Chapter 18
Exploring the Application of Digital Twin Technology in Investigating the Relationship Between Contraceptive Use and Breast Cancer Incidence

Banashree Bondhopadhyay
https://orcid.org/0000-0002-6679-7791
Amity University, Noida, India

Hina Bansal
https://orcid.org/0000-0003-1683-1581
Amity University, Noida, India

Navya Aggarwal
Amity University, Noida, India

Aastha Tanwar
Amity University, Noida, India

ABSTRACT

Contraception has long been scrutinized for its impact on women's health, particularly concerning breast cancer risk. The study explores the analysis of digital twin (DT) tools and technologies. Leveraging DTs in healthcare, by integrating medical data and employing machine learning, predictive models can be developed, representing individual patients, assessing the influence of contraceptive methods on breast cancer risk. They may aid in finding associations between specific contraceptive methods and breast cancer incidence. DTs pave the way for the development of smart IUDs/IUSs, which can be termed as "cyclic-release" devices/systems, that could tailor progesterone release based on the phases of the female ovulation cycle, potentially enhancing effectiveness and minimizing side effects. Moreover, real-time monitoring in DTs offer insights into dynamic changes in risk profiles. Thus, DTs may help in personalized contraceptive counselling and preventive strategies, fostering better-informed decision-making

DOI: 10.4018/979-8-3693-5893-1.ch018

and improved health outcomes for women worldwide.

INTRODUCTION

Oral contraceptive pills (OCPs), commonly known as birth control pills, are pharmaceutical formulations designed to prevent pregnancy. Presently, there are two types of oral contraceptive formulations: progesterone only and combined estrogen-progesterone pills, which work together to inhibit ovulation, the release of eggs from the ovaries. One such synthetic progestogen widely used is levonorgestrel (LNG), a synthetic progestogen akin to Progesterone, holds pivotal roles in contraception and hormone therapy across various reproductive stages.

Availability of medications and access to modern contraception has reduced the incidence of unplanned pregnancies and reduce maternal mortality. In addition to providing high contraceptive efficacy, long-acting reversible contraceptives (LARCs) are also cost-effective, providing benefits to both women and healthcare services. In 1990, Mirena (LNG-IUS 20) became the first levonorgestrel-releasing intrauterine system (LNG-IUS) (Gemzell-Danielsson et al., 2021). This highly effective contraceptive could reduce menstrual blood loss and provide other therapeutic benefits. Then came OCPs, which apart from birth control, can help regulate the menstrual cycle, leading to more predictable and lighter periods, management of ovarian and endometrial cancers, menstrual disorders like dysmenorrhea treatment, Polycystic Ovary Syndrome (PCOS).

However, amid the plethora of beneficial uses of oral contraceptives, it has a significant potential for misuse by the masses. This widespread, uncontrolled, and unaware use of levonorgestrel, is causing havoc on women and the environment. The use of medications for reasons other than medical ones is known as medication misuse. The most often abused pharmaceuticals are those that include laxatives, stimulants, and opioids (Ciccarone, 2011; Roerig et al., 2010). Despite the presence of unspurious uses, oral contraceptive pill (OCP) misuse, including that of levonorgestrel, remains an area that has not received adequate attention. The potential environmental repercussions, investigations of how the accumulation of levonorgestrel in water supplies and ecosystems might disrupt delicate ecological balances, affect human health, leading to unsuspected infertility, menstrual disruption and sexual disorders.

Modern healthcare recognizes the unique biological and clinical characteristics of each individual patient through the practice of personalized medicine and counselling. A one-size-fits-all approach may not always be appropriate for every patient, which is why healthcare providers strive to adapt treatments according to their needs (Blix, 2014; Mathur & Sutton, 2017). A patient's history, clinicopathological features such as age or sex, existing ailments and concurrent medications may be overlooked by current healthcare practices due to generalized guidelines and consultations. Healthcare providers must take into account individual risk factors, such as a family history of breast cancer, when prescribing contraception e.g. LNG. Depending on these factors, the duration of treatment may need to be adjusted (Conz et al., 2020). In the field of oncology, personalized medicine allows for targeted cancer treatments that are tailored to an individual's specific tumor characteristics, improving the chances of successful outcomes (Bondhopadhyay et al., 2020, 2023). Digital twins offer personalized insights into treatment outcomes by simulating patient-specific scenarios and predicting the effectiveness of different interventions. For instance, in the case of Levonorgestrel administration, digital twin technology can recommend precise dosage regimens and predict the likelihood of cancer development based on an individual's unique characteristics.