Scholars LITERATURE

La Prensa Medica Argentina

Short Communication

DOI: https://doi.org/10.47275/2953-4763-433
Volume 110 Issue 6

Analyzing Data Science in Women's Health and Gynecology: Old Challenges, New Insights

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Abstract

Women's health is complex beyond medical and surgical knowledge and obstetrics and gynecology's clinical accomplishments; it encompasses not only the research dimensions of molecular biology, genetics, epidemiology, and health services, but also factors such as gender, social, and psychological influence. To improve women's quality of life (QoL) and healthcare, those involved in and responsible for clinical or health policy management of women's health should reflect on the findings. Providing a comprehensive review of gynecological and obstetrical topics is the objective of this short communication to review issues relevant to women's health. The study also examines contemporary issues that still require strong scientific evidence in this clinical area, as well as the intersection between women's health and data science. Data science has grown not only as a result of new investigators moving into this field, but also due to new methodologies, resources, and technologies. Furthermore, we discussed the opportunities and limitations of repurposing existing methodologies for women's health and the future of the field, with an emphasis on advancing women's health outcomes.

Keywords: Women's health, Molecular biology, Genetics, Epidemiology, Health services

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Citation: Gaddalay SL, Srinaini CH, Kambhampati K, Myneni H (2024) Analyzing Data Science in Women's Health and Gynecology: Old Challenges, New Insights. Prensa Med Argent, Volume 110:6. 433. DOI: https://doi.org/10.47275/2953-4763-433

Received: September 04, 2024; **Accepted:** November 22, 2024; **Published:** November 25, 2024

Introduction

Women's health is the study, diagnosis, and treatment of conditions affecting women, including those of female biological sex and those who identify as female. In most cases, biological sex directly impacts health outcomes [1]. Human sexual dimorphism involves differences in tissues and physiological processes, and asymmetry is often associated with health conditions. Several phenotypes, including susceptibility to certain diseases, are also influenced by sex-specific genetic architecture. Gene regulation and expression are affected by differences in levels of circulating sex steroid hormones early in development as a result of sexual differentiation. It has been shown that sex differences influence hundreds of phenotypes, as diseases can vary in susceptibility, pathogenesis, symptom severity, and response to treatment [2]. According to some theories, sex-specific evolutionary pressures exerted on humans over the course of evolution could be responsible for sex differences in disease. A variety of immune threats, including external pathogens as well as the fetus, were required for maternal adaptation to high rates of fecundity and disease burden in prehistoric human reproduction. As a result of this increased immunomodulation, the fetus was able to compensate for the foreign genetic material in its body while maintaining defenses against diseases before, during, and after pregnancy. Recently, global industrialization has been associated with an increase in breast and reproductive cancers due to conflicts between women's reproductive agency and ancestral adaptations to pregnancy. As a result of human evolution, sex-specific patterns of disease prevalence and pathophysiology can also be observed [3].

Leiomyomas

Most benign female genital neoplasias originate from smooth muscle cells forming the myometrium. There is no clear etiopathogenesis for leiomyomas, and the cluster of agonists and antagonists involved in their development needs to be clarified [4]. There are two papers included in this special issue that provide insightful information about leiomyomas. A common cause of primary amenorrhea is Mayer–Rokitansky–Küster–Hauser (MRKH) syndrome [5]. It causes uterine and vaginal aplasia or hypoplasia. It is rare for patients with MRKH syndrome to develop leiomyomas, but it is always important to look for gynecological complications. According to previous studies, since new myomatous neoplasms can develop in patients with MRKH, whether they are based on uterine rudiments or not, resulting in an acute abdomen that requires urgent surgery, patients who undergo pelvic surgery may benefit from minimally invasive procedures to remove uterine residues. Cotyledonoid leiomyoma is an uncommon uterine myoma due to its ultrasound features which mimic a malignant lesion macroscopically resembling placental cotyledons, with large reddish nodules protruding into the pelvic cavity. Sometimes, it takes on extremely atypical characteristics that lead to suspicion of malignancy, prompting surgeons to perform radical surgery even though the diagnosis was entirely accidental [6]. Consequently, previous studies, emphasize the importance of knowing about this dissecting variant of the fibroid to avoid unnecessary extensive surgery. The bulky mass during surgery may resemble a placenta and may be diagnosed and

treated appropriately with typical ultrasound and magnetic resonance imaging features (Figure 1).

Pelvic Floor Disorders

There are significant psychosocial effects associated with pelvic floor disorders, including low self-esteem, anxiety, frustration, and depression, as well as significant health, social, and economic burdens associated with urinary incontinence and organ prolapse [7, 8]. However, in comparison to other antenatal issues, most maternity healthcare providers seldom discuss this topic with patients. Health care providers should bridge knowledge gaps, making pregnancy a great opportunity for educational interventions, avoiding women not seeking medical attention and suffering in silence as a result. In the case of pelvic floor disorders, providing effective alternatives is not easy. Interventions aimed at improving pelvic floor disorders have been investigated in a variety of papers. According to previous studies, 3D/4D ultrasound could predict the success of PFMT using pelvic floor muscle morphometry. This problem is complex and lacks evidence, which may explain the different approaches and outcomes reported in those papers [2, 9, 10].

Fertility

There are also significant social, clinical, and public health dimensions to fertility. There has long been concern among social, clinical, and public health scientists about the decline in birth rates. Kohler first defined maternity postponement as a "postponement transition" that arises from several factors. A major factor is the increasing maternal age. The age-dependent progressive decline in ovarian reserve also adversely affects female reproductive efficiency. There is potential for a stronger belief that parenthood postponement lessens the biological limits of human reproduction due to the advent and diffusion of assisted reproductive technologies (ART) [11]. A lively debate has erupted over the possibility of using cryopreservation technology when it comes to "social egg freezing" or "social egg preservation". A common alternative favored by many women is planned oocyte cryopreservation (POC). Providing a policy, clinical, and ethical perspective on POC, previous studies discuss the Italian viewpoint on the topic [12].

Achieving gender equity in infertility diagnosis and treatment can be achieved by integrating the gender dimension throughout the diagnostic and therapeutic journeys of couples struggling with infertility. Male factors are not systematically analyzed and are neglected as a result of social constructs, but female factors are more likely to seek medical attention [13]. In order to provide a tailored treatment and targeted use of ART, it is crucial to consider not only their sperm concentration, motility, and morphology, but also genetic tests, testicular histology, and psychological factors.

Table 1: Patients characters, tumors and surgery.

Premature Ovarian Insufficiency (POI)

POI is defined as the loss of ovarian activity before the age of 40, resulting in chronic hypoestrogenic states. As a result of Tong's presentation, the knowledge structure and themes trends within POI therapy are highlighted on the map. POI therapy's hot spots are hormone replacement therapy and fertility preservation, according to their findings [14]. Various techniques and novel therapeutic strategies for fertility preservation have gained a lot of attention in recent years, providing researchers with valuable resources for diagnosing and treating POI in the future.

Polycystic Ovary Syndrome (PCOS)

Women of reproductive age commonly experience anovulatory infertility due to PCOS. PCOS is caused by a combination of genetic and environmental factors. It affects women's metabolic, cardiovascular, immune, and psychological health beyond the reproductive system. Menopause irregularities, hirsutism, and infertility are some of the symptoms of PCOS [15, 16]. There is a greater risk of diabetes mellitus, obstructive sleep apnea, obesity, and depression among women with PCOS. According to several research papers, PCOS patients have significant biochemical alterations, including fasting glucose, free insulin, HOMA-IR, LDL, HDL, cholesterol, and hormones such as FSH, LH, testosterone, and progesterone. As a result of their genetic analysis, it was found that, when comparing PCOS patients to controls, the T allele frequency (fT) was significantly higher in patients with PCOS than the C allele frequency (fC) (0.36 vs 0.56). Additionally, they found a strong association between miRNA-146a (rs2910164 C > G) gene polymorphisms and PCOS risk. There was also a significant increase in the frequency of the C allele (fC). In patients, fG (fG) was less frequent. A statistically significant association between polymorphic variations and PCOS can be found in all three models: codominant, dominant, and recessive. PCOS susceptibility was also strongly associated with the G allele [17].

Endometriosis

There is still considerable clinical and epidemiological controversy surrounding endometriosis, whose incidence may range from 1.36 to 3.53 per 1000 persons per year. It may be due not only to methodological issues and the limitations of the different designs and data analyses, including case definitions and subject selection strategies, but also to the inherent heterogeneity of endometriosis. In an industrialized and polluted area, Elsakr et al. [18] estimated a 1.11/1000 incidence rate with a maximum of 1.60 for the 31-35-year-old age group [18]. A complex, heterogeneous, multisystem disorder, pre-eclampsia represents a serious threat to maternal and fetal safety and is a leading cause of maternal mortality. There are several "great obstetrical syndromes" that share a common pathophysiology based on disordered placentation, including pre-eclampsia, which is primarily a placental disorder. During implantation of blastocysts, spiral arterial remodeling, and placenta formation, matrix metalloproteinases (MMPs) play a critical role in angiogenesis and uterine remodeling. Several studies have implicated MMPs in preeclampsia development. According to previous studies, the level of trace elements such as Zinc, nickel, iron, manganese, copper, magnesium and hormone levels are correlated with obesity and PCOS, suggesting nickel may inhibit folliculogenesis and ovulation in obese women with PCOS. As a result of their interactions

with enzymes and hormones, trace elements affect the body's normal metabolism and play a critical role in ovulation. Endocrine disorders can be caused by changes in trace element concentration in the body [19-21]. The presence of trace elements can contribute to the formation of oxygen free radicals during oxidative stress reactions. It is unclear, however, whether this process is the cause or the effect.

Cervical Cancer

It is estimated that more than 90% of cervical cancer cases worldwide are caused by HPV infection [22]. There is a reduction in cervical cancer mortality due to HPV screenings and vaccinations, but environmental factors may also contribute to the disease's development. According to previous studies, bacteria, fungi, and viruses were found in the cervix of precancerous HPV16 and Hr-HPV-infected patients. HPV-infected patients can be divided into Lactobacilli-dominant (LD) and non-Lactobacillus-dominant (NLD) cases, indicating that *Lactobacillus* spp. Human viruses were also significantly influenced by HPV infection, as well as bacterial diversity. While pathogenesis occurs, many microorganisms remain unclear, particularly viruses. Women in low- and middle-income countries (LMIC) continue to undergo under-screening at too high a rate [23]. A number of self-sampling methods, including vaginal self-sampling and urine sampling, have demonstrated high acceptability and sensitivity for cervical cancer screening; since they are less invasive, they might be more attractive to women who have never been screened or who are under screened, as well as overcome barriers at different levels of interaction [24]. Educators in rural areas should consider the influence of sociocultural barriers on cervical cancer screening behavior when developing educational materials. Healthcare information is a major challenge for women diagnosed with cervical cancer. A strong body of evidence indicates that hierarchical medical encounters prevent women from expressing their doubts and concerns, limiting their ability to acquire knowledge about their health condition, as well as their ability to adhere to medical recommendations or self-care. As a result, women become increasingly anxious and fearful about cancer, making it difficult for them to understand and take part in decisions effectively [25]. It has been found that gendered relations in cervical cancer medical encounters are based on hidden, judgmental moral assumptions, which lead to women feeling irresponsible and blamed for contracting the human papillomavirus. Women's non-biomedical rationalities, self-care skills, and the need to respect their decisions must be considered by healthcare providers. Women and their partners (whether male, female, gender non-conforming, cis, or transgender) should both have access to healthcare to reduce the negative impact of being solely responsible for cervical cancer management [26].

An investigation of vaginal perforation with organ evisceration after consensual sexual interaction was reported by Stabile and coauthors, as well as a systematic review of vaginal perforations in women with or without evisceration. In addition to a detailed anamnesis, checking the patient's vital signs, and a prompt vaginal and rectal examination to identify the lesion, it is essential to reduce the patient's embarrassment, as well as determine whether the patient has been sexually abused. Creating an appropriate patient-professional partnership appears to be crucial to achieving successful wound healing by avoiding risky sexual behavior and providing psychological support. In addition to health and psychological well-being, level of independence, social relationships, personal beliefs, and the environment, QoL is influenced by a variety of factors [2]. In order to improve healthcare, assessing QoL is becoming increasingly important. Cancer survivors are less well-adjusted psychologically, socially, and physically as a result of their diagnosis of gynecological cancer. As a result of caring for women with gynecological cancers, family caregivers are also significantly less physically and psychologically healthy. Family members may experience changes in their expectations and responsibilities when a family member is diagnosed with cancer, which may have material and economic consequences. Healthcare management of complex diseases, such as most gynecological and obstetric diseases, is becoming increasingly intricate and requires the highest standards in quality of care and patient safety, as well as maximizing patients' expectations and value.

Data Science Study Design Considerations for Women's Health

Research on women's health and studies involving sex or gender issues require additional considerations beyond the basics of study design. To design human participant studies, it is generally necessary to define the study age ranges and availability, as well as the prevalence and measurement of exposures and outcomes, as well as the ascertainment methods to be used. Most of these areas are unique to women's studies, including inclusion and exclusion criteria, recruitment, measurement, and analytic methods. Research must consider women's specific life stages, including menarche, pregnancy, and menopause, as well as the length of time spent in each life stage, when defining comparison groups. Conclusions may be incorrect if these stages are not considered [27].

Historical Context of Women's Health Research

The majority of research has been conducted on men and merely generalized to women historically. Many studies excluded women because of concerns regarding exposures during childbearing years, to avoid the additional complexity of study design and analysis that would result from including them, or because women were viewed as vulnerable groups that were more likely to be coerced into research as a result. During 1990, the U.S. Government Accountability Office (GAO) published a report highlighting national institutes of health (NIH) policies regarding women's inclusion in study populations. This led to the creation of the women's health initiative (WHI) and the office of research on women's health (ORWH). Women's inclusion and participation in research were also enhanced by a number of laws. According to the NIH Revitalization Act of 1993 (PL 103–43), the NIH must establish guidelines for the inclusion of women and minorities in clinical research and ensure that all clinical trials are conducted so that effects can be analyzed in these populations. As early as 1994, the food and drug administration established an office of women's health to prioritize research on sex-based differences [2, 28].

The Intersectional Nature of Women's Health Conditions Create Challenges for Data Science

Research on women's health often intersects health conditions that disproportionately affect underrepresented groups, such as racial and ethnic minorities. Black women are more likely to die in childbirth, have a pregnancy loss, or suffer adverse pregnancy complications such as preterm delivery than women of other races [29]. In addition to stereotyping and insurance access, there is a lack of access to quality healthcare, such as clinics serving the community. In order to reduce disparities, there are efforts to improve access to contraception, increase prenatal care, and prevent STDs and HIV. It is difficult for an EHR to capture the unique mental health and healthcare challenges of transgender women, for instance. Minorities of sex and gender are also intersectional categories. This intersectional aspect of women's health poses challenges for data scientists attempting to design studies to

capture the complex network of factors that contribute to outcomes in intersectional risk populations [30, 31]. Social determinants of health, such as socioeconomic factors, systemic racism, mental health stressors, nutrition, and behaviors such as smoking, drug use, and alcohol use, will be absent from studies conducted with EHR. Additionally, EHRs do not adequately capture the risk factors related to the health care system itself, such as those related to access to care. EHR repositories, state-wide registries, and electronic health record repositories are the major types of studies with designs that allow testing of hypotheses with particular emphasis on those generating large volumes of data suitable for data science applications [32, 33].

Insufficient resource allocation, inadequate resource development, cultural biases, ethical dilemmas, and methodological challenges have all slowed the pace of scientific discovery that benefits women's health [34]. With new approaches to gathering data, statistical analyses, and a growing workforce of researchers in the field, there are opportunities for rapidly improving the quality and quantity of population-based women's health research.

Conclusion

Women have unique health needs, and most diseases and conditions affect women differently than men. Women may experience health disparities throughout their lifespans because of their gender, historic health inequities in the healthcare system, and socioeconomic conditions. This article highlights relevant conditions that affect women's health focusing on epidemiology, health services research, or qualitative methods, exploring how to improve our scientific knowledge to improve women's health and developing high-performing gynecology and obstetrical care. The digitalization of health services has reached a new level. Digital technologies will become irreplaceable tools in healthcare. The internet of things, big data, machine learning, and artificial intelligence are changing the delivery of health services, providing faster decision-making in-patient diagnosis, treatment, and day-to-day monitoring, which can be especially valuable when healthcare professionals and systems experience extremely high workloads. Population-based science using data science approaches is also rapidly growing and developing aspect of women's health research. In our view, it is an essential element of developing precision medicine to reduce the burden of disease in women. Research in women's health has previously been slowed by ethical, cultural, and logistical obstacles. However, the development of large-scale electronic health record databases and biobanks can alleviate many of those challenges. The issue of processing these resources to derive the benefits for the field can be addressed by developing the workforce and building the community of data scientists in women's health. Expanded career development awards from the NIH and other enterprises for early career scientists to pursue these goals will be necessary to take advantage of the opportunities for discovery, innovation, and translational impact that are available in women's health.

Acknowledgements

None.

Conflict of Interest

None.

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