Digital Health and Precision Medicine in Reproductive Health in the AI Era: Data, Methods, and Translation

From Real-World Data to Equitable Clinical Impact

Shefali Setia Verma
Department of Pathology and Laboratory Medicine, Department of Epidemiology, Biostatistics and Informatics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA
shefali.setiaverma@pennmedicine.upenn.edu

Samantha Piekos
Department of Epidemiology, Biostatistics and Informatics, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA
Samantha.Piekos@PennMedicine.upenn.edu

Tomiko Oskotsky
Division of Clinical Informatics and Digital Transformation, Bakar Computational Health Sciences Institute, University of California, San Francisco, CA
Tomiko.Oskotsky@ucsf.edu

Roxana Daneshjou
Department of Biomedical Data Science, Stanford University, Palo Alto, CA
roxanad@stanford.edu

Digna R. Velez Edwards
Department of Obstetrics and Gynecology and Biomedical Informatics, Vanderbilt University, Nashville, TN
digna.r.velez.edwards@vumc.org

Marina Sirota
Bakar Computational Health Sciences Institute, University of California, San Francisco, CA
Marina.Sirota@ucsf.edu

This workshop aims to examine how artificial intelligence, digital health, and precision medicine can be adapted to the distinctive data, biological, and clinical challenges of reproductive health. The program will connect computational methodology with clinically grounded applications across the reproductive lifespan, drawing on electronic health records, genomics and other molecular data, wearables, and patient-generated data. Emphasis will be placed on longitudinal modeling, multimodal integration, risk prediction, clinical decision support, responsible AI, and the practical requirements for translation into care. By convening computational scientists, reproductive health researchers, clinicians, and industry and implementation experts, the workshop will identify shared methodological challenges and opportunities for rigorous, equitable, and clinically meaningful innovation.

Keywords: reproductive health; artificial intelligence; precision medicine; digital health; multimodal data; clinical decision support

1. Motivation and Rationale

Reproductive health is central to population health and clinical decision-making, yet it remains underrepresented in precision medicine and biocomputing research relative to its complexity and impact[1,2]. At the same time, there has been a rapid rise in enthusiasm around predictive modeling,

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artificial intelligence, and clinical decision support (CDS) tools in healthcare[3,4]. Reproductive health presents both a high-impact opportunity and a rigorous testing ground for these approaches[5].

Advances in digital health have enabled large-scale, longitudinal data streams relevant to reproductive health, including electronic health records, genomics and other molecular data, wearable sensor data, and patient-generated data from mobile health applications[6,7]. These multimodal data sources are increasingly being used to develop AI-driven risk prediction models, patient stratification approaches, and CDS tools to support clinical management across fertility, pregnancy, and menopause[8]. While these developments create new opportunities for precision medicine, they also introduce substantial methodological and translational challenges[5].

Reproductive health data are characterized by strong temporal dynamics, heterogeneous phenotypes, and clinically meaningful subpopulations that are often poorly captured by traditional modeling approaches[8,9]. Issues of missingness, bias, and limited generalizability are particularly acute, especially for pregnancy-related outcomes and conditions that disproportionately affect historically underrepresented populations. In addition, despite the inherently longitudinal nature of reproductive health, it remains difficult to effectively link data across life stages, limiting our ability to examine how acute reproductive events shape long-term health trajectories and chronic disease risk[10–12].

This workshop aims to bring together researchers, practitioners, and stakeholders working at the intersection of biocomputing, digital health, reproductive medicine, and health AI to examine how computational methods and new tools can be adapted, extended, and translated to address these challenges. Topics of interest include AI approaches for modeling longitudinal reproductive health trajectories, chronic disease prediction models, and design and evaluation of precision medicine frameworks and CDS tools that advance care in pregnancy and menopause. By focusing on reproductive health as a use case, the workshop will surface methodological and translational insights that generalize broadly across precision medicine while addressing a critical and timely application area with implications for understanding sex differences in health across the lifespan.

2. Objectives

This workshop will bring together computational scientists, biomedical researchers, technologists, and clinicians working at the intersection of AI and reproductive health. Through invited talks, the workshop will highlight recent methodological advances, explore open problems, and encourage discussion of future directions. Key objectives include:

- Showcase recent advances in computational and statistical methods applied to reproductive health and digital health data, including multimodal data integration and longitudinal modeling[8,9].
- Highlight emerging applications of AI-driven prediction and risk stratification, spanning fertility, pregnancy, postpartum health, menopause, and reproductive-related chronic disease risk[3].
- Examine the development and evaluation of clinical decision support (CDS) tools that translate predictive models into actionable insights across clinical and digital health settings[13].
- Facilitate cross-sector dialogue between academic researchers, clinicians, and industry practitioners working on precision medicine and AI-enabled care delivery[14].

- Identify shared challenges and open research questions related to data quality, bias, interpretability, generalizability across populations, and clinical integration[15].
- Discuss methodological and implementation barriers to integrating AI and CDS tools into reproductive healthcare workflows, including usability, regulatory considerations, and provider trust[16,17].
- Encourage responsible and equitable translation of precision medicine approaches into reproductive health settings, with attention to fairness, representation, and patient-centered outcomes[15].

3. Workshop Format

The workshop will be organized as a half-day session that balances invited presentations with interactive discussion. Opening remarks will frame reproductive health within broader precision medicine and health AI efforts, emphasizing both the opportunity created by emerging data sources and the challenges of developing models that are clinically useful, trustworthy, and generalizable.

The scientific program will consist of a sequence of focused presentations spanning methods and applications. Rather than organizing the program around a fixed speaker roster, the session is designed around complementary perspectives: computational method development, disease- and life-stage-specific applications, population and genetic epidemiology, clinical informatics, digital health, and responsible AI. This structure allows the program to remain responsive to new work while preserving coherent scientific coverage.

The workshop will conclude with a moderated discussion and audience Q&A focused on the transition from research prototypes to real-world care. Discussion will address evidence standards, external validation, data fragmentation, regulation, workflow integration, bias and equity, patient and clinician trust, and the conditions under which predictive tools can meaningfully improve reproductive healthcare.

4. Scientific and Translational Scope

The program will cover reproductive health across multiple conditions and life stages rather than centering on a single clinical problem. Pregnancy and maternal-fetal health provide a natural setting for longitudinal modeling because care is structured around repeated measurements over a defined interval, while menopause creates a complementary challenge involving heterogeneous symptoms, changing risk profiles, and long-term health consequences. Chronic and often underdiagnosed conditions such as uterine fibroids and endometriosis further highlight the need for improved phenotyping, population-scale data resources, and individualized risk assessment. Fertility, menstrual health, and postpartum trajectories provide additional settings in which patient-generated data and digital health tools can complement clinical records.

Across these applications, the workshop will emphasize several methodological themes: integration of EHR, genomic, multi-omic, imaging, wearable, and mobile-health data; temporal and trajectory modeling; disease and outcome phenotyping; risk prediction and patient stratification; systems-level and mechanistic modeling; foundation and generative models where appropriate; and methods for evaluating uncertainty, robustness, interpretability, and fairness.

A central translational theme will be the distinction between model performance and clinical impact. Predictive accuracy alone is insufficient when data are fragmented, interventions are limited, or clinical workflows cannot act on model outputs. The workshop will therefore consider how decision-support tools should be evaluated, what evidence is needed for deployment, how models should be monitored after implementation, and how regulatory, usability, and trust considerations shape adoption[12,17].

5. Participant Perspectives and Cross-Sector Discussion

The workshop will intentionally draw on different kinds of expertise. Computational and statistical investigators will contribute approaches for high-dimensional and longitudinal modeling. Reproductive health researchers and clinicians will ground these methods in biological mechanisms, disease-specific phenotypes, clinical decision points, and unmet needs. Population health and genetic epidemiology perspectives will address heterogeneity, environmental context, and generalizability across populations. Clinical informatics and responsible AI perspectives will focus on workflow integration, validation, bias, transparency, and governance. Digital health and industry participants will add practical experience with patient-generated data, product development, diagnostics, implementation, and real-world evidence.

Bringing these perspectives together is particularly important because many barriers to reproductive-health AI are not purely technical. Data ownership, interoperability, missingness, representation, regulatory pathways, reimbursement, clinician burden, patient engagement, and the availability of effective interventions all influence whether a model can create value. The discussion will therefore emphasize the full translational pathway from data and methods to validation, implementation, and measurable patient benefit.

6. Organizers Contributions

The organizing team spans computational genetics, biobank analytics, biomedical informatics, systems biology, multi-omics, genetic epidemiology, maternal and reproductive health, clinical informatics, digital health, and responsible machine learning. Organizers will contribute scientific framing, selected presentations, moderation, and synthesis across the workshop. This breadth is intended to ensure that methodological innovation remains connected to disease biology, clinical needs, population-level evidence, implementation realities, and equity.

7. Overall Impact

The workshop is intended for researchers, practitioners and industry partners in biocomputing, computational biology, biomedical informatics, digital health, and related fields, with particular relevance for those working on predictive modeling and AI for health using real-world data. By bringing together stakeholders across academic and industry environments, we will provide participants with exposure to differing perspectives and experiences. This will facilitate opportunities for scientific and resource exchange as well as encourage the formation of new collaborations.

There is no shortage of hype around AI and prediction in healthcare. This workshop will take a more grounded view. Reproductive health offers a setting where the promises and limits of predictive modeling are immediately visible: outcomes are time-dependent, data are noisy and biased, and clinical decisions carry real consequences. Pregnancy, in particular, represents an exceptional model system for developing and evaluating precision medicine approaches. It is a defined period with clear start and endpoints, during which patients engage regularly with the healthcare system through routine prenatal care, generating rich longitudinal data. Pregnant individuals are highly motivated to optimize health outcomes but frequently experience complications for which there are limited to no effective interventions. Moreover, pregnancy represents a period during which traditional pharmaceutical trials are rarely conducted, making pregnant individuals systematically excluded from evidence-based therapeutic development. This creates both an urgent need and a unique opportunity for precision medicine approaches that can stratify risk, optimize the timing of surveillance and intervention, and identify modifiable factors. Importantly, events during pregnancy have lifelong consequences for both maternal and offspring health.

By centering reproductive health, the workshop creates space to move past abstract claims and examine how precision medicine methods actually perform in practice. In doing so, it highlights methodological challenges that extend well beyond this domain and helps shape a research agenda focused on clinically meaningful, trustworthy, and equitable models.

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