Contraceptive Evolution: Unveiling Emerging Paradigms

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ABSTRACT

This chapter is focused on contraceptive innovation within the realm of reproductive health. The paramount role of contraception in family planning and reproductive well-being is initially underscored. Through an exhaustive exploration of the evolutionary trajectory of contraceptive methods, a solid foundation is established for comprehending the existing array of techniques. Central to the chapter's objective is the illumination of prevailing constraints and complexities linked to current methods, spanning adverse effects, cultural impediments, and issues of reach. Subsequently, the discourse delves into auspicious emerging strategies, encompassing male contraceptives, enduring reversible contraceptives, non-hormonal substitutes, pioneering pharmaceutical distribution systems, precision molecular mechanisms, and breakthroughs in contraceptive technology. Concluding reflections reinforce the imperative of ethical contemplation, pivotal research directions, and endeavors directed at surmounting cultural and societal barriers, all while upholding universal availability and economic viability.

I. INTRODUCTION

A. Importance of contraception in reproductive health

Contraception is defined as an intervention that prevents unintentional pregnancy. It includes various devices, sexual practices, chemicals, drugs, and surgical procedures. Efficient contraception enables a couple to engage in a physical relationship without concerns about an unintended pregnancy and grants them the freedom to plan and have children at their chosen time. A growing array of contraceptives is becoming accessible to couples. Each method has its own distinct advantages and disadvantages. The perfect contraceptive should be effective, reversible, user-friendly, safe, devoid of side effects, independent of coital timing, readily available, and affordable. As an objectively perfect method does not currently exist, the selection of a family planning approach should be tailored to each couple's needs and may evolve over a woman's reproductive life. In addition to safeguarding women from pregnancy-related health risks, contraception presents potential non-health advantages such as enhanced educational opportunities, empowerment of women, and fostering sustainable population growth and economic development in countries [1, 2]. An essential guiding principle in contraceptive counseling is the voluntary and informed selection of the contraceptive method, which significantly contributes to its successful utilization [3].

B. Evolution of contraceptive methods over time

The history of contraception dates back thousands of years and involves varied methods and practices to prevent pregnancy. Ancient civilizations used natural methods like the withdrawal technique, barrier material insertion like honey and lint into the vagina to block the semen, and herbal contraceptives. Condoms as a barrier method were used for the first time using animal intestines and linen sheaths during the 16th and 18th centuries. Vulcanization in the mid-19th century enabled the production of modern rubber condoms, increasing their accessibility and effectiveness. The diaphragm, a reusable barrier method, was also introduced around the same time. In the early 20th century, the first Intrauterine Devices (IUDs) were developed, initially made of metal but later evolving to include plastic and hormonal variations. Cervical caps, another barrier method placed over the cervix, were also introduced during this period. Contraception was revolutionized in the 1960s by the introduction of synthetic hormonal birth control pills. Other hormonal methods, such as the contraceptive patch, injectables, implants, and vaginal rings, were later developed to provide alternative options. Emergency contraception, also known as the morning-after pill, was introduced to prevent pregnancy after unprotected sex or contraceptive failure during the 1970s and 1990s. Initially, high-dose hormone pills were used, but later, dedicated emergency contraceptive pills and copper IUDs became more common.

Contraceptive technology has continued to advance with the development of long-acting reversible contraceptives (LARCs) like the intrauterine device (IUD) and subdermal implants, offering highly effective, low-maintenance options. Male contraceptive methods, such as male condoms, vasectomy, and experimental hormonal injections, are also being researched and explored. Additionally, there is ongoing progress in the development of non-hormonal contraceptives and innovative approaches, such as male contraceptive pills and non-invasive methods.

Overall, the history of contraception showcases a progression from natural and less reliable methods to the development of more effective and diverse contraceptive options. The availability and accessibility of contraception have played a significant role in empowering individuals and allowing them to make informed choices about family planning and reproductive health.

C. Purpose of the chapter

This chapter discusses the present and future of contraception. It serves as a comprehensive guide and an up-to-date review of existing contraceptive methods, their effectiveness, side effects, user considerations, and their limitations and challenges for healthcare professionals, policymakers, and researchers. The chapter also explores emerging trends, including advancements in technology, non-hormonal and male contraceptive methods, and social and cultural factors influencing contraception. By offering a thorough evaluation of current approaches and highlighting innovative developments, the chapter aims to serve as a valuable resource, stimulating further research and development in the field of contraception.

II. EXISTING CONTRACEPTIVE METHODS

Barrier methods

1. Condoms

Male condom: Male condoms are barrier devices that prevent sperm from entering a woman's body during sexual intercourse. They are available in various materials, with latex condoms being the most common type. The primary purpose of male condoms is to prevent pregnancy and protect against sexually transmitted infections (STIs), including HIV, gonorrhea, chlamydia, syphilis, herpes, and the human papillomavirus (HPV). The estimated efficacy rate is 98% with perfect use and 85% with typical use [4].

Female Condom: Female condoms, also known as internal or receptive condoms, are barrier devices made of nitrile or polyurethane. They consist of a flexible pouch with inner and outer rings. Studies indicate an overall effectiveness of about 95% in preventing pregnancy and reducing the risk of STIs when used correctly and consistently. The failure rate is 21% with typical use. Female condoms provide advantages like empowerment, control, and enhanced sexual pleasure. They can be inserted up to 8 hours prior to intercourse, allowing for spontaneity. Proper education on insertion and use is crucial. Female condoms are available at drugstores and clinics, with ongoing efforts to improve accessibility and awareness.

2. Diaphragms and cervical caps

Diaphragms and cervical caps are barrier contraceptive devices made of latex or silicone and designed to cover the cervix and block sperm from entering the uterus. These are typically used with a spermicide. Diaphragms have a typical use failure rate of 17%. Cervical caps are thimble-shaped devices that function similarly and can be left in place for up to 48 hours. They have a typical use failure rate of 14%.

3. The Contraceptive Sponge

The contraceptive sponge forms a barrier containing spermicide and is placed in the vagina to cover the cervix. It acts by preventing sperm from reaching the uterus and is designed to be effective for up to 24 hours. After intercourse, it must be left in the vagina for at least 6 hours before removal and disposal. The typical use failure rate is 14% for women who have never given birth and 27% for women who have previously given birth.

4. Spermicides

Spermicide products consist of two main components: a chemical that is toxic to sperm and a carrier or base for its delivery [5]. The chemicals commonly used in available spermicides are typically surfactants, with nonoxynol-9 being the most common. Other agents like octoxynol, menfegol, and benzalkonium chloride are also used. These agents work by dissolving the lipid components in the spermatozoa's cell membrane, leading to their death or inactivation. Spermicides are placed in the vagina an hour before intercourse and should be left for at least six to eight hours. They are commonly used in combination with a male condom, diaphragm, or cervical cap to increase effectiveness. Typical use failure rate for spermicides is 21% [6].

B. Hormonal methods

Progesterone is primarily responsible for preventing pregnancy. It prevents ovulation by negative feedback at the hypothalamus that reduces the frequency of gonadotropin-releasing hormone (GnRH), which in turn decreases the secretion of gonadotropins– follicular stimulating hormone (FSH) and luteinizing hormone (LH)– from the pituitary gland. The follicles, due to the lack of FSH, fail to develop and raise estrogen, which prevents the LH surge required for ovulation. Estrogen has some effect on slowing follicle development by negative feedback to the pituitary for decreased FSH secretion [7].

1. Combined oral contraceptives (COC) pills:

These are available in two forms- monophasic, where the active pills contain the same dose of both components throughout the cycle, and multiphasic, where the active pills have varying weekly doses of either or both components. Prescribing it depends on the patient's desired withdrawal bleeding as follows:

a. Cyclic formulations- 21-24 days of active pills followed by 4-7 days of placebo days leading to withdrawal bleeding

b. Extended cycle formulations- 3 months of daily active pills followed by a week of placebo days and withdrawal bleeding

c. Continuous formulation- using active pills for longer durations (one year), functionally stops all the bleeding, but may lead to breakthrough bleeding as a side effect [8].

Early formulations of COCs contained up to 500 µg of estrogen. Over the years, researchers have been able to reduce the dose of estrogen to lower the adverse effects while still maintaining efficacy. Today, most pills have 20-35 mcg of estrogen. Estrogen is most commonly available as ethinyl estradiol (EE); other compounds are

mestranol and estradiol valerate. Newer COCs also contain newer progestins with more potency, longer half-life, and reduced androgenic effects. **Table 1** depicts the activity of various progestins.

Generation of progestins	Progestin	Progestational	Estrogenic	Androgenic
First	Norethindrone Ethynodiol diacetate Norgestrel Norethindrone acetate	++ +++ +++ ++	++ ++ - ++	++ + +++ ++
Second	Levonorgestrel	++++	-	++++
Third	Norgestimate Desogestrel	++ +++	- +/-	++ ++
Fourth	Drospirenone	+/-	-	-

Table 1. Activity of Progestin agents [9]

In the past decade, researchers explored an "ultra-low-dose" COC regimen (10 g EE and 1 mg norethindrone acetate for 24 days, followed by 10 μg EE alone for 2 days, and then 2 days of placebo in a 28-day cycle) to enhance effectiveness and reduce breakthrough bleeding by shortening the hormone-free interval [10]. A year-long study on women using this regimen found low pregnancy rates similar to perfect-use failure rates in other COC trials. However, up to 50% of participants experienced breakthrough bleeding during the second cycle, which persisted, and the discontinuation rate was relatively high. Therefore, despite the theoretical safety benefits of very low EE doses in COCs, available data do not fully support this concept due to increased bleeding pattern disruptions [11]. **Figure 1** demonstrates the falling trend in dosage of estrogen in contraceptive pills over time.

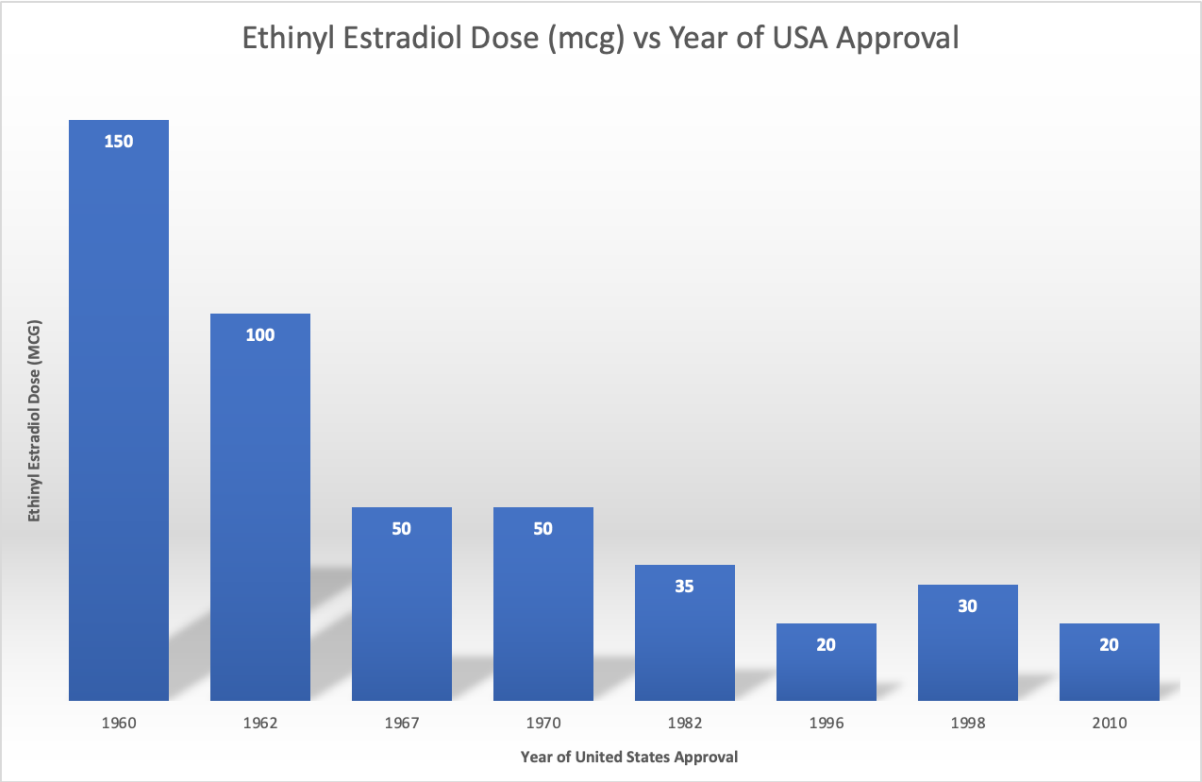

Figure 1. Reduction in estrogen dosing in oral contraceptive pills over time [7]

Eligibility for hormonal contraceptives: The WHO Medical Eligibility Criteria (MEC) classifies contraceptive eligibility into four categories. Category 3 (relative contraindication) denotes a condition where the method's theoretical or proven risks typically outweigh its benefits. Category 4 (absolute contraindication) refers to a condition where using the contraceptive method poses an unacceptable health risk. The various contraindications are discussed in **Table 2**.

WHO category 4	WHO category 3
• Postpartum for less than 21 days with other risk factors for VTE • Breastfeeding from less than 6 weeks postpartum • Age 35 or older and smokes ≥15 cigarettes/day • Vascular disease • Hypertension: systolic blood pressure ≥160 mmHg or diastolic blood pressure ≥100 mmHg • History of acute deep vein thrombosis/pulmonary embolism (DVT/PE) and/or on anticoagulant therapy for the same • Major surgery with prolonged immobilization • Migraine headaches with aura (at any age) • Current breast cancer • Severe (decompensated) cirrhosis • Malignant liver tumors • Hepatocellular adenoma	• Postpartum for less than 21 days without other risk factors for venous thromboembolism (VTE) • Postpartum between 21 and 42 days with other risk factors for VTE • Breastfeeding between six weeks and six months postpartum (primarily breastfeeding) • Age 35 or older and smokes less than 15 cigarettes/day • History of hypertension where blood pressure cannot be evaluated (including hypertension in pregnancy) • Adequately controlled hypertension where blood pressure can be evaluated • Systolic blood pressure of 140–159 mmHg or diastolic blood pressure of 90–99 mmHg • Migraine headaches without aura at age ≥35 years

● Known thrombogenic mutation ● Current and history of ischemic heart disease ● History of stroke ● Complicated valvular heart disease (pulmonary hypertension, risk of atrial fibrillation, and history of subacute bacterial endocarditis) ● Systemic lupus erythematosus (SLE) with positive (or unknown) antiphospholipid antibodies	● Past and no evidence of current breast cancer for five years ● Past or current gall bladder disease ● Past COC-related cholestasis ● Anticonvulsant therapy (phenytoin, carbamazepine, barbiturates, primidone, topiramate, oxcarbazepine, or lamotrigine) ● Antimicrobial therapy (rifampicin or rifabutin)

Table 2. Contraindications to COCs [12]

2. Progestin-only pill

The progestin-only pill, also called the mini-pill, contains progesterone alone. It is taken continuously and acts mainly by thickening the cervical mucus and preventing implantation. Additional effects encompass incomplete ovulation suppression via gonadotropin inhibition and modification of the endometrial environment. Mini-pill is a suitable contraceptive choice for women with contraindications to COCs. Typical use failure rate is 7% [7].

3. Injectable contraceptives:

The injectable contraceptives are formulated with synthetic hormones that mimic natural female hormones. When given as intramuscular or subcutaneous injections, they gradually release hormones into the bloodstream, offering long-lasting protection against pregnancy to the recipient.

Two primary categories of injectable contraceptives are available:

a. Progestogen-only Injectables (POI)

Progestogen-only Injectables (POI) contain solely synthetic progesterone. Depot MedroxyProgesterone Acetate (DMPA), commonly known as Depo-Provera is administered deep intramuscularly every 3 months whereas, Norethisterone enanthate (NET-EN) is administered 200 mg every 2 months. Both have similar mechanisms of action, safety profile, effectiveness, benefits, limitations, and eligibility criteria. DMPA is cheaper and is more widely used and available.

i. Mechanism of action:

• Inhibiting ovulation - by suppressing mid-cycle peaks of LH and FSH

• Thickening of cervical mucus - due to depletion of estrogen. The thick mucus prevents sperm penetration into the upper reproductive tract.

• Thinning of endometrial lining - due to high progesterone and depleted estrogen, making it unfavorable for implantation of fertilized ovum.

ii. Safety:

DMPA is a safe, highly effective contraceptive suitable for women who can't use estrogen-based methods or are breastfeeding. Extensive research shows no increased cancer, birth defect, or infertility risks. It protects against endometrial cancer and doesn't raise breast, ovarian, or cervical cancer risks, like oral contraceptives. It doesn't impact blood pressure or thrombosis. While it doesn't impair fertility, conception may take 4-6 months longer after discontinuation compared to other methods like COCs, IUDs, or barriers methods.

iii. Effectiveness:

DMPA is highly effective, with a first-year rate of 99.7% when used correctly. Even in typical use, its perfect-use failure rate of 0.3% is lower than methods like female sterilization (0.5%), IUCD (0.8%), and combined oral contraceptives (0.3%), according to the World Health Organization's Family Planning Handbook.

iv. DMPA is a safe, highly effective, and user-friendly contraceptive with long-term benefits:

- Convenient, requiring only one injection every 3 months, with a 4-week grace period.
- Reversible within 7-10 months after the last injection (typically 4-6 months after the 3-month effect ends).
- Private and doesn't interfere with sexual intercourse or pleasure.
- No pelvic examination needed before use.
- Suitable for those who can't use estrogen-based contraceptives.
- Safe for breastfeeding women (after 6 weeks postpartum) without affecting breast milk.
- Provides immediate postpartum and post-abortion contraception.

- Appropriate for women of any age or parity at risk of pregnancy.

v. Non-contraceptive benefits-

- Reduced menstrual cramps and premenstrual syndrome.
- Improved anemia by lowering menstrual blood loss, potentially leading to amenorrhea.
- Relief from endometriosis symptoms.
- Decreased risk of benign breast disease and ovarian cysts.
- Protection against uterine tumors (fibroids) and symptomatic PID.
- Guards against endometrial cancer and possibly ovarian cancer.
- Lessens sickle-cell crises for women with sickle-cell anemia.
- Prevents ectopic pregnancy through ovulation inhibition.
- Minimal drug interactions, with no significant issues with antibiotics or enzyme-inducing drugs.

vi. Considerations for DMPA use:

- No protection against STIs or HIV.
- Delayed return of fertility (7-10 months) after discontinuation, usually 4-6 months after the last injection.
- Potential menstrual cycle and bleeding pattern changes due to hormonal impact.
- Requires a repeat injection every three months for contraceptive efficacy.
- Reversible decrease in bone mineral density, primarily within the first 2 years of use.

b. Combined Injectable Contraceptives (CIC)

CICs incorporate both estrogen (typically EE) and progesterone, with monthly administration. Two common formulations include medroxyprogesterone acetate (MPA)/estradiol cypionate and NET-EN/estradiol valerate. CICs were developed as an alternative to progestin-only injections, aiming to mitigate adverse effects and regulate menstrual bleeding patterns. When used correctly and consistently, CICs effectively prevent ovulation in 99% of cases. These contraceptives have gained popularity due to their convenient monthly administration and reduced metabolic risks, making them an attractive choice for women who may struggle with oral contraceptive adherence and prefer the monthly injection method.[13].

4. Transdermal patch

A transdermal patch is a convenient and effective hormonal contraceptive method. It's applied weekly for three weeks, followed by a patch-free week. This approach minimizes estrogen-related side effects by providing stable estrogen levels. However, it increases the risk of venous thromboembolism (VTE) compared to daily contraceptive pills.

The Ortho Evra contraceptive patch, measuring 20 cm2, releases 35 µg of ethinyl estradiol (EE) and 150 µg of norelgestromin (NGMN) daily. NGMN and EE work by thickening cervical mucus, reducing endometrial receptivity for implantation, and inhibiting ovulation through gonadotropin suppression. Common side effects include breast tenderness and skin reactions at the application site.

New patches with different progestins have been developed, providing a user-friendly alternative to combined oral contraceptives (COCs) with similar effectiveness and tolerability. The convenience of weekly patch changes may enhance adherence compared to daily pills.[14].

5. Hormonal vaginal contraceptive ring

NuvaRing and Annovera are intravaginal hormonal contraceptives releasing daily hormones to prevent pregnancy. NuvaRing, with progestin etonogestrel (ENG) and estrogen EE, has a monthly insertion cycle lasting one month. In contrast, Annovera contains progestin segesterone acetate (SA) and estrogen EE, usable continuously for a full year. Both methods are effective and well-received by patients, but they may be costlier and have absolute contraindications like other hormonal contraceptives.

Common side effects encompass headaches, nausea, vaginal mycotic infections, hypersensitivity reactions, mood changes, and device-related events. While both offer convenient and reversible contraception, healthcare providers should consider individual patient characteristics and preferences when recommending either option [15].

C. Long-acting reversible contraceptives (LARC)

LARC encompass intrauterine devices and contraceptive implants, offering highly effective and long-term birth control. Their primary advantage is providing strong protection without continuous ongoing effort from the patient. Also, fertility quickly returns after removal.

1. Intrauterine devices (IUDs):

The IUD is a small, T-shaped device inserted into the uterus to provide long-term contraception. Two primary types of IUDs are available: hormonal IUDs, which release progestin, and non-hormonal IUDs coated with copper.

a. Hormonal IUD:

These IUDs release a progestin levonorgestrel (LNG) into the uterus over time. Hormonal IUDs are effective for 3 to 8 years, depending on the specific brand. Examples of hormonal IUDs include Mirena, Kyleena, Liletta, and Skyla.

b. Copper IUD (Non-hormonal):

Copper IUDs are made of plastic with a copper wire wrapped around them. The copper ions released by the IUD create a toxic environment for sperm, impairing their movement and preventing fertilization. The copper IUD can be used for an extended period, typically up to 10 or more years, depending on the specific model. An example of a copper IUD is Paragard (Copper T).

IUDs are considered one of the most effective forms of contraception. Studies have shown their first-year efficacy to range from 99% to 99.8%. However, the effectiveness is influenced by proper insertion techniques, adherence to follow-up appointments, and user compliance.

2. Implants:

Subdermal implants, containing progestin ENG or LNG, are highly effective contraceptives placed under the skin. They release hormones consistently without peaks, lasting for varying durations. Proper insertion and counseling are crucial. The LNG implant (Norplant R) delivers steady LNG release for 5 years, causing irregular bleeding, mood changes, and skin reactions. Discontinuation rates are up to 64% in 5 years due to irregular bleeding or pregnancy desire. Norplant II (Jadelle) offers simpler insertion/removal than original Norplant. Jadelle and Norplant have comparable rates and pregnancy outcomes, but Jadelle has shorter removal times. Adverse effects include bleeding and ovarian cysts, with prompt fertility return post-removal.

The ENG implant (Implanon/Nexplanon) in the arm provides 3-year protection. Etonogestrel's slow release ensures effectiveness. A study covering 53,530 cycles and 4103 women years found no pregnancies, with a Pearl Index of 0.0 (95% CI, 0.00–0.09). Common side effects include irregular periods, weight gain, acne, and headache. Compared to LNG, ENG implant has similar effectiveness and continuation rates, quicker insertion/removal, positive safety profile, and no significant impact on cardiovascular risk or bone density.[16].

D. Permanent methods (sterilization)

1. Tubal ligation (female sterilization):

Tubal ligation is a widely chosen method of permanent sterilization, preventing sperm and eggs from meeting for fertilization by tying or blocking the fallopian tubes. This method is used by over 220 million couples globally and is both safe and effective. It may also have non-contraceptive benefits, like improving menstrual bleeding patterns and reducing ovarian cancer risks.

Tubal ligation is appropriate for individuals who have finished childbearing and want permanent contraception. Patients should receive comprehensive counseling on its permanence, risks, benefits, and alternatives, including male partners considering vasectomy or reversible contraceptive options like long-acting methods.

Ethical considerations, particularly ensuring informed consent and avoiding coercion, are vital, especially in specific populations such as incarcerated women. For patients unsure about permanent sterilization but seeking effective contraception, information on reversible options with similar effectiveness should be provided.

Preparation for tubal ligation involves thorough patient counseling and informed consent. The procedure can be performed postpartum during cesarean section or after vaginal delivery before discharge, postabortion immediately following an uncomplicated abortion, or as an interval procedure separate from pregnancy. **Table 3** demonstrates the various techniques of tubal ligation.

Laparoscopic	The most common method for interval sterilization offers immediate effectiveness and allows inspection of the abdomen and pelvis. Techniques used are: 1. Electrocoagulation 2. Tubal excision

	3. Mechanical devices (such as silicone rubber bands, spring-loaded clips, and titanium clips are applied using specialized applicators)
Hysteroscopic	Uses microinserts that have stainless steel/polyethylene terephthalate fibers and nitinol coils. Block fallopian tubes non-invasively by inducing tissue ingrowth.
Laparotomy/Minilaparotomy	Commonly used for postpartum procedures, and is suitable for low-resource settings. Involves creating a small incision relative to the fundus. Techniques used are: 1. Pomeroy: Fold and tie mid-isthmic tube, excise folded part. 2. Parkland: Create an avascular opening in mesosalpinx, tie, and excise tube ends. 3. Uchida: Excise midportion, pull proximal stump into mesosalpinx, close peritoneum. 4. Irving: Excise midportion, insert proximal stump into the myometrium, and secure with sutures. 5. Distal Fimbriectomy: Ligature and excise fimbriated end of the tube. 6. Complete Salpingectomy: Excise the entire tube except the interstitial part using various methods. It is essential to confirm the transection of the tubal segments and ensure hemostasis during the procedure.

Table 3. Techniques of tubal ligation [17]

Complications of tubal ligation include mortality (1 to 2 per 100,000 procedures) mostly due to anesthesia-related issues. Laparoscopic complications are infrequent (0.9 to 1.6 per 100 procedures) but may involve major surgery, infection, bleeding, and readmission. Mini-laparotomy has low morbidity (0.39% major, 0.8% minor). Failure rates vary by technique. Ectopic pregnancy risk ranges from 1.5 to 17.1 per 1000 procedures. **Table 4** discusses the 10-year risk of failure and risk of ectopic pregnancy with various techniques.

Technique used	10-year risk of failure (per 1000 procedures)	Risk of ectopic pregnancy (per 1000 procedures)
Postpartum partial salpingectomy	7.4	1.5
Bipolar coagulation	24.8	17.2
Silicone band	17.7	7.3
Spring clip	36.5	8.5

Table 4. 10-year risk of failure and risk of ectopic pregnancy with various techniques [17]

2. Vasectomy (male sterilization)

Vasectomy is an irreversible male sterilization procedure that obstructs the passage of sperm through the vas deferens. The success rate is high (99.7%), with low complication rates (1%-2%). Vasectomy is an elective

procedure for male sterilization, and the decision should be thoroughly discussed with the patient. The vasectomy procedure involves identifying the vas deferens and providing local anesthesia. A small incision is made in the scrotum, and the vas deferens are isolated and separated from surrounding tissue. The vas sheath is opened, and a portion of the vas deferens is removed. Clips are used to secure the ends, and the wound is closed. The same procedure is repeated on the opposite side. A semen analysis is a crucial post-procedure to confirm sterility, usually done after 3 months. Patients are advised to use alternative contraception until confirmation of sterility.

Complications of vasectomy can include abdominal and surgical site pain, nausea, and lightheadedness. The risk of hematoma and infection is around 1% to 2%, and epididymitis occurs in about 1% of cases. Azoospermia or low sperm count reduces the risk of pregnancy to approximately 1 in 2000, and there is a 0.24% possibility of vasectomy failure necessitating a repeat procedure [18].

E. Calendar-based methods

Calendar-based methods, also known as fertility awareness-based methods or natural family planning, involve tracking menstrual cycle patterns to identify fertile and infertile days. These methods rely on understanding and predicting the timing of ovulation to determine when intercourse can be avoided or additional contraceptive methods should be used.

1. Basal body temperature (BBT) monitoring- Involves daily measurement of a woman's resting body temperature to detect a slight rise indicating ovulation. Ovulation typically causes a slight increase in BBT, indicating the fertile period.

2. Calendar or rhythm method- The calendar or rhythm method predicts fertile days by tracking menstrual cycle lengths over several months, assuming ovulation happens around mid-cycle. It estimates fertility by subtracting days from the shortest and longest cycle lengths.

3. Cervical mucus method- The cervical mucus method involves observing changes in the consistency and appearance of cervical mucus throughout the menstrual cycle. During the fertile period, cervical mucus becomes clear, slippery, and stretchy, resembling raw egg whites [4].

4. The latest technology in fertility awareness methods is discussed in **Table 5**.

Digital Fertility Monitors	Employ algorithms and sensors to monitor signs like BBT, hormone levels, and cervical mucus for accurate fertility predictions. Some include smartphone apps for personalized insights and reminders.
Smartphone Apps	Assist in tracking menstrual cycles and fertility signs by using user-input data to predict fertile windows and ovulation, serving as natural family planning tools.
Saliva-Based Ovulation Tests	Detect estrogen level changes in a woman's menstrual cycle to identify her fertile days.
Wearable Fertility Trackers	Devices attached to the skin or clothing monitor physiological parameters related to fertility (skin temperature, heart rate, etc.) to predict ovulation and fertility windows accurately.

Table 5. Latest technology in fertility awareness methods

Figure 2 summarizes the various tiers of contraceptive methods based on their effectiveness.

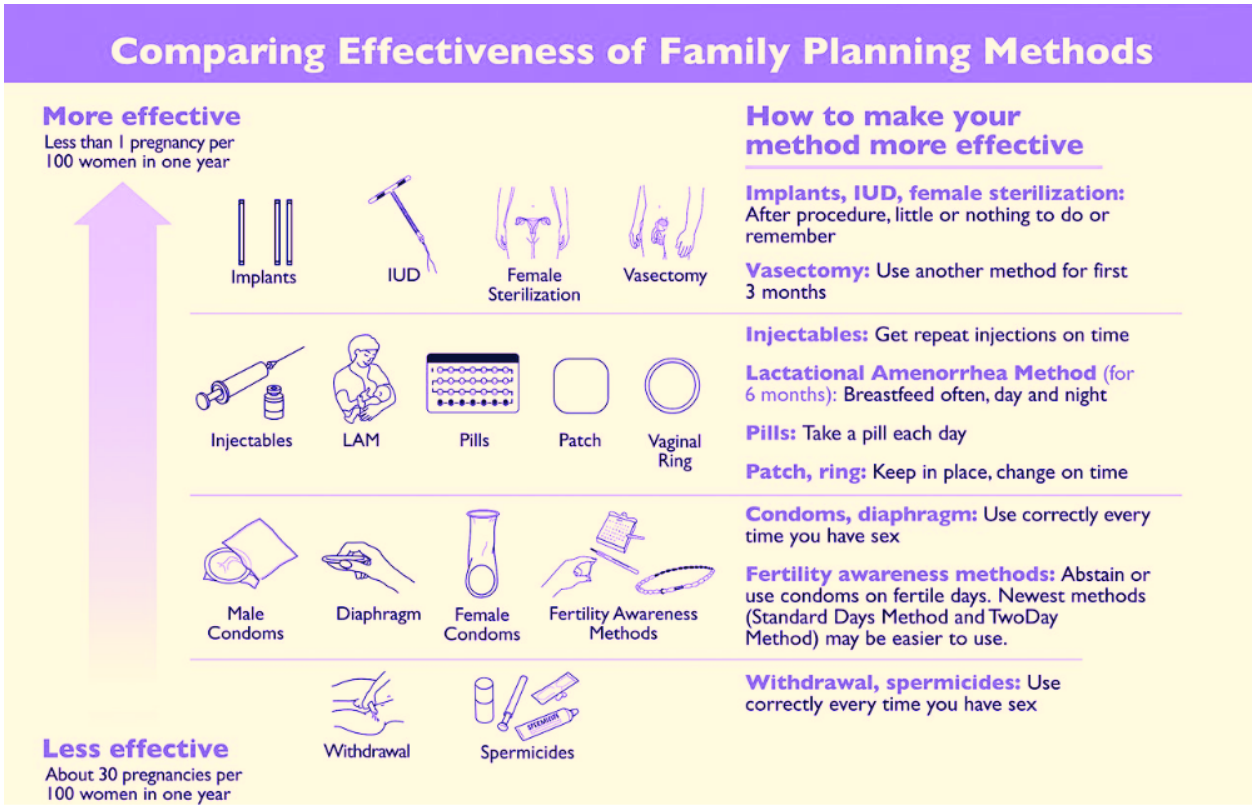

Figure 2. Comparing effectiveness of various family planning methods

III. LIMITATIONS AND CHALLENGES OF EXISTING METHODS

A. Side effects and health risks

Contraceptives can pose challenges due to associated side effects. Barrier methods require correct use and may have insertion difficulties. Spermicides can irritate the skin and increase infection risk, while latex or spermicides can trigger allergies, leading to discomfort. Psychological effects such as embarrassment and frustration have been reported.

Hormonal methods like oral contraceptive pills can induce or worsen conditions like hypertension, dyslipidemia, thromboembolism, stroke, and myocardial infarction, especially in older women and smokers. They may also lead to nausea, breast tenderness, and mood changes. DMPA injections can cause a reversible reduction in bone mineral density and minor weight gain.

IUD complications are generally rare but can be influenced by factors like provider experience, patient nulliparity, and poor cervical dilation in older patients. The most common complication is IUD displacement or accidental removal shortly after insertion, increasing pregnancy risk without alternative contraception. Copper IUDs are associated with increased menstrual bleeding and pain in some women [19].

B. Non-compliance and user-dependent methods

Non-compliance in contraceptive use refers to incorrect or inconsistent usage, reducing effectiveness. This can result from difficulties in adhering to prescribed regimens, misunderstanding instructions, or user errors. For oral contraceptives, daily intake is crucial, and inconsistent use contributes to unintended pregnancies [20]. Condoms, being user-dependent, risk breakage or slippage due to incorrect usage or inconsistent use, raising the chance of unintended pregnancies and STIs [21]. With intrauterine devices (IUDs), user compliance issues may stem from discomfort during insertion or side effect concerns, leading to premature removal and a gap in contraceptive protection [22].

C. Limited options for men

Historically, men have had limited contraceptive options, primarily relying on condoms and vasectomy, both with their drawbacks. Developing male contraceptives is challenging due to the complex biology of the male reproductive system, requiring interference with sperm production, function, or delivery. Research investment has been lower than for female contraceptives due to lower demand. Creating safe and effective male contraceptives with minimal side effects has proven difficult, though early research on hormonal methods shows promise.[23].

D. Cultural and societal barriers

Cultural and societal barriers to contraceptive use encompass diverse factors inhibiting adoption within communities. Religious beliefs can restrict access due to resistance or limited availability of family planning methods. Stigma surrounding sexual health conversations and cultural taboos may deter individuals from seeking information or using contraceptives. Gender inequality can curtail women's autonomy in family planning decisions. Insufficient sexual education and access to information can lead to misconceptions about contraceptive options. Societal pressures, healthcare disparities, economic constraints, and misconceptions contribute to these hindrances.[24].

E. Accessibility and affordability issues

Accessibility and affordability critically impact global contraceptive use. Geographic, economic, and social barriers can restrict access, leading to unintended pregnancies and hampering family planning. Affordability problems particularly affect lower-income individuals. Geographic limitations, healthcare shortages, stigma, and information gaps also hinder use. High costs, insurance gaps, supply issues, and limited government support further block access. Global disparities worsen the divide, favoring high-income countries. Policy initiatives, public health programs, and community awareness efforts are essential to enhance access, reduce unintended pregnancies, and bridge the gap [25] [26] [27].

IV. EMERGING APPROACHES TO CONTRACEPTION

A. Male contraceptive methodstestoster

Male contraceptives encompass methods used by men alone or with their partners to prevent pregnancy. These methods include vasectomy, condoms, withdrawal, and fertility awareness. Vasectomy is highly effective but irreversible. Reversible methods like condoms and spermicides have a higher long-term failure rate, leading to unintended pregnancies in 13% to 20% of users within a year. As male involvement in family planning decisions is crucial and some couples face limitations with female methods, there is a need for alternative options.

1. Male hormonal contraceptives

Hormonal male contraception suppresses spermatogenesis, preventing mature spermatozoa development and fertilization in the female partner. Sertoli cells and germ cells in the testes drive spermatogenesis. Under FSH influence, Sertoli cells support spermatogonial stem cell development into spermatozoa. Leydig cells, stimulated by LH, produce testosterone needed for spermatogenesis.

The pituitary relies on pulsatile GnRH secretion from the hypothalamus for gonadotropin release. Deficient GnRH, nonpulsatile stimulation, or exogenous hormones like testosterone, progestins, and estradiol can inhibit gonadotropin secretion, reducing Sertoli cell function and testicular testosterone production.

a. Androgens

Research into novel male contraceptives is ongoing. Modified oral androgens that do not affect liver function are being studied. Transdermal testosterone through gels and lotions provides steady release, often combined with progestins for faster spermatogenesis suppression. Testosterone implants, more effective with injectable progestins, have been explored.

In a multicenter trial, testosterone enanthate (TE) was as effective as hormonal contraceptives for men but had drawbacks like fluctuating testosterone levels, frequent injections, and androgen-related side effects. TE implants suppressed sperm counts with some implant issues.

With testosterone undecanoate (TU) injections, only 1.1% of couples experienced suppression failure at 24 months. Adverse events included injection site discomfort, acne, mood changes, and skin issues. Fertility returned after stopping injections.

Novel oral androgens like Dimethandrolone undecanoate (DMAU) are being studied as once-daily oral male contraceptives. They bind androgen and progesterone receptors, effectively suppressing testosterone and

gonadotropins but with some androgenic effects. Another, 11β-methyl-19-nortestosterone dodecylcarbonate (11βMNTDC), shares similar features and is being studied as a long-acting contraceptive injection [28].

b. GnRH antagonists

GnRH antagonists are synthetic analogs that suppress gonadotropin secretion, lowering systemic testosterone and inhibiting spermatogenesis. Combining GnRH antagonists with testosterone has shown better suppression of sperm production than using testosterone alone. However, GnRH antagonists have drawbacks like a short half-life and limited oral bioavailability, necessitating frequent subcutaneous injections. They are also associated with local skin irritation and high costs. Research is ongoing to develop orally bioavailable or long-acting depot preparations of potent GnRH antagonists, which could provide new options for male hormonal contraception in the future.

c. Progestins

Progestins combined with androgens show promise for male contraception by effectively suppressing gonadotropins and spermatogenesis. Different progestins have been studied with varying efficacy and side effects as shown in **Table 6**.

Progestins used for male contraception (in combination with testosterone)	Features
Cyproterone acetate (CPA)	potential for azoospermia but may cause antiandrogenic adverse effects
Levonorgestrel (LNG) and desogestrel (DSG)	Suppress spermatogenesis but may cause decreased HDL cholesterol levels
DMPA	Improved suppression but may affect reversibility
Norethisterone enanthate (NETE)	Improved suppression but some pregnancies were reported in studies
Nestorone® (NES) gel	Potential as a topical method with minimal side effects

Table 6. Progestins used for male contraception [29]

Androgen replacement therapy in hypogonadal men provides a model for potential side effects, including acne, weight gain, mood changes, and libido fluctuations. Progestin effects in men are not well-known. Long-term effects on the prostate and cardiovascular risk need further investigation. Comprehensive and longer-term studies are necessary to accurately assess the safety of hormonal [29].

2. Non-hormonal male contraceptives

Non-hormonal male contraception seeks to disrupt different stages of sperm production and function. This approach offers advantages over hormonal methods by avoiding changes in testosterone levels and preserving sexual function and body composition.

Naturally derived non-hormonal contraceptives like Gossypol and triptolide have been studied. Gossypol reduced sperm production and motility but had side effects like hypokalemia and incomplete spermatogenesis recovery. Triptolide also impaired sperm motility and counts but led to irreversible spermatogenesis suppression.
Adjudin, disrupts spermatid-Sertoli cell adhesion, causing infertility in rodents. Although it doesn't affect hormone levels, it causes liver inflammation. Gendarussa, an Indonesian traditional medicine, is used as contraception in Papua New Guinea. Its active ingredient, gendarusin A, has shown some contraceptive efficacy, but the mechanism is unclear, requiring further research.

Various research groups have explored reversible vas occlusion methods for male contraception. RISUG (reversible inhibition of sperm under guidance) is an Indian vas occlusion device, showing effective contraception for up to a year in small clinical trials but larger trials and evidence of reversibility are lacking. Vas occlusion devices using medical-grade materials were studied in China in the 1990s but had incomplete recovery of sperm parameters after attempted reversal, leading to abandonment of this approach [28].

B. Long-acting reversible contraceptives (LARCs)

1. Advances in intrauterine devices (IUDs)

Hormonal IUDs provide effective and long-term contraception. The Mirena and Liletta, both containing 52-mg LNG, received FDA approval for 5 and 3 years of use, respectively. Skyla, with 13.5-mg LNG, offers a less painful insertion but may cause more frequent menstruation. Bayer Pharmaceuticals is also developing a 19.5-mg LNG IUD intended for 5 years of use, which offers an intermediate bleeding profile. These devices cater to various preferences and needs of hormonal IUD users.

The standard copper T 380A IUD is used by over 200 million women globally. New copper IUDs are aimed at improving efficacy and reducing side effects. Researchers are conducting a clinical trial to compare the efficacy and side effects of two copper IUDs: the standard copper T 380A IUD and the newer, smaller Mona Lisa NT Cu380 Mini IUD. The study aims to assess if the smaller IUD offers similar efficacy to the standard one with fewer side effects. The trial seeks to provide additional non-hormonal, long-acting contraceptive options if the smaller IUD proves to be effective and well-tolerated, particularly in nulliparous women [30]. **Table 7** discusses the features of newer IUDs.

IUD	Features
VeraCept IUD	● Flexible copper IUD with lower copper content in Phase III trials, ● Promising results with fewer adverse events ● Efficacy comparable to the copper T 380A IUD
LevoCept	● LNG-releasing system with a nitinol wire frame ● Aims to provide long-term contraception like existing Mirena and Liletta (52 mg LNG IUDs) ● Low pregnancy rates in the first year of use ● Still in development
Frameless IUDs e.g. GyneFix 200 and 330	● Frameless- lack ‘T” frame ● Address uterine size and discomfort issues ● Slightly higher rates of insertion failures, expulsions, and first-year pregnancies compared to traditional IUDs
FibroPlant LNG-IUS	● Frameless ● Offers five years of contraception ● Reduced menstrual bleeding ● Potentially better insertion tolerability
Femilis 60-mg LNG-IUS and Femilis 40-mg Slim (available in Europe)	● Feature a unique "push-in technique" inserter, making insertion easier ● Reduced expulsion rates ● Cause less pain

Table 7. Newer IUDs and their features [31] [32].

2. Injectable LARC

Sayana® Press is a newer contraceptive option that combines a long-acting, reversible, contraceptive (DMPA) with an all-in-one prefilled, single-use, non-reusable Uniject™ injection system, eliminating the need to

prepare a needle and syringe. Each subcutaneous injection provides contraception for at least 13 weeks (+/- one week).

C. Non-hormonal contraceptives

1. Barrier methods with improved designs

The future of condoms lies in graphene condoms and nano-lubricated condoms. Graphene condoms are made of a thin, strong layer of crystalline carbon, providing better heat conductivity and reduced thickness compared to latex condoms. Nano-lubricated condoms use super-hydrophilic nanoparticles for more resilient lubrication. Futuristic approaches include technology-driven condoms and invisible condoms that harden after insertion to block HIV and HSV. Additionally, drug-treated condoms with erectogenic compounds aim to help maintain erections and reduce slippage.

2. Non-hormonal contraceptive gels or films

Phexxi, a chemical barrier, is a prescription vaginal gel that was FDA-approved as a contraceptive method in May 2020. It is a non-hormonal option for on-demand contraception, which can also be used with other contraceptive methods.

Phexxi is a gel applied intravaginally before intercourse, different from other FDA-approved vaginal contraceptives. It enhances natural antimicrobial defenses by regulating vaginal pH with lactic acid, citric acid, and potassium bitartrate, reducing sperm motility and potentially improving antimicrobial protection. It has high bioadhesive properties, minimizing product leakage.

A study showed that the cumulative pregnancy rate was 13.7% after seven cumulative cycles. Common adverse events included vulvovaginal burning sensation, pruritus, and pain. Serious adverse events were rare, and participants reported high satisfaction with the product [33].

D. Novel drug delivery systems

1. Vaginal rings with non-hormonal contraceptives

The Population Council's Center for Biomedical Research is developing a non-hormonal multi-purpose technology (MPT) vaginal ring for contraception, STI protection, and vaginal health support, addressing various women's needs. This ring offers an alternative to hormonal methods and helps combat the increasing issue of STIs [34].

2. Novel transdermal patches

Two new contraceptive patches are being developed: EE/GSD and EE/LNG. The EE/GSD patch provides 0.5 mg EE and 2.1 mg gestodene, while the EE/LNG patch contains 2.3 mg EE and 2.6 mg LNG. These patches are applied for 7 days followed by a patch-free week in a 21/7 cycle. Both have shown effectiveness in preventing pregnancy and maintaining similar bleeding patterns as traditional patches or pills. The EE/GSD patch is advantageous due to its established safety profile and good skin absorption. The EE/LNG patch offers a reduced estrogen area and uses LNG, associated with lower VTE rates than other progestins. However, clinical trials have reported some adverse events and noncompliance.[15].

E. Targeted molecular approaches

1. Novel targets for contraception

a. Estetrol (E4) is a natural estrogen produced by the fetal liver, acting as a selective estrogen receptor modulator, favoring estrogen receptor alpha (ERα). E4 combined with drospirenone (DRSP) in contraceptive pills has shown high acceptability and effectiveness, inhibiting ovulation similarly to other pills. It also offers improved tolerability, cycle control, and potential cardiovascular benefits compared to EE-containing pills. However, more extensive studies are needed for cardiovascular safety and user satisfaction evaluation.[35].
b. Soluble adenylyl cyclase (sAC) is vital for male fertility and a potential contraceptive target. It plays a crucial role in sperm development and fertilization. Studies in mice and humans suggest sAC's importance in male reproduction, making sAC inhibitors potential contraceptives. Intravaginal drug delivery offers a safe, on-demand method for male contraception. sAC inhibitors can also be used in multi-purpose

technologies (MPTs) for contraception and STI protection. sAC inhibitors can be potentially developed as "couples' pills" as they may be explored for females and simplify contraceptive choices [36].

c. EPPIN is a protein on sperm that affects fertility. Studies in male primates immunized against EPPIN led to reversible infertility. Researchers are working on molecules that inhibit EPPIN, reducing sperm motility. Promising results in macaques suggest the development of an oral male contraceptive pill.[28].

2. Molecular technologies and their potential role

a. Researchers have identified α-arrestin (ARRDC5) as a key regulator of spermatogenesis, with its absence causing male sterility in mice by reducing sperm production and affecting spermiogenesis. ARRDC5 is considered a potential target for male contraceptives [37].
b. Progress in non-surgical male contraception involves using CRISPR to turn off the PNLDC1 gene in mice, resulting in reduced sperm production and sterility. This method could offer a less invasive alternative to vasectomy, though concerns about gene modification's effects on offspring and fertility reversibility persist [38].
c. BRDT, identified through epigenetic research, is a potential male contraceptive target as mutations lead to abnormal sperm heads and motility. A modified inhibitor of BRDT could provide reversible contraception with reduced side effects [28] [39].
d. CatSper, a sperm-specific calcium channel, is vital for fertility. An antagonist called HC-056456 shows potential for inhibiting sperm motility in vitro, but more in vivo research is needed.
e. Retinoic Acid Receptor Antagonists are being explored for male contraception by blocking spermatogenesis. BMS-189453 demonstrated infertility and liver toxicity, while lower doses showed sperm suppression without liver issues. Other specific antagonists are also under investigation [28].

3. Emerging developments in contraceptive vaccines

Contraceptive vaccines offer potential population control solutions, targeting hormones like GnRH, LH, and FSH, gonadotropin receptors, sperm-specific proteins, and zona pellucida glycoproteins. These vaccines have shown efficacy in experimental animal models.

In the 1970s, contraceptive vaccine development in India aimed for periodic intake, no ovulation or hormone interference, and no auto-reactivity. They focused on human Chorionic Gonadotropin (hCG) as a target to block embryo implantation without causing autoimmunity. Phase II trials with β-hCG-based vaccines in women demonstrated reversible contraceptive effects [40].

GnRH-based vaccines have applications in male pig immuno-castration and population management for wild horses and deer [41].

Zona pellucida (ZP) vaccines reduce fertility in animals but need further research to address ovarian concerns [42].

Male contraceptive vaccines face challenges like side effects with anti-LH vaccines and inconsistent azoospermia with FSH vaccines. Promising candidates include sperm-specific proteins and nonhormonal antigens, particularly anti-sperm antibodies targeting sperm antigens like IZUMO1, SACA3, and PH20. Additional research is essential to establish safety, immunogenicity, and novel vaccine delivery platforms [43].

V. ADVANCEMENTS IN CONTRACEPTIVE TECHNOLOGIES

A. Nanotechnology in contraception

Biomaterials-based contraception is gaining attention due to its controlled drug delivery capabilities. These materials act as carriers for contraceptives, offering stable drug release, responsiveness to stimuli, and tissue environment modulation.

Delivery methods include subcutaneous implants using materials like polylactic acid (PLA) and poly-(ε-caprolactone) (PCL). However, further research is needed to address inflammation and menstrual patterns.

Transdermal patches and dissolving microneedles (DMN) provide stable drug release and improved compliance. DMN advancements with materials like PLA and Poly(D,L-lactide-co-glycolide) (PLGA) show promise.

Biomaterial-based oral contraception offers self-administration with lower dosing frequency and reduced gastrointestinal risks. The V-shaped dosage form with six polymer arms allows one-month contraception.

Vaginal contraception uses rings made of hormones and slow-release polymers. Newer materials like polyethylene vinyl acetate copolymers and biodegradable polymers show potential.

Intravenous administration, especially for immunocontraception, explores nanobiomaterials like chitosan-based nanoparticles and iron oxide nanoparticles. Ongoing research, particularly in nanomaterials, continues to advance contraception options [44].

B. Microfluidics and lab-on-a-chip devices

Researchers have developed a microfluidic device for testing contraceptive effects on cumulus-oocyte complex maturation, a crucial fertility step. This device allows simultaneous study of multiple drug conditions, streamlines biochemical procedures, and uses oil-water interfaces and filter membranes. It measures cumulus expansion and oocyte maturation, offering insights into potential contraceptives. This platform promises efficient screening of new contraceptive agents, potentially leading to safer non-hormonal options. However, more research and automation are needed for full utilization [45].

C. Wearable contraceptive technologies

Convenient contraception concepts now include drug-delivering wearable devices (WDs), implantable devices (IDs), and wearable fertility trackers. The contraceptive vaginal ring is a WD, while the subcutaneous implant serves as an ID, as discussed earlier.

D. Integration of contraception with digital health platforms

The digital age and the COVID-19 pandemic have boosted digital healthcare, particularly in women's health or "femtech." Fertility-related technology, part of femtech, has become popular, offering digital contraceptives. These contraceptives, known as Fertility-Related Femtech Contraceptives (FRFCs), blend traditional methods with algorithms. Users monitor menstrual cycle signs, and the app forecasts fertile times, helping them avoid pregnancy. This approach, combining modern algorithms with ancient fertility tracking, has gained traction [46].

VI. FUTURE DIRECTIONS AND CONSIDERATIONS

A. Regulatory and ethical considerations

Regulatory and ethical considerations play a crucial role in the development, approval, and use of current and future contraceptive methods. These considerations ensure the safety, efficacy, and respect for human rights in contraceptive research and practice. **Table 8** discusses some key regulatory and ethical aspects related to contraceptive methods.

Regulatory and ethical considerations	
Regulatory Approval and Safety	Regulatory bodies, such as the U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA), evaluate contraceptive methods to ensure their safety and effectiveness before they are approved for use. Rigorous clinical trials and post-marketing surveillance are conducted to assess the benefits and risks of each method.
Informed Consent	Informed consent is essential in contraceptive research and practice. Patients must be provided with clear and accurate information about the contraceptive method, its potential benefits, risks, and side effects. Informed consent ensures that individuals can make autonomous decisions about their reproductive health.
Accessibility and Equity	Ethical considerations include ensuring equitable access to contraceptive methods, especially for vulnerable populations. Contraceptive services should

	be available to all individuals, regardless of socioeconomic status, ethnicity, or geographical location.
Respect for Reproductive Autonomy	Reproductive autonomy refers to an individual's right to make informed decisions about their reproductive health. Contraceptive methods should respect the autonomy of users and be free from coercion or pressure to use specific methods.
Privacy and Confidentiality	Contraceptive services should protect patients' privacy and confidentiality. Personal information and medical records must be kept confidential to maintain patient trust and ensure ethical practice.
Respect for Human Rights	Contraceptive methods should align with international human rights principles, including the right to health, the right to access information, and the right to make decisions about one's own body. Human rights frameworks guide the ethical development and provision of contraceptive methods.
Long-Term Safety and Monitoring	Long-term safety monitoring of contraceptive methods is essential to detect and address potential adverse effects. Post-marketing surveillance ensures ongoing assessment of safety and effectiveness.
Ethical Research with Vulnerable Populations	Research involving vulnerable populations, such as adolescents or pregnant women, must follow specific ethical guidelines to protect their rights and well-being.
Gender Equality and Social Norms	Ethical considerations include addressing gender inequalities and social norms that may impact contraceptive access and decision-making. Contraceptive methods should empower individuals to exercise their reproductive rights.

Table 8. Regulatory and ethical considerations of contraception [12] [47] [48].

B. Research and development priorities

Current priorities in contraceptive research and development encompass several key areas. One focal point involves enhancing LARCs, with a focus on improving their efficacy, reducing side effects, and expanding accessibility. Another critical avenue of research aims to develop effective non-hormonal contraceptive methods, addressing the need for options that prevent pregnancy without hormonal side effects. Additionally, the development of Multipurpose Prevention Technologies (MPTs) is underway, which involves innovatively combining contraception and STI protection through forms like rings or gels. Research into male contraception methods is ongoing to provide men with a wider range of contraceptive choices and shared responsibility in family planning. Furthermore, a user-centered design approach is being applied, taking into account user preferences and needs to create more acceptable and adherent contraceptive solutions. Finally, the integration of digital health and mobile technologies, such as mobile apps and digital platforms, is being explored to enhance contraceptive access and support.

C. Addressing cultural and societal barriers

Addressing cultural and societal barriers to contraception requires a multifaceted approach that involves education, advocacy, and collaboration with communities and stakeholders. Here are some ways to address these barriers.

1. Culturally sensitive education: Provide accurate contraception information with consideration of local customs and beliefs.
2. Community engagement: Involve leaders and organizations to reduce stigma and misconceptions about contraception.
3. Healthcare provider training: Offer non-judgmental counseling with diverse contraceptive options.
4. Addressing gender norms: Empower women in decision-making about reproductive health.
5. Overcoming cost and access barriers: Improve affordability and availability of contraception services.
6. Leveraging social media: Disseminate information and address misconceptions through online platforms.
7. Policy advocacy: Advocate for evidence-based family planning policies that respect individual rights and choices.

D. Ensuring accessibility and affordability

Following strategies can be implied to improve accessibility and affordability of contraception:

1. Task-Shifting and Training: Train community health workers to improve contraceptive access in underserved areas.
2. Integration of Services: Integrate contraceptive services with other healthcare programs to reach a wider population.
3. Mobile Outreach Programs: Use mobile clinics to provide contraceptive services to remote communities.
4. Subsidies and Vouchers: Offer financial support to make contraceptives more affordable.
5. Public-Private Partnerships: Collaborate with private sector providers to expand contraceptive availability.
6. Supply Chain Strengthening: Improve supply chain for consistent contraceptive availability.
7. Policy and Advocacy: Advocate for supportive policies to improve contraceptive access.
8. Community-Based Distribution: Train community members to provide contraceptive information locally.

VII. CONCLUSION

In conclusion, the evolving landscape of contraceptive methods represents a crucial stride towards better reproductive health worldwide. This chapter emphasized the historical significance of contraception, tracing its evolution through various existing methods, while acknowledging the challenges they pose, such as side effects, limited options for men, and cultural barriers. However, a brighter future lies ahead with emerging approaches to contraception. From male contraceptive advancements to innovative drug delivery systems and targeted molecular approaches, the field is poised for transformative breakthroughs. To maximize their potential, it is essential to address regulatory, ethical, and accessibility concerns while promoting research and development efforts. Ultimately, these advancements promise a more empowered and healthier future for individuals globally.

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