

Advancing Access and Innovation in Contraceptive Technology: Current Progress and Future Directions for Meeting Global Family Planning Needs

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Abstract

Background: Expanding access to voluntary family planning supports reproductive autonomy and improves public health outcomes globally. Over 200 million women have an unmet need for modern contraception. Meeting this need could prevent over 30% of maternal deaths and 10% of child mortality.

Purpose: This paper reviews recent developments in contraceptive methods and evidence-based strategies for improving access, quality, and utilization of family planning services to empower reproductive choice.

Main body: Advances in combined oral contraceptives, injectables, intrauterine devices, implants, and novel delivery systems like vaginal rings have expanded options for fertility regulation. Task-shifting service delivery to community health workers, integrating family planning into immunization and postpartum care platforms, eliminating user fees, and utilizing mobile outreach improve contraceptive access and uptake. Quality youth-friendly services, comprehensive patient counseling and education, addressing discontinuation, and adherence interventions also facilitate effective contraceptive use. Meanwhile, digital health innovations create opportunities to advance access through telehealth, supply chain analytics, computer modeling, and artificial intelligence-supported programming.

Conclusion: Increasing investment in family planning research, quality improvement initiatives, policy reforms, public education programs, and thoughtfully designed technological solutions can help fulfill worldwide unmet need for contraception to further reproductive autonomy and health.

Key words: family planning; contraception; reproductive health; maternal health; telemedicine; health education

1.Introduction

Voluntary family planning is a vital health and development priority globally, enabling individuals to achieve their desired family size and spacing of births. An estimated 214 million women in developing regions have an unmet need for modern contraception, facing barriers to access due to limited choices, distance, costs, and social opposition. Fulfilling this

unmet need could prevent over 30% of maternal deaths and 10% of child mortality through increased birth spacing [1]. At the same time, the field of contraceptive technology continues to rapidly evolve, with new methods expanding options for women and men. Recent decades have brought introductions of lower-dose oral contraceptives, new long-acting reversible

contraceptives like implants and intrauterine devices, and novel delivery systems like transdermal patches and vaginal rings. Meanwhile, research aims to develop improved reversible methods for men, who currently have only condoms and withdrawal available for fertility regulation. This continuous progress in the contraceptive method mix has dramatically expanded the choices available to meet diverse reproductive health needs and goals [2]. Realizing the benefits of these innovations globally requires focused efforts to improve access and quality of family planning services, especially among disadvantaged populations. This involves addressing barriers around awareness, provider skills, geographic distance, costs, restrictions, and gender norms that deter contraceptive use. Implementation of evidence-based strategies to increase access—like task-sharing with community health workers, integrating family planning into other health services, and mobile outreach delivery—has significantly expanded utilization in regions with the greatest needs [3]. At the same time, digital health technologies offer unprecedented opportunities to transform service quality and monitoring of family planning programs. SMS reminders, fertility tracking apps, telehealth platforms, supply chain analytics, and machine learning modeling are being harnessed to individualize care, strengthen health systems, guide policies, and improve reproductive empowerment [4-5]. This review analyzes recent developments in methods, evidence-based delivery models, digital health integration, and policies to provide a comprehensive update. It uniquely emphasizes patient-centered, rights-based care quality alongside new technologies to equip comprehensive, ethical family planning programs benefiting underserved populations. By spotlighting promising directions across research, services, and policy.

II. Recent developments in contraceptive methods

Modern contraceptive methods provide individuals and couples greater options to plan their families and avoid unintended pregnancy as depicted in **table 1**. In recent decades, the contraceptive landscape has rapidly evolved with the introduction of new formulations, delivery systems and modes of action. Researchers continue efforts to expand the method mix, particularly developing new reversible options for men that are safe, effective, and acceptable to meet diverse reproductive needs and preferences [6-9]. Hormonal contraceptives remain among the most effective reversible options for women. Combined oral contraceptives (COCs) containing estrogen and progestin work primarily by suppressing ovulation. With perfect use, COCs have a first-year failure rate around 0.3%, but typical use is associated with a 9% failure rate due to missed pills. While safe for most, COCs carry small increased risks of venous thromboembolism, stroke, and myocardial infarction in some populations. New extended cycle COC regimens reduce hormone-free intervals, decreasing side effects like headaches or menstrual cramps. However, diminished withdrawal bleeding raises safety concerns including higher venous thromboembolism risk with extended use [10-13]. Progestin-only pills (POPs) avoid estrogen-related adverse effects. They thicken cervical mucus to block sperm penetration and may inhibit ovulation, but are slightly less effective than COCs. POPs have a 0.3% perfect use but

typical use failure rate around 9%. Strict adherence is required as pills must be taken within a 3-hour window daily [14]. Transdermal and intravaginal hormonal delivery methods offer added convenience and stability. Contraceptive patches contain estrogen and progestin, while vaginal rings use progestin-only. These methods provide consistent hormone levels without first-pass hepatic metabolism. The patch and ring have 0.3% perfect use but typical use failure rates around 9%. Skin reactions may occur with patches and expulsion is a risk with the vaginal ring. Both require regular replacement—the patch weekly and the ring monthly [15-17]. Long-acting reversible contraceptives (LARCs) like implants and intrauterine devices (IUDs) offer exceptional efficacy up to 3-10 years with one-time placement. LARCs act independently of user adherence. The etonogestrel implant releases progestin steadily, with a failure rate under 1% over 3 years. The levonorgestrel IUD releases progestin locally for up to 5 years with failure rates below 0.2%. Copper IUDs provide nonhormonal contraception for up to 10 years primarily by inducing a sterile inflammatory reaction [18-20]. Emerging LARCs aim to further improve efficacy and acceptability. The segesterone acetate/ethinyl estradiol contraceptive vaginal ring provides one year of contraception with fewer systemic progestogenic effects compared to other LARCs. The levonorgestrel-releasing intrauterine ball has a spherical shape designed to reduce expulsion. Rings and devices releasing antiprogesterins like ulipristal acetate or mifepristone are under study, with 1-year pregnancy rates under 1% [21-24]. For permanent contraception, female sterilization procedures and vasectomy remain options. Tubal ligation techniques including clips, rings, or electrocautery reliably obstruct the fallopian tubes with a first-year failure rate around 0.5%. Vasectomy occludes the vas deferens ducts to prevent sperm passage with a failure rate of 0.15% after initial clearance. Both are considered permanent and reversal is less effective, costly, and involved than the original sterilization procedure [25-26]. Among temporary methods for men, condoms remain most common. With perfect use, the failure rate is 2% within a year. However typical use results in 10-15% annual failure, often due to issues like incorrect sizing, inconsistent/incorrect use, and breakage. The female condom provides protection comparable to male condoms but has not gained widespread use [27]. Natural family planning relies on fertility awareness methods to identify fertile periods to abstain or use barriers. Approaches include monitoring basal body temperature, cervical mucus, or urinary hormones. In theory, perfect use provides over 80% effectiveness, but typical use results in 10-25% failure rates due to challenges adhering consistently and correctly. Apps integrating cycle tracking aim to improve efficacy but require more research [28]. For men, progress continues on reversible non-hormonal methods. Intravasal approaches like Vasalgel™ involve injectable polymers to temporarily block the vas deferens. Primate studies show fertility recovery after removal, but human trials are still needed. Partial occlusion through vas ultrasound heating shows short-term effectiveness in animals and humans but inconsistent long-term blockage. Non-hormonal oral pills target sperm production and transport but optimizing efficacy and safety remains challenging [29].

Method	Mechanism of Action	Effectiveness (with typical use)	Duration of Action	Considerations
Combined oral contraceptive pill	Prevents ovulation	91%	One menstrual cycle	Daily adherence required; estrogen-related side effects
Progestin-only pill	Thickens cervical mucus, may inhibit ovulation	91%	One menstrual cycle	Strict daily adherence required
Contraceptive patch	Prevents ovulation	91%	One week	Weekly replacement; skin reactions may occur
Vaginal ring	Prevents ovulation	91%	One month	Risk of expulsion

Method	Mechanism of Action	Effectiveness (with typical use)	Duration of Action	Considerations
Injectable (depot medroxyprogesterone acetate)	Prevents ovulation	94%	3 months	Requires reinjection every 12-14 weeks
Implant (etonogestrel)	Prevents ovulation	>99%	Up to 3 years	Requires removal after 3 years
Copper intrauterine device	Induces sterile inflammatory reaction	>99%	Up to 10 years	Risk of heavier, more painful periods
Levonorgestrel intrauterine system	Thickens cervical mucus, may inhibit ovulation	>99%	Up to 5 years	-

Table 1: Comparison of modern contraceptive methods for women

III. Improving access and utilization of family planning services

Expanding access to voluntary, high-quality family planning information and services is critical to empowering individuals and couples to achieve their reproductive goals. Globally, over 200 million women have an unmet need for modern contraception. Addressing this unmet need could prevent over 30% of maternal deaths and 10% of child mortality if couples spaced pregnancies appropriately. Interventions to increase access and utilization of family planning, especially in low-resource settings, can significantly improve reproductive, maternal, and child health [30-31]. In many regions, lack of knowledge, geographic barriers, provider bias, and cost limit contraceptive access and use. Structural interventions like task-shifting, integration of services, and innovative financing models are effective strategies to address these barriers. Task-shifting family planning service provision from physicians to community health workers (CHWs) has expanded access in regions with health professional shortages [32]. CHWs can provide counseling, contraceptive education, basic medical screening, and offer certain methods like pills, condoms, injectables, and implants. Studies across sub-Saharan Africa have demonstrated CHWs can deliver injectable contraceptives safely and effectively in community settings, increasing use compared to facility-only access [33]. Integration of family planning with immunization services is another successful model as depicted in **table 2**. Women bringing children for vaccines are offered same-visit contraceptive counseling and provision, removing geographic and time barriers. Kenya and Zambia programs integrating family planning during childhood immunization days increased long-acting and permanent method uptake substantially [34]. Mobile outreach services also improve access in remote areas. Transporting health workers, contraceptive supplies, and mobile clinical units directly to villages surmounts transportation barriers for clients. In rural Tanzania, a mobile service increased contraceptive use by over 15% versus fixed-site clinics alone [35]. Social marketing—selling subsidized contraceptives through community vendors, pharmacies, and shops—further expands community access and distribution. In Pakistan, branded hormonal contraceptives sold by female health workers at low cost doubled use of modern methods in rural areas. Successfully extending family

planning services into communities requires building transportation, supply chain, supervision, and monitoring systems alongside service delivery models [36-37]. Financial and information barriers also limit family planning access. User fees at public facilities prevent access for lower-income clients. Removing such fees increased facility birth and antenatal care rates substantially in Kenya, South Africa, and Ghana. Social insurance models like India’s national health insurance scheme for low-income households helped reduce out-of-pocket costs for maternal and reproductive health services [38]. Conditional cash transfers provide payment to clients for accessing preventive services including contraceptive counseling. Multiple programs in Latin America significantly boosted attendance for contraceptive services through small cash transfers. Mobile payment platforms like mPesa in Kenya have facilitated cash transfers and payment of user fees digitally, overcoming costs and distance [39-40]. Lack of knowledge and misconceptions deter contraceptive use, particularly among youth and men. Comprehensive sexuality education through schools, community groups, and health facilities helps overcome stigma and inform choice. Mass media campaigns using radio, television, social media also improve awareness and acceptance. Soul City’s edutainment initiative in South Africa increased discussions between partners about family planning through its serialized television and radio dramas. Some programs have also provided financial incentives for men to participate, for example offering food packages to male partners who attended counseling along with wives at Nigerian health centers [41].

Expanding method choice is equally important to access. Task-shifting helps ensure health workers can deliver a range of methods safely. Mobile outreach and social marketing provide community access beyond short-term methods like condoms and pills. Strong supply chains with sufficient stocks of implants, IUDs, injectables help women switch to more effective methods. In Senegal, giving community health volunteers implants to distribute resulted in higher uptake compared to referral alone. Integration of family planning into HIV services also enables HIV positive women access methods compatible with antiretroviral [42-43].

Strategy	Description	Evidence of Impact
Task-shifting to community health workers	Shifting contraceptive counseling and provision responsibilities from facility-based providers to trained community health workers	Increased modern contraceptive utilization by 30%; expanded access to injectables
Integration into immunization services	Offering same-visit contraceptive counseling and methods during childhood immunization visits	Increased uptake of long-acting and permanent methods; greater continuation
Mobile outreach models	Transporting trained providers, contraceptive supplies, and clinical units to rural communities directly	Increased contraceptive use by 15% compared to fixed site clinics alone
Comprehensive sexuality education	School-based and community programs providing age-appropriate education on relationships, contraception, protection	Increased modern contraceptive use 5-10 percentage points among adolescents
Male engagement initiatives	Community programs and incentives promoting men's approval and use of contraception	20-30% relative increase in couples' modern contraceptive use

Strategy	Description	Evidence of Impact
User fee removal	Eliminating out-of-pocket fees at public health facilities for family planning services	Increased facility births by 20-40% in multiple African countries

Table 2: Strategies to improve family planning access and utilization

IV. Optimizing counseling and services for family planning

High-quality, patient-centered counseling and care are essential to ensure individuals can make informed contraceptive choices and use methods effectively. Evidence-based guidelines exist for providing family planning services, but quality gaps remain globally. Optimizing counseling and integrating services to meet clients' needs and preferences is critical for positive experiences and effective use of contraception.

The CDC and WHO provide evidence-based guidance on best practices for family planning care. Recommended components include comprehensive needs assessments discussing fertility goals, contraindications, client preferences, and method attributes. Clients should receive counseling supporting free and informed choice with clear, tailored information on effectiveness, side effects, risks, and benefits for relevant methods. Shared decision-making facilitates method selection aligned with individual priorities. Screening, provision, and instructions for use should enable correct, consistent utilization. Follow-up helps identify issues and support continued use or changes in methods if desired [44-46]. High-quality counseling and care requires skilled providers with technical competence delivering respectful, non-biased support. Values clarification exercises help providers reflect on biases to provide ethical, non-coercive care. Job aids, checklists, and decision tools facilitate standardized screening and counseling protocols. Expanding provider types through task-shifting can improve access and rapport in underserved regions but requires robust training, supervision and referral networks. Checklists help CHWs in Tanzania screen contraindications, discuss side effects, and probe women's preferences during community counseling, with high-quality scores comparable to facility nurses [47-48]. Integrating family planning into other health services facilitates access for clients already engaged in care. Postpartum, post-abortion, HIV, and primary care visits provide opportunities to address unmet needs for contraception. Providing quality counseling, prompt postpartum IUD insertion, and same-visit provision of injectables, implants and oral contraceptives within other consultations improves uptake and continuation versus referral alone. Young women in Kenya were 23 times more likely to use contraception after receiving integrated post-abortion and family planning care versus routine discharge [49-50]. Adolescent-friendly contraceptive services are essential given the risks of early unintended pregnancy. Confidentiality concerns are barriers, highlighting value of community distribution programs. Training providers in youth-focused counseling builds competence discussing sexuality, relationships, and respecting adolescent autonomy in decision-making. SMS reminders and discreet packaging improve adherence and continuation for young oral contraceptive users. Holistic youth center models like the Adolescent Girls Empowerment Program in Zambia provide peer support, youth leaders, and male engagement alongside integrated health services with dramatic effects increasing contraceptive uptake and reducing unintended pregnancy [51-53]. The postpartum period poses unique risks of short interpregnancy intervals, underscoring integration with prenatal, delivery, and newborn services. Providing LARCs immediately post-delivery holds advantages as women are not yet fertile but motivated to begin contraception. However, quality counseling during pregnancy and postpartum is essential given increased contraindication risks. Women delivering in facilities without quality counseling have reported being pressured into IUD insertion post-delivery without full information in some regions [54-55]. Counseling also must meet needs of underserved groups like HIV positive individuals, persons with disabilities, those using traditional medicines, or groups facing discrimination. Understanding interactions between hormonal methods and antiretrovirals guides appropriate choices

for HIV positive women. Asking about herbal medicine use identifies possible drug interactions. Discussing previous negative provider experiences or fears related to disability, gender identity, or ethnicity provides patient-centered care [56].

V. Effects of Medical Conditions on Contraceptive Choices

For individuals with certain medical conditions, family planning options may be affected or limited. Understanding impacts of diseases on pregnancy risks and contraceptive safety is key to counseling patients effectively and identifying appropriate methods aligned with their reproductive preferences and health status.

V.1. Liver Disease

Chronic liver conditions like cirrhosis and viral hepatitis can negatively impact maternal and fetal health during pregnancy. However, fertility is often preserved. Combined hormonal contraceptives are contraindicated due to risks of thrombosis, fluid retention, and jaundice. Progestin-only options like pills, injections, implants, or IUDs are generally considered safe, but may require closer monitoring. Barrier methods or permanent sterilization can also be offered. Pregnancy risks should be counseled so patients can make informed choices [57-69].

V.2. Kidney Disease

Women with chronic kidney disease face increased maternal risks including preeclampsia, preterm delivery, infection, and bleeding. Still, fertility persists and pregnancy is often possible for those not on dialysis, if kidney function is stable. Combined hormonal methods are relatively contraindicated, but progestin-only options are appropriate. Counseling should include discussion of pregnancy risks based on level of kidney function. Fertility preservation options can be considered for women undergoing dialysis or transplant [70-73].

V.3. Cardiovascular Disease

Heart conditions like hypertension, coronary artery disease, and congenital disorders increase pregnancy-associated mortality and morbidity. Combined hormonal contraceptives may pose thrombotic risks, favoring progestin-only methods or non-hormonal options. Pregnancy risks need to be balanced given patient preferences. Preconception assessment of cardiac status and close monitoring throughout is warranted. Some medications for heart conditions like ACE inhibitors are contraindicated in pregnancy [74-76].

V.4. Gastrointestinal Disorders

Diseases like inflammatory bowel disease (IBD) generally do not impair fertility, but IBD flares during pregnancy raise risks. Oral contraceptives may worsen IBD symptoms in some women. Progestin-only methods, IUDs, or barriers are preferred to avoid estrogen exposure. Medications used to manage IBD can complicate pregnancy outcomes. Counseling should cover these risks and the need for specialist oversight during conception attempts [77-83].

VI. Overcoming barriers

Despite progress expanding access, barriers to consistent and effective contraceptive use persist globally. Addressing misinformation, lack of involvement of male partners, discontinuation due to side effects or other issues, and incorrect use leading to unintended pregnancy remain challenges as depicted in **table 3**. Innovative interventions aim to overcome these barriers by improving knowledge, involving men, and supporting adherence and continuation [84]. Religious and cultural barriers may also influence use.

Qualitative research highlighted fertility concerns, taboos discussing sex, and perceived contraception unacceptability in Islam as barriers among Afghan couples. Sensitizing faith leaders and providing counseling to reinforce birth spacing for health benefits has improved acceptance and use in settings like Pakistan. Similarly, integrating contraception into maternal and child health messaging frames spacing as beneficial for families. Mother peer groups in Indonesia roleplayed discussing contraception with spouses to build self-efficacy and communication skills. Following participation, modern contraceptive use rose by 10 percentage points versus controls [85]. Partner opposition and male disengagement frequently hinder women’s access and use of contraception. Interventions promoting spousal communication and joint-decision making have successfully increased uptake, particularly for underutilized methods like IUDs and sterilization. Male health workers providing outreach and counseling to husbands increased modern contraceptive use substantially in Niger. Financial incentives also boost men’s engagement. Small conditional cash transfers in India rewarded men’s attendance at health education sessions alongside wives, increasing consent for female sterilization eight-fold versus standard invitation alone [86-89]. For user-dependent methods like pills, rings, and

condoms, adherence support interventions are key. Packaging innovations like daily blister packs improved oral contraceptive adherence in India versus standard packs. Discreet pill cases and SMS reminders also reduced missed pills among young women in the US. The PSI Impact2 model uses private sector marketing techniques to promote consistent condom use, with interactive counselling, attractive packaging, mass media branding, and affordable pricing tailored to young adults. This approach achieved 45-70% lower discontinuation compared to public sector condom distribution [90-92]. Proper utilization is equally important as uptake and continuation to achieve desired effects. Comprehensive counseling and instructions on correct use are essential for methods like condoms, spermicides, and natural family planning requiring accurate technique. Teach-back and return demonstrations build skills applying condoms or measuring basal body temperature. Follow-up and support facilitate corrections in use. New mobile apps use fertility tracking and sperm survival data to provide dynamic fertility windows and alerts for natural planning methods—dramatically reducing unintended pregnancy versus traditional calendar methods in one NIH-funded study [93-94].

Factor	Examples	Evidence-based strategies
Side effects	Headaches, menstrual irregularities, weight changes, mood changes	Counseling on expected side effects before initiation; proactive follow-up and management guidance
Health concerns	Fears of infertility, cancer risks	Comprehensive counseling addressing common myths and misconceptions
Lack of partner support	Partner opposition, lack of prior discussion	Educational initiatives targeting men; couple counseling; promoting spousal communication skills
Access barriers	Costs, distance, stockouts	User fee elimination; task-shifting to community providers; supply chain strengthening
Forgetfulness	Missed pills, injections, appointments	SMS reminders; discreet pill packaging; multiple cycle/dose provision
Difficulties with use	Improper technique with condoms, fertility awareness methods	Skills training; teach-back; follow-up correction guidance

Table 3: Factors influencing contraceptive discontinuation and adherence

VII. Harnessing technology to advance family planning access and quality

Digital health innovations offer tremendous potential to advance family planning services as depicted in **table 4**. Mobile applications, text messaging, telemedicine, artificial intelligence, and big data analytics are transforming access, quality, and outcomes across the reproductive health continuum. Integrating these technologies into health systems and community programs expands reach, facilitates utilization, and enables data-driven improvement [95-96]. SMS and application-based interventions are enhancing contraceptive access and adherence, particularly for adolescents and youth. Young Kenyans receiving SMS appointment reminders were twice as likely to return for contraceptive implants removal or replacement versus controls. Daily pill reminder texts doubled oral contraceptive adherence over 6 months among US teens. Chatbots like Anuradha provide on-demand counseling and method information to Indian youth through Facebook Messenger. Mobile games like Ghana’s Kuukuwa integrate family planning content and virtual clinic visits to break down barriers for first-time contraceptive users [97-98]. Telehealth approaches extend expert consultation and counseling. 24/7 family planning nurse hotlines support method inquiries, side effect management, and emergency contraception requests, with high satisfaction among US callers. Project ECHO trains community health workers (CHWs) in best practices through virtual case-based learning using Zoom. ECHO’s contraceptive technology hubs reduced CHWs’ knowledge gaps around IUDs and implants by over 50% in Mozambique and Tanzania. Teleconsultations also enable remote specialist oversight for CHWs providing implants in South Africa and medical abortion in Canada [99]. Digital systems strengthen supply chains and improve data visibility. Senegal’s Informed Push Model uses data analytics to predict contraceptive

needs across the country, reducing stockouts. Drones transport supplies to remote clinics in Ghana within 30 minutes versus hours by road. Mobile tracking apps digitize inventory counts, expiries, and consumption data that inform logistics. Some platforms integrate across the value chain—Tanzania’s Duka Smart links to health worker ordering apps, drone delivery, and analytics dashboards to streamline last-mile distribution [100]. Artificial intelligence and big data techniques can optimize programs and policies using insights from diverse health, demographic, and econometric datasets. Machine learning models identify which contraceptive promotion strategies will be most effective for different communities using sociodemographic data. Neural networks analyze retail sales and clinic data to forecast contraceptive demand across geographic areas. Real-time mortality, stock-out, and service statistics could trigger automated, personalized recommendations for regional program administrators [101-102]. Computer simulation modeling also informs strategy and investment decisions. Family planning scenarios from the Spectrum Model estimate adding new contraceptive options in India could avert 2 million unintended pregnancies over 5 years versus the status quo. Modeling enables comparing long-term costs and health impacts of programs and predicting effects of policy changes. Expanding age and risk criteria for public insurance coverage of contraception could be tested given eligibility, enrollment, and method type data [103-104]. However, thoughtfully integrating digital health into family planning care models raises ethical considerations. Protecting personal health information through data encryption, access controls, and consent processes maintains confidentiality. Ensuring communities ultimately govern use of their data for social good is critical, avoiding imposition of technical models not aligned with local values and human rights. As algorithms influence more decisions, transparency, oversight and

accountability measures must safeguard against replication of underlying biases that could exclude or endanger marginalized groups.

Technology	Example Use Cases	Potential Impact	Considerations
SMS/app reminders	Pill taking reminders; appointment reminders	Doubled oral contraceptive adherence; increased implant insertion/removal attendance	Requires phone access; privacy protections needed
Chatbots/digital assistants	Provide personalized counseling, method recommendations	Increased knowledge, self-efficacy to use contraception	Must provide accurate, unbiased guidance
Telehealth consultation	CHW training; specialist advice on side effects / complex cases	Built provider capacity and competence	Requires equipment, connectivity investments
Supply chain analytics	Demand forecasting; inventory optimization	Reduced contraceptive stockouts; lowered delivery costs	Needs consistent data collection; training
Computer modeling	Future projections of outcomes and costs under policy/program scenarios	Inform investment cases, services expansion decisions	Results dependent on model assumptions
Machine learning	Predict most effective targeting strategies; analyze determinants of discontinuation	Potential to optimize interventions to different communities	Risk of perpetuating biases; ethical oversight essential

Table 4: Applications of digital health technologies for family planning

VIII. Conclusions

Access to voluntary family planning is essential for public health, gender equity, and sustainable development globally. Ongoing innovation in contraceptive methods continues expanding options for women and men to control their fertility, while advances in service delivery models are needed to ensure access without bias or coercion. Harnessing digital technologies provides unprecedented opportunities to transform family planning programs through individualized care, strengthened systems, and data-driven policies. Fulfilling the worldwide unmet need for contraception would empower reproductive autonomy, reduce maternal and child mortality, improve educational and economic participation, slow population growth, and mitigate environmental impacts. Achieving universal access requires rights-based policies valuing reproductive health alongside faith, culture, and equity. Further innovation and integration of services across sectors can create a future where individuals and couples at all life stages are empowered to make informed decisions about childbearing according to their needs and circumstances.

IX. Recommendations

Realizing universal access to voluntary family planning aligned with human rights obligations requires coordinated efforts across research, clinical services, public health policies, and community engagement:

- Continue funding development and introduction of new contraceptive methods to expand options, especially reversible methods for men
- Implement quality improvement initiatives focused on competency-based training, patient-centered care, integrated models, and digital systems
- Increase accessibility and affordability through inclusive public insurance coverage, primary care integration, community task-sharing, and mobile outreach
- Address cultural barriers and misconceptions through faith leader dialogue, community participation, comprehensive sexuality education, and male engagement
- Protect confidentiality, privacy and informed choice, especially among young and marginalized populations through laws, policies and monitoring
- Apply health data analytics responsibly to optimize interventions, strengthen health systems, guide investment and policies, and monitor progress

- Support multisectoral coordination and reproductive health leadership across public health, development, environment, education, finance, and human rights agencies.

List of abbreviations

- **COCs** - Combined oral contraceptives
- **POPs** - Progestin-only pills
- **LARCs** - Long-acting reversible contraceptives
- **IUDs** - Intrauterine devices
- **CHWs** - Community health workers
- **CDC** - Centers for Disease Control and Prevention
- **WHO** - World Health Organization
- **SDGs** - Sustainable Development Goals
- **GDP** - Gross domestic product

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