizes small, medium, and large (Hales, 2008). The small cap is for women who have never been pregnant, medium for women who have been pregnant but had an abortion or c-section, and large for women who have delivered full terms babies vaginally (Hales, 2008).

There are other changes that are taken into account such as bodily reactions during menstruation, ovulation and intercourse (Unzeitig & Lunsen, 2000). During intercourse there is a 3-5 cm elongating of the vagina and after ovulation the cervix lowers and firms by similar lengths. While after menstruation the cervix is low in vagina and firm to touch. As the cycle progresses the cervix rises higher in the vagina and softens in response to an increase in estrogen levels (Unzeitig & Lunsen, 2000).
After the doctor’s visit the patient receives two devices, one to be kept at home and the other to be placed in a purse for easy access (Unzeitig & Lunsen, 2000). The device must be inserted before sexual arousal begins in order to ensuring a proper fitting, it should however not be inserted after arousal has begun. This requires pre-planning of sexual activities. It can be left in place for a couple of hours for a maximum of 48 hours (Unzeitig & Lunsen, 2000).

During application, apply the spermicide to outer brim and round the edge of the side facing into the vagina (Unzeitig & Lunsen, 2000). The cap fits into the fornices of the vagina by using contraction causing the brim to adhere and conform to the vaginal walls. The Fem Cap® has also been proven to be very durable in that it is made from a silicon rubber that can be heated and cooled uniformly. It is also able to withstand extreme temperatures and cannot be punctured by fingernails. It is easy to clean, with stand petroleum products (lubricant, oils), and does not absorb or cause odors (Unzeitig & Lunsen, 2000).

**Male Condom** is made of a thin, plastic, latex that helps to protect against sexual transmitted diseases (STD), prevent pregnancy and keep sperm away from the egg (“Planned Parenthood,” n.d.). The use of condoms can lead to a decrease in the incidence and transmission of STDs like HIV (Strauss III & Barbieri, 2013). STDs are transmitted by infectious semen, vaginal discharge, infected skin or mucosal surfaces. When applying the condom it is important to have a fully erect penis and about half an inch at the tip of the condom for ejaculation. When removing after intercourse one must be careful of spillage
upon withdrawal. Failure rates have been reported to be about 14%. Sexually active teenagers have been shown to be the most likely to use condoms (at approximately 60-80%) (Strauss III & Barbieri, 2013).

There are three commonly used materials to make condoms; latex, polyurethane, and lamb caecum (Sloane, 2008). Each of the three has its advantages and disadvantage over the other. The latex condom has been shown to be better at providing protection against vaginal or penal discharges rather than protecting against exposure to skin or tissue. The polyurethane condoms are more prone to slippage but can be stored virtually anywhere. Lastly the lamb caecum has small pores that allow viruses and bacteria to pass but allows for a natural feeling. Possible side effects condom use include skin irritation, abrasions to skin, allergic reaction to latex, and the development of dermatitis from the use of lubricants and spermicides. If one of these problems occur, the best solution is to try another brand (Sloane, 2008).

The male condom is the oldest form of birth control and prevention. It is also the least expensive and is readily available (Smith, 1998). The condom comes in a variety of colors, textures, flavors, and sizes. It was designed to fit the average penis size of most Americans, which measure at 6.8 inches (17 cm) long, 2 inches (5cm) wide and 0.001 to 0.004 inches thick. It can also come lubricated or unlubricated and come with or without spermicides. If choosing to use a latex condom it is recommended to use a water-based lubricant to limit deterioration. Condom are manufactured based on how there are going
to be used. Therefore, individuals can purchase different condoms for vaginal, anal or oral sex (Smith, 1998).

It is important to not reuse the condoms after first usage, to change condoms after 30 minutes of intercourse, check expiration dates regularly, store properly, and don’t use along with female condom (Brown, 2012). You do not want to use with the female condom because it causes friction and slippage (Brown, 2012).

**Female condoms** are a plastic pouch where one end is closed, while the other end is open and spanning the entire vagina (Planned Parenthood, n.d.). It provides protection from STDs such as HIV and leads to a decrease in their incidence rates (Holden, 2008). The female condom is not very accessible due to the lack of availability. It has been shown to provide women with a sense of empowerment by having an edge in their ability to negotiate for safer sex, increasing their sense of control and safety during sex. The condom is preferred more than the male counterpart because it increases flexibility with timing of wearing and taking off, and it provides a more natural feel (Holden, 2008).

It can also be referred to as femidom® and is strong, soft, and can be made of polyurethane plastic or nitrile (Dyk, 2008). The polyurethane material allows for the use of oil-based or water based lubricants, high temperatures, and high humidity because they won’t break down the material, unlike latex. The material allows it to be stored anywhere unlike the latex in the male condom. The design is very unique in that it has two flexible rings, one at the closed end that is inserted into the vagina and the other at
the open end which remains outside of the vagina and spreads over the external genitalia. The pouch spans the same length as the male condom and is also a one-time use only product. It can be inserted hours before intercourse and can be left in place several hours after for repeated use (Dyk, 2008).

The condom provides extra protection because it can be used during a woman’s menstrual cycle and it covers the areas on the penis and vagina where STIs can easily enter the body (Dyk, 2008). The cons with this product is that they are normally more expansive, not as acceptable or accessible (Dyk, 2008). This product is not meant to replace the male condoms, but to be an available market option.

**Fertility awareness** is based on the charting of a woman’s monthly cycle to avoid the ovulation week. This is based on the life span of the egg and sperm. Since the egg can live for a day and the sperm for 6, you then have five days before ovulation, the day of ovulation, and a day or two after ovulation (Planned Parenthood, n.d.).

**Outer course** is any sexual activity with or without vaginal intercourse. This means no oral, anal or vaginal penetration (“Planned Parenthood,” n.d.).

**Permanent Birth Control Method**

There are three permanent sterilization methods that are used to ensure that pregnancy will not occur. They consist of tubal ligation and transcervical sterilization, which are both conducted on a female, as well as vasectomy done on males. These
methods have all shown to have a failure rate of less than one percent, resulting in an accurate birth control method.

**Tubal ligation**, also known as tying of tubes, is a procedure carried out by a physician in office. The surgery must be performed when the patient is at the end of her menstrual flow but before the ovulation time period (Korenbrot, 1981). There are three ways to performing a tubal ligation, either abdominally (also known as the Pomeray technique), vaginally, or endoscopic (Laparoscopic technique). They can be done at the time of abortion, after delivery, or when not pregnant (Korenbrot, 1981).

The physician provides both a local and general anesthesia and makes an incision less than one centimeters under the umbilicus through a laparoscopy technique (Pillitteri, 2013). A lighted laparoscopy is placed into the incision and pump in carbon dioxide in order to lift the abdominal wall upward. This allows for the belly to be out of the physical line of vision and allows them to view the fallopian tube. Once this is obtained there are three ways to block the fallopian tube and stop the passage of the sperm or the ova (Pillitteri, 2013).

The first method is to pump an electrical current through the tube for three to five seconds to coagulate the tissue (Pillitteri, 2013). The second is to clamp the tubes with either plastic, metal or rubber rings and then cut. The last method is to fill a portion of the tubes with a silicone gel to block flow. Either three can lead to the same result, lack of pregnancy. After the procedure, the patient can be discharged from the hospital within a
few hours. Surgical side effects within 24 hours include abdominal discomfort, bloating, and sharp shoulder pains (due to gas) until carbon dioxide is absorbed. There could also be bowel perforation and hemorrhage from the surgery (Pillitteri, 2013).

Side effects from the surgery include changes to the ovaries blood supply (which can result in an increased risk of starting menopause earlier (due to blood supply being compromised)), a somewhat protectiveness against ovarian cancer and post-tubal-ligation syndromes (Pillitteri, 2013). These syndromes consist of an increase in menstrual cramping, irregular periods, and heavier bleeding which all can occur if the patient was on the pill prior to procedure (Pillitteri, 2013). The risk of death from this procedure is less than those of hysterectomy but there is a 0.05 to 0.10 percent chance for a health women 35 years old (Korenbrot, 1981). These women also have a 5 to 10 chance of subsequent pregnancies.

Transcervical Sterilization- this method does not involve surgical incisions and general anesthesia and is sometimes referred to as Essure®. The Essure® technique was approved by the FDA in 2002 to provide a less invasive option for patients (King, Brucker, Kriebs, & Fahey, 2013). It can be done as an outpatient or office setting without general anesthesia or prolonged hospital admission. What generally occurs is a device is insert in through the vaginal and travel to the fallopian tubes (Figure 4). This device contains polyester fibers within micro inserts that create an irritation and growth of new tissue that results in a permanent occlusion of the tubes. The micro inserts are small metal springs that
are placed at the proximal end of each tube. When released they expand and anchor to the tube. This overtime creates a scar tissue that leads to the occlusion of the fallopian tube (King et al., 2013).

Figure 4: Tubal Ligation. Shown is the steps on how tubal ligation using the Essure® method occurs (King et al., 2013).

Vasectomies are the most popular form of male sterilization (Pollard, 2011). They are done by an urologist. A vasectomy occurs when the physician makes a small incision and gives a local anesthetic to the scrotum area. In this procedure they locate the vas deferens which functions as a passage avenue for sperm to then be released. The physician attempts to remove a section of the vas deferens but cutting and blocking off the route. This blockage can be done by using a combination of titanium clamps and scarring of
tissue. It is important to note that the vas deferens has been known to regenerate, in order to fully prevent the fallopian tubes need to be cauterized (burned) using electricity (Pollard, 2011). The failure rate is less than one percent but requires several months to achieve full contraceptive efficiency (Chao, Page, & Anderson, 2014). It should also be noted that reversal of the procedure can be costly and unreliable (Chao, Page, & Anderson, 2014).
CURRENT STUDIES

**Vaginal Rings**

The use of vagina rings has been proven as an effective contraceptive that can provide a good inhibition of ovulation (Table 1) (Titia, Mulders, & Dieben, 2001).

**Table 1: Contraceptive efficacy and ovulation inhibition.** Shown is the currently approved or under investigation of vaginal rings. (Johansson & Sitruk-Ware, 200)

<table>
<thead>
<tr>
<th>Type</th>
<th>Effectiveness (in mon)</th>
<th>Ovulation inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Etonogestrel/EE*</td>
<td>1</td>
<td>Yes</td>
</tr>
<tr>
<td>Progesterone†</td>
<td>3-4</td>
<td>Yes</td>
</tr>
<tr>
<td>Nestorone</td>
<td>6</td>
<td>Yes</td>
</tr>
<tr>
<td>Nestorone/EE</td>
<td>12</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* NuvaRing approved in United States and Europe.
† Approved in Chile and Peru.

Roumen et al., reported only six pregnancies occurring in their population of 1145 women treated with the etonogestrel-containing ring, three of these pregnancies were in women who had clearly violated compliance criteria during the cycle of conception (Roumen, Apter, Mulders, & Dieben, 2001). Weisberg et al. reported no pregnancies in
either of the two trials of the NETA/EE ring used for 60 and 61 women (Weisberg et al., 1991). Combined oral contraceptives, IUD’s and contraceptive implants have unwanted pregnancy rates of 0.1%, 1.5 to 0.6%, and 0.5% in the first year of use, respectively (Weisberg et al., 1999).

The most common schedule is the three week in/ one week out (Johansson & Sitruk-Ware, 2004). The ring is inserted in the vagina on day five of the menstrual cycle and left in place for three weeks. The following ring (week four) the ring is removed for withdrawal bleeding. The old ring can then be discarded and a new one reinserted or the same ring can be reinserted after a one week break. It is important to note that a specific day and hour must be chosen for insertion and withdrawal to avoid confusion (Johansson & Sitruk-Ware, 2004).

To avoid bleeding issues researchers have used the 26 days on and four days out schedule (Johansson & Sitruk-Ware, 2004). Others have used methods that are based on the insertion of bleeding, signals where the ring is inserted and removed only when menstrual bleeding begins. The ring then remains out for four days and is reinserted at that point whether bleeding has stopped. However, this method has shown to lead to an irregular bleeding pattern (Johansson & Sitruk-Ware, 2004).

Researchers have also tried to gather ways to accurately balance the hormone levels that are released from the ring (Johansson & Sitruk-Ware, 2004). In the ring with NES only delivery the experimental rate for ovulation suppression was 50, 75, or 100
μg/day. This dosage method leads to a high rate of ovulation suppression. With 100μg/day having 1.2% of the cycles studied showed little to no luteal activity (Table 2). In the ring combined with EE and NES, the delivery rate was 150 μg/day, which showed a high percentage of ovulation suppression with good bleeding pattern and few side effects (Johansson & Sitruk-Ware, 2004).

Table 2: NES Rings: Percent of Total Cycles with no Luteal Activity. Samples were measured at 50, 75 and 100μg/d. (Johansson & Sitruk-Ware, 2004).

<table>
<thead>
<tr>
<th>NES</th>
<th>50 μg/d</th>
<th>NES</th>
<th>75 μg/d</th>
<th>NES</th>
<th>100 μg/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>% cycles with P &lt; 10 nmol/L</td>
<td>97.5%</td>
<td>97.4%</td>
<td>98.8%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P, Progesterone. (Adapted with permission from Brache et al.)

* Luteal activity is defined as P ≥ 10 nmol/L.

A recently approved ring combination with etonogestrel (active derivative of deogestrell) and EE (Nuvaring®, Organon USA) was evaluated and found that the bleeding pattern in the experiment varied when compared to the regular cycle (Johansson & Sitruk-Ware, 2004). In the study with NES-containing combination ring it was associated with good bleeding control with the period of menstrual bleeding being less than one week (Johansson & Sitruk-Ware, 2004). In the experiment with the etonogestral/
EE ring carried out by Roumen et al., irregular bleeding occurred at a rate of only 2.6% to 6.4% (Roumen et al., 2001). This consisted of primary spotting with breakthrough bleeding reported in only 0.4% to 1.1% of cycles (Johansson & Sitruk-Ware, 2004). Withdrawal bleeding (with one week of treatment) occurs in only 5.4 to 7.4% of cycles and was absent in 0.6 to 0.2% of treatment breaks. The duration of withdrawal bleeding being 4.7 to 5.3 days (Johansson & Sitruk-Ware, 2004).

**Copper IUD and Emergency Contraception Levonorgestrel**

In a study evaluating a total of 7,034 patients there were only 10 pregnancies with a failure rate of only 0.14 percent (Koyama et al., 2013). Some evidence showed that copper IUDs are more effective if they contain at least 380mm² of copper. It can be the only form of Emergency contraception (EC) that can provide an ongoing contraception for years when left in place. It requires expertise and equipment necessary for insertion. Side effects include pain during the insertion process and increases menstrual bleeding. If discomfort occurs, the use of non-steroidal anti-inflammatory drugs (NSAIDs) and local anesthesia are commonly utilized if discomfort if experienced during the procedure (Koyama et al., 2013).

Studies have found that with the use of the emergency contraceptive pill LNG, it can lead to an increase in the amount of glycodelin in the body which prohibits fertilization after ovulation occurs (Koyama et al., 2013). After ovulation occurs LNG has only minor effects on corpus luteum function and is thought to be ineffective after fertilization occurs. This can be proven in experiments with rats and monkeys where
studies indicate little fertilization problems by LNG. Researcher generally agree that LNG does inhibit ovulation (Koyama et al., 2013).

A trail experiment done on the LNG pill versus the Yuzpe® method (an earlier regimen which consisted of higher doses of estrogen/ progesterone combination oral contraceptives) using 1998 women in a double-blind study, indicated that pregnancy rates were quite low with the use of LNG (Koyama et al., 2013). The data showed pregnancy rate being 1.1% in the LNG group and 3.2% in the Yuzpe® group with a yielding relative risk of 0.36. If used within 72 hours of intercourse the efficacy for LNG was 85% vs the counterpart, Yuzpe® with 52% (Table 3) (Koyama et al. 2013).

When estimating the conception probability efficacies of LNG, researchers have found that it decreases with time from 95% at 24 hours to 58% within 48-72 hours (Koyama et al., 2013). This finding showed that early administration of LNG is imperative to the efficacy of the pill. To guarantee accurate results, the recommended time is within 72 hours, even though it can be used between 72 to 120 hours after sex. However, LNG has been proven ineffective once fertilization has occurred (Koyama et al., 2013).
Table 3: Methods and Efficacy of Emergency Contraception. Table taken from Koyama et al., 2013

<table>
<thead>
<tr>
<th>Method</th>
<th>Dose</th>
<th>Timing after intercourse</th>
<th>Adverse effects</th>
<th>Relative contra-indications</th>
<th>Absolute contra-indications*</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper IUD</td>
<td>Single IUD</td>
<td>0–120 hours</td>
<td>Pain, bleeding</td>
<td>Bleeding disorders, ovarian cancer, high individual likelihood of exposure to gonorrhea/chlamydia, AIDS</td>
<td>Current pregnancy, active pelvic infection, copper allergy, undiagnosed vaginal bleeding, pelvic tuberculosis, Wilson’s disease, known or suspected pelvic malignancy, uterine abnormalities that distort the uterine cavity</td>
<td></td>
</tr>
<tr>
<td>Levonorgestrel</td>
<td>1.5 mg</td>
<td>0–72 hours (may be used up to 120 hrs with decreased efficacy, and off-label) 0–120 hours</td>
<td>Nausea, vomiting, headache, menstrual changes</td>
<td>None</td>
<td>None</td>
<td>Efficacy decreased in morbidly obese Efficacy decreases with time</td>
</tr>
<tr>
<td>0.75 mg × 2 (equal efficacy)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ulipristal acetate</td>
<td>30 mg</td>
<td>0–120 hours</td>
<td>Nausea, vomiting, headache, menstrual changes</td>
<td>Renal/hepatic impairment, uncontrolled asthma, breast feeding (can pump and discard milk for 36 hours)</td>
<td>Sensitivity to Lactose monohydrate (including galactose intolerance)</td>
<td>Efficacy decreased in morbidly obese Limited safety data in &lt; age 18 No change in efficacy with time (up to 120 hours) Availability limited to Armenia, China, Russia, and Vietnam</td>
</tr>
<tr>
<td>Mifepristone</td>
<td>10–50 mg</td>
<td>0–120 hours</td>
<td>Nausea, vomiting, headache, menstrual changes</td>
<td>None</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Yuzpe method</td>
<td>Combination estrogen/ progesterone pill- dose depends on pill brand used</td>
<td>0–72 hours</td>
<td>Nausea, vomiting, headache, menstrual changes</td>
<td>None</td>
<td>None</td>
<td>Higher side effect profile</td>
</tr>
</tbody>
</table>

Notes: *An established pregnancy is a contraindication to all of the above. While LNG and UPA are not abortifacients, an established pregnancy is a contraindication as they will not be efficacious. For the copper IUD, pregnancy is a contraindication as there is an increased risk of septic abortion and serious pelvic infection. For ulipristal acetate, it is contraindicated in pregnancy as animal studies showed increased pregnancy loss. **Low doses of mifepristone are used for EC. High doses of mifepristone (200 to 600 mg) are used as an abortifacient either alone or with misoprostol, a prostaglandin analogue.**
**Male Birth Control**

The idea that prevention of pregnancy can only be targeted for only women has been thrown out due to the new feminist movement. There have been many research conducted on birth control methods for women but for a man the methods are limited with the use of the condom and vasectomy. Within the last 20 years there has been a shift and a push for male contraceptives. Researchers have attempted to evaluate several methods in limiting a male’s sperm count (oligospermia) or to completely cause infertility (Table 4) (Chao, Page, & Anderson, 2014). There have been many obstacles in producing a drug that can be fully reversible, safe for long term use, and render a male infertile (Chao et al., 2014).

**Table 4: Causes of male infertility.** Shown is the infertility chart based on semen analysis. (Becker, 2001)
So far condoms use have shown to have high failure rates (with 12 out of 100 couples conceiving in the first year of use) and inconsistent usage (Chao et al., 2014). There have been several drugs tested on mice and other mammals that are either hormonal or non-hormonal. Hormonal drugs work by suppressing the hypothalamic-pituitary-gonadal axis to stop spermatogenesis (Figure 5). This can occur through the bodies’ use of gonadotropin-releasing hormone (GnRH). GnRH is secreted from the hypothalamus and travels to the pituitary to trigger the release of the hormone FSH (follicle stimulating hormone) and LH (Luteinising hormone) into the blood circulation. The LH in males stimulate Leydig cells of the testes to produce testosterone and the FSH stimulates the Sertoli cells to support spermatogenesis (Chao et al., 2014).

**Figure 5: The hormone basis of male contraception**: Shown below is the pathway of spermatogenesis. (Chao et al., 2014)
Both hormones are required to produce sufficient amounts of sperm (Chao et al., 2014). If pathway is hinder or suppress, it can lead to a man to become azoospermia (infertile) or have low sperm in ejaculate (Table 4). To suppress the product in of GnRH, LH, or FSH, one must administer exogenous testosterone (Chao et al., 2014). This in turn causes a reversible inhibition on endogenous testosterone production and spermatogenesis (Becker, 2001).

With the dosing of these types of hormones, one must be able to maintain serum and testosterone levels and extend androgen action at target tissue within a normal physiological range (Chao et al., 2014). Androgens with or without progesterone or GNRH analogues can be used to suppress endogenous gonadotropin and sperm production (Becker, 2001). It is absolutely required to both suppress gonadotropin secretions and replace endogenous testosterone suppressed by other agents (Becker, 2001).

**Table 5: Semen Characteristics.** Shown below is the various concentration of semen. (Becker, 2001)

<table>
<thead>
<tr>
<th>Semen Characteristic</th>
<th>Good</th>
<th>Equivocal</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sperm</td>
<td>&gt;60 × 10⁶</td>
<td>40–59 × 10⁶</td>
<td>&lt;40 × 10⁶</td>
</tr>
<tr>
<td>Sperm density</td>
<td>&gt;20 × 10⁶/mL</td>
<td>10–19 × 10⁶/mL</td>
<td>&lt;10 × 10⁶/mL</td>
</tr>
<tr>
<td>Volume</td>
<td>&gt;2.0 mL</td>
<td>1.0–1.9 mL</td>
<td>&lt;1.0 mL</td>
</tr>
<tr>
<td>Motility</td>
<td>&gt;60%</td>
<td>40–59%</td>
<td>&lt;40%</td>
</tr>
<tr>
<td>Motility grade</td>
<td>&gt;3.0</td>
<td>2.5–2.9</td>
<td>&lt;2.5</td>
</tr>
<tr>
<td>Oval forms</td>
<td>&gt;60%</td>
<td>40–59%</td>
<td>&lt;40%</td>
</tr>
</tbody>
</table>

The hormonal agent first used to create these results was testosterone enanthate. This hormone was reversible and effective in provide a contraceptive regime (Becker,
Researchers found that 65 percent of test subjects became azoospermic, 30 percent had oligospermia, and 0 to 0.8 pregnancies out of 100 per year resulted and had an efficacy rate of 99% (Chao et al., 2014). They also saw no serious side effects. What resulted was acne, weight gain, a decrease in testicular volume, an increase in haemoglobin and a 10 to 15 percent decrease in HDL levels. The researcher did however find that there was a delay in effectiveness (3-4 months), potential fertility reversal, and inconvenient weekly injection became a problem (Chao et al., 2014).

Other studies were conducted using testosterone undecaonate, testosterone pallets, patches, shots, gels etc… With the undecaonate drug, one dose was given every 10 to 12 weeks (Chao et al., 2014). Studies showed that 208 out of 299 men either developed azoospermia or oligospermia (less than 3 million sperm/ml) with 96.7 percent effectiveness. They saw a slower recover time for spermatogenesis when compared to the testosterone enanthate but side effects were similar. In the study with the testosterone pallets researchers found that it delivered a steady concentration, but need replacement every 3-6 months and needed to be combined with the etonogestrel implant. The transdermal testosterone (patch) found that it was not effective in 50 percent of men because of the delivery concentration (Chao et al., 2014).

The non-hormonal method aimed to disrupt spermatogenesis or sperm-egg interaction by interfering with sperm motility, testicular targets, and epididymal targets (Chao et al., 2014). A non- hormonal example for inhibiting sperm motility or sperm-egg fusion is 3-phosphate dehydrogenase-S or GAPDS. GAPDS is an enzyme that is specific
for sperm glycolysis. With this enzyme blocked sperm consumption of ATP is hindered. Studies done on mice found that infertility and a shorter contraceptive action resulted with the use. An example of a testicular target is JQ1, which is a molecule inhibitor of testis-specific bromodomain (BRDT) an epigenetic reader protein. BRDT is essential for chromatin remodeling during spermatogenesis. Results showed a complete or reversible contraceptive agent in mice and found the drug to have an apparent toxicity (Chao et al., 2014).

HE6 and CRISP-1 have been shown to be epididymal targets in male contraceptives (Chao et al., 2014). HE6 displays an epididymis-specific expression pattern that has been studied in mice. This experiment showed to result in a defect in the reabsorption of testicular fluids in the efferent epididymal ductals. CRISP-1 however is a glycoprotein that is secreted by the epididymal epithelium. In experiments done on rats it was show for CRISP-1 to suppress the sperm capacitation and inhibit sperm-egg fusion (Chao et al., 2014).

Health Care –Affordability

There has been an increasing need for control of the world and national population size. A few years ago the idea of birth control was considered to be offensive or taboo but now with the earths limiting resources and space the issues has become acceptable to talk about (JAMA, 2014). All groups (including Roman Catholic Church) agree that parenthood should be for those that can responsibly care for children. A child should not be brought into the world if they cannot be loved, educated or wanted. They
also agree that unintended pregnancies tend to result social problems such as illegal abortions, desertion, despair, and hopeless poverty (JAMA, 2014).

Nearly 49 percent of all pregnancies are unintended (Trussell et al., 2013). The reason is because of their lack of adherence to contraceptive use. This results in the total cost to U.S. taxpayer of 9.6 to 12.6 billion dollars per year. If adherence is high, the risk of unintended pregnancies (UP) would be significantly lower, but due to real world situation that is not always possible (Trussell et al., 2013). Studies show that 23% of minority women reported that they were unable to visit a doctor due to cost, lack of child care, etc as compared with 15% of white women (Table 5) (Majority Staff of the Joint Economic Committee, 2011). Also, 26% Native American and 27% Hispanic reported the same due to prohibitive cost (Committee, 2011).
**Table 6: Income.** Shown is the various reason for not going to the doctors based on income levels (Majority Staff of the Joint Economic Committee, 2011).

The 2010 Federal Medicaid reform stated that women of low-income shall have the same choices for family services (Winter, 2013). The women qualifying for medical assistance were covered based on four situations. The first was there access to contraception services (including abortion), the prescription birth control option, and availability of the morning after pill and lastly access to clinics (Winter, 2013). The U.S Patient Protection and Affordable Act promoted funding for family planning services (Chuang et al., 2012). Since then coverage has become a standard practice for private insurance and federally funded insurance programs (Chuang et al., 2012).

Also, along with this President Obama upheld the Hyde Amendment which continued the ban on federal funds for abortion in the context of health reform (Chuang et al., 2012). The Affordable Care Act (ACA) or Obama Care requires private health plans
to cover contraceptive methods, services, and counseling without the out-of-pocket fee (Sonfield, Tapales, Jones, & Finer, n.d.). It also changed patients cost sharing, which has the potential to eliminate cost as a reason for choosing one method of contraception over the other. The ACA provided religious affiliated non-profits an accommodation under which they are supposed to be absolved from involvement in covering contraception. It however states that employees and family members must receive coverage through the insurance company (Sonfield, Tapales, Jones, & Finer, 2015).

Twenty-eight out of the fifty states have regulation for requiring private insurers to cover contraceptives (Chuang et al., 2012). Physicians have been a firsthand witness to the consequences of restricted access to family planning services but their voices have been unheard. They endorse insurance coverage and public funding for contraceptives and abortion services (Chuang et al., 2012).

Children of UP are known to have worse health and long term outcomes than children from planned pregnancies (Burlone et al., 2013). It has been shown that by providing contraception’s, it can help to reduce cost-effective and cost-saving use of public funds (Burlone et al., 2013).

Data show that there is a huge difference in access between economic income statues. Women who can afford private physicians are adequately informed and instructed on various birth control methods and are provided with contraceptive supplies (“Birth control in comprehensive health care,” 2014). Meanwhile, indigent women have
to visit public health and welfare agencies and are discriminated against and denied services. There are several reason behind these differences. In some cases, services are prohibited by regulation or local statutes in tax supported health facilities and are omitted from social welfare programs or excluded from public hospitals. Other reasons are due to physicians and public health official act in deference to the law due to a fear of criticism or fear of stirring up controversy (“Birth control in comprehensive health care,” 2014).

Unintended pregnancy are five times more likely in poor women than in affluent women and can impact a women’s health, prospect for education, and impose financial burden on families and society (Laliberté et al., 2014). Children of unintended pregnancies are known to have worse health and long term outcomes than children from planned pregnancies (Burlone et al., 2013). It has been shown that by providing contraception, it can help to reduce cost-effective and cost-saving use of public funds (Burlone et al., 2013).

The Affordable Care Act wants to expand Medicaid coverage to low income Americans because even though it may be costly in some states, it could lead to a potential cost-offset (Laliberté et al., 2014). This is due to the provision of contraceptives which result in fewer pregnancies (Laliberté et al., 2014).
DISCUSSION

Birth control usage has become a trendy topic in today’s society. There are many forms and methods of contraception that can greatly impact a woman’s life. Even though there are many opinions that are against its usage, it has been proven to be effective in reducing the number of unintended pregnancies and decreasing the risks of sexual transmitted diseases. Most options like the shot, implant, and patch, provide a way to rapidly get the protection that is needed. However, many require a certain amount of time to become effective.

All methods described within this thesis can provide an efficient way to protect oneself from getting pregnant but not all can protect against acquired disease from sexual intercourse (Figure 6). Figure 6 below is a summary of the birth control options listed as the least to the most effective. According to the CDC just using a spermicide is not efficient in prevent against pregnancy, it must be used in conjunction with another type of protection. The most effective forms of contraceptive are the IUD, implants and sterilization (both male and female) with risk of pregnancy being less than one percent. The other methods have a high success rate but can also result in failures.

The most effective birth control options are also the most invasive. They require consultation from a medical provider and can be expansive. Many women, especially minorities, are not informed about these options because of lack of insurance coverage.
Figure 6: Effectiveness of Planned Parenthood Methods. Shown are permanent and reversible methods. ("CDC - Contraception - Reproductive Health," n.d.)
There is much research being conducted on ways of improving the already available birth control options. One such approach is through the development of an effective male contraceptive option. However, to fund the projects it sometimes requires government subsides. Many religious groups and local states are against using public money to further advance birth control contraceptives. The Affordable Care Act helps to ensure that uninsured women can be covered for any contraceptive method of their choosing. Since passing the bill, many minorities for the first time can receive and afford medical care and are being informed on options for prevention.

CONCLUSIONS

Contraceptives are a needed protection if one is going to partake in sexual activities. Being able to distinguish between the various methods can help a women to make a proper and educated decision on which method is right for her. It is important that healthcare providers, spouses, partners and parents be able to have an open dialogue about birth control usage. It is important for women to know that inconsistent use and non-use of contraception contribute to high rates of unintended pregnancies. Minorities (Black and Hispanic women) are especially at a higher risk of these events and should be informed of the risk associated with noncompliance. Intervention to ensure counseling and information exchange during health care visits can increase a women’s ability to make an informed decision.
REFERENCES


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11.
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EDUCATION

Boston University, Boston, MA • 2013 (current)
Master of Arts in Medical Sciences

University of North Carolina, Charlotte, NC• 2008
Bachelor of Science in Biology, GPA: 3.19
Bachelor of Science in Psychology

WORK EXPERIENCE

Once Upon a Child, Winston-Salem, NC • January 2013 – July 2013
Sales Associate
• Cashier

WBT Holiday on Ice, Charlotte, NC• November 2010 – January 2011
Sales Associate
• Worked at concession stands-sold food and winter gear
• Worked at ticket booth – tickets for admission and ice skates
• Worked at door of the rings- received ticket stubs
• Assisted customers
• Photographer for Santa

Week of Welcome Team Leader, Charlotte, NC • August 2008 – August 2008
Mentor
• Participated in peer-leadership, team-building and multicultural-conscientiousness workshops
• Mentored incoming students to the University of North Carolina at Charlotte
• Aided coordinators with new student orientation events and training of other leaders

VOLUNTEER EXPERIENCE

Relay for Life, Charlotte, NC • March 2009 – March 2009

Student Volunteer
• Participated in the walk for cancer
• Raised Donation

McMillian Green House UNCC, Charlotte, NC • January 2009-June 2009

Volunteer
• Assisted with the upkeep of the Green House

WOW Family Volunteer, Charlotte, NC • August 2008 – August 2008

Volunteer
• Assisted students in improving academic achievement by meeting with them on a regular basis to clarify learning problems and work on study skills

Organization of African Students (OAS), Charlotte, NC, Sept 2008-June 2011

Treasure
• Planned and coordinated special events, service projects, fund raisers and other activities throughout the year
• Presided at board and other meetings, prepared meeting agendas, and ensured that valid voting procedures are used

Carolinas Medical Center (CMC), Charlotte, NC, Jan 2008- April 2008

Volunteer
• Interacted with and assisted Patients
• Took blood pressure

RESEARCH EXPERIENCE

University of North Carolina, Charlotte, NC • August 2009 – April 2012

Undergraduate research assistant
• X-ray Crystallography

Boston University, Boston, MA • August 2014 – April 2015
Graduate Research

- Studying the association between arthritis and periodontal disease

LEADERSHIP AND ACTIVITIES

**Biology Learning Community**, August 2008-2009 Member
- Attended professional development workshops
- Participated events held by the organization

**Organization of African Students (OAS)**, Sept 2008 – 2012
- Attended general meetings
- Vice President- September 2008-May 2009
- Helped promote diversity on campus through various educational, cultural and social activities.

**Beta Beta Beta (TriBeta)**, September 2008-Present
- Attended professional development workshops
- Participated events held by the organization
- Treasurer- January 2010-May 2010

**Campus Advisory Board (CAB)**, September 2008-Present
- Attended professional development workshops
- Participated events held by the organization

**Pre-dental Club**, January 2008 -Present
- Attended events hosted by the organization
- Helped in the implementation of event on campus

**Pilot Leadership Program**, January 2008-Present
- Attended professional development workshops
- Participated events held by the organization

**Campus Bible Fellowship (CBF)**, August 2010-May 2011
- Attended general meetings
- Participated events held by the organization

**Chemistry Club**, January 2012-Present
- Attended general meetings
- Participated events held by the organization