OHIO COLLEGES OF MEDICINE
GOVERNMENT RESOURCE CENTER

Infant Mortality Research Partnership

Reducing Infant Mortality in Ohio: Individuals, Communities, Systems, and Interventions

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Ohio Colleges of Medicine Government Resource Center

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Executive Summary

The Infant Mortality Research Partnership (IMRP) is a collaboration between state agencies, researchers, and subject matter experts to bring rigorous and innovative methodological approaches to lowering infant mortality (IM), severe maternal morbidity (SMM) and preterm birth (PTB) in Ohio. IMRP has proceeded through a series of five phases, each of which has built upon prior work with the goal of leveraging technology to improve outcomes. In **Phase I**, the IMRP created a novel multi-agency linked dataset, and cross-disciplinary research teams examined the obstetrical, other clinical, sociodemographic, and contextual factors associated with IM and PTB, as well as the trends in their distribution across the State. In **Phase II,** researchers developed predictive models that could be used throughout the course of pregnancy to identify pregnant individuals and infants at high risk of suffering PTB and/or IM and examined the impact of neighborhood structural factors on preterm birth in urban settings and the spatial distributions of additional outcomes. In **Phase III**, the IMRP made this prior work available to healthcare providers in clinical settings and Medicaid members through the development of a toolkit of innovative applications including the Medicaid Perinatal Risk Tool (MPRT), an application that provides access to predictive models and the Perinatal Risk Assessment Form (PRAF) at the point of care. The IMRP team then tested the impact of these tools through a small clinical trial. In **Phase IV** researchers created predictive models for SMM as well as training materials to support dissemination of MPRT. In **Phase V**, researchers are turning their focus to the postpartum period, developing predictive models linked to interventions to ensure infants and families are fully supported through the transition of pregnancy to routine health maintenance. This report will focus on new findings and products developed in Phases III-V. These include:

- **New predictive models** for preterm birth and severe maternal morbidity, updated based on clinician feedback and optimized for use within a clinical encounter.
- **Development of a patient-facing risk calculator (PFRC)** based on risks identified using the preterm birth risk calculator, to provide personalized patient education and further support clinician-patient communication.
- **Continuous updating and deployment of the components of the Epic-integrated MPRT including:**
    - PRAF-EHR: updated to version 2.0
    - Preterm birth risk calculator
    - Patient-facing risk calculator
- **Completion of the Clinical Trial** with findings demonstrating the impact of the risk calculator on risk perception, understanding, and worry.

- **Recruitment and expansion of MPRT to 14 hospital sites.**
- **Validation of preterm birth models in a large cohort of Medicaid-insured individuals** using electronic health record data in hospitals across Ohio.

Section 1: Introduction and Background

1.0 Background and Rationale

The infant mortality rate (IMR), defined as the number of deaths in the first year of life per 1,000 live births, reflects not only maternal and infant health but also the overall health of a community, state, or nation.[1] In the United States in 2022, the IMR was 5.6/1,000, a rate below the Healthy People 2020 goal of 6.0/1,000 but still above the Healthy People 2030 goal of 5.0/1,000.[2,3] However, the IMR for non-Hispanic Black (NHB) infants in many U.S. states and cities is more than twice as high as the rate for non-Hispanic White (NHW) infants.

In 2017, Ohio had one of the higher reported IMRs in the United States at 7.2/1000[4]. A variety of strategies, including national, statewide, and community-based initiatives, have been undertaken to reduce both the overall IMR in Ohio and its associated racial and ethnic disparities. In 2021, Ohio's IMR was 7.0/1,000, increasing from 6.7 in 2020.[5] The NHB IMR was 15.6/1,000 in 2017, 13.6/1,000 in 2020 and 14.2/1,000 in 2021. Meanwhile, the NHW IMR was 5.3/1,000 in 2017, and most recently 5.4/1,000 in 2021, showing a persistent disparity.[5]

To reduce this disparity, The Ohio Department of Health (ODH) joined the National Institute for Equity in Birth Outcomes initiative and designated the nine counties and communities in which the majority of Ohio's NHB babies are born as Ohio Equity Institute (OEI) communities. Building on the Ohio Department of Health Infant Mortality Reduction plan and the Ohio Commission on Infant Mortality report, legislators enacted S.B. 332. Also known as the Infant Mortality Reduction Bill, it contains provisions that address factors known to affect infant mortality. The State Health Improvement Plan for 2020-2022 included a strong focus on maternal and infant health to achieve health equity and reduce infant mortality. To examine the specific risk factors for different populations as well as individual risks, a more coordinated effort, grounded in Ohio-specific data, was needed.

The need for a statewide research collaboration to address this public health issue was identified by the Ohio Legislature and the Ohio Departments of Medicaid (ODM), Health (ODH), and Higher Education (ODHE). The IMRP was launched to address this gap. The IMRP project design incorporated multiple methodologies to span multiple domains and levels. The design was intended to explicitly model nuance in infant mortality risk factors (i.e., move beyond poverty as the primary risk factor), as well as capture a cohesive and more comprehensive portrait of the complexity of infant mortality.

The Ohio Colleges of Medicine Government Resource Center (GRC) was charged with administering the IMRP.

1.1 Data Used for the IMRP

Thanks to a multi-agency effort, facilitated by data preparation and linkage and management by GRC, infant mortality researchers had access to comprehensive, linked datasets that included physical and mental health variables, numerous social determinants of health indicators, and data on the utilization of some community and government programs. This application of big data to the pervasive, complex problem of infant mortality enabled researchers to develop more accurate models of the factors impacting risk, and the interventions that can improve maternal and child health outcomes across the state of Ohio.

Section 2: Updating and Optimizing Preterm Birth Models

2.1 Introduction and Objectives

Preterm birth (birth at less than 37 weeks) is a major contributor to infant mortality. In Ohio in 2021, 10.6% of babies were born preterm, and of those infants that died within the first year of life, two-thirds were born preterm.[5] IMRP previously developed models to predict preterm birth as well as very preterm birth (births before 32 weeks). Separate models were designed to be used at different time-points during pregnancy including pre-pregnancy, early-, mid-, and late-pregnancy. These models were integrated into MPRT and used as part of the clinical trial (see Section 6). Feedback from the clinical trial, from usability studies, and during training sessions led the research team to re-develop the PTB models.

1. Based on clinical expert feedback, the IMRP researchers:

    a. Created new variables to be considered for inclusion into the PTB models. Some of these variables included hypertensive disorders of pregnancy, chronic kidney disease, sickle cell disease, and UTI during pregnancy;
    b. Changed model time frames to better align with time-periods that would fit into clinical workflow and allow for timely interventions (see Table 1).

2. Based on user feedback, the IMRP research team:

    a. Removed educational level as a variable, as this was not often available in the Electronic Health Record (EHR), and users reported asking patients about this was outside of their normal clinical workflow;
    b. Only included variables that could be automatically pulled from the EHR using Fast Healthcare Interoperability Resources (FHIR). This resulted in manual entry no longer being required to estimate risk using the models.

3. Based on researcher and other expert recommendations, the IMRP research team:

    a. Updated the dataset used for modeling to include the week of gestation when diagnoses were reported during pregnancy, to ensure the diagnosis had occurred at the relevant time in pregnancy to be included in that model.
    b. Based on feedback and results of the forum the IMRP conducted, the research team assessed the feasibility of replacing race as a variable in the PTB models with variables that accounted for community needs and structural racism. After extensive investigation, the only new variables identified were the social vulnerability index (SVI)[6] and the area deprivation index (ADI)[7]. These did not significantly impact the models, so were not included. The Ohio opportunity index (OI)[8] continues to be included in the models.

2.2 Methods

To create the dataset, data from birth certificates were linked with Medicaid claims and enrollment and demographic data.

Commented [DN1]: We consistently call this eligibility data internally at GRC. But I wonder if it would serve this document better to call it enrollment and demographic data.

Births occurring between 2018 and 2022 were included in the dataset. Three preterm birth models were created, to be used at different time periods during pregnancy (Table 1). Only billing codes that had a billing date prior to the end of the period were used to define variables in each of the models. Births that occurred prior to the start of the period for each model were excluded from that dataset.

Table 1: Updated Preterm Birth Models

Model	Timeframe	Exclusions	Included variables	Outcome
PTB model 1	20w0d-23w6d	births prior to 20w0d	billing dates prior to 23w6d	Birth prior to 37w0d
PTB model 2	24w0d-27w6d	births prior to 24w0d	billing dates prior to 27w6d	Birth prior to 37w0d
PTB model 3	28w0d-31w6d	births prior to 28w0d	billing dates prior to 31w6d	Birth prior to 37w0d

Three logistic regression models were created (PTB 1-3). The same general modeling strategy was employed for all 16 models.[9] To meet the independence of observations assumption required in logistic regression modeling, only the most recent pregnancy was included for individuals with more than one pregnancy in the dataset. Relevant variables were chosen by subject matter experts for each of the outcomes and timeframes based on their ease of interpretation, clinical relevance, and availability within discrete fields in the EHR. Univariable analyses were completed and variables with p-values of <0.05 were put into a multivariable logistic regression model. Variables were removed and replaced until all variables in the model had a p value of <0.05 and were clinically relevant. Calibration of models was evaluated using the Hosmer-Lemeshow Goodness of Fit (GOF) test. Discrimination was evaluated with the area under the receiver operator characteristic curve (AUC). All models were validated on a 10% randomly sampled, held out cohort.

2.3 Results

There were 257,665 pregnancies over this period. 28,211(11%) involved a PTB. Please see Table 2 for a summary of the variables considered for the final models.

Table 2: Summary information on cohort for PTB models

Variable[1]	**Preterm birth** **28,211 (11%)**	**Term birth** **229,454 (89%)**
Demographics		
Age of Mother	27 (23, 32)	26 (22, 31)
Mother's age > 35	4,184 (14.8%)	24,213 (10.6%)
Medical History		
Diagnosis of short cervix	1,956 (6.9%)	4,370 (1.9%)
Personal history of preterm labor	6,053 (21.5%)	14,911 (6.5%)
Diagnosis of pregestational diabetes	2,258 (8.0%)	6,017 (2.6%)
Pre-existing hypertension complicating pregnancy	5,222 (18.5%)	17,239 (7.5%)
Congenital uterine abnormalities	308 (1.1%)	1,337 (0.60%)
Chronic kidney disease	228 (0.81%)	477 (0.21%)
Sickle cell disease	146 (0.52%)	729 (0.32%)
Systemic Lupus Erythematosus or antiphospholipid antibody syndrome	263 (0.93%)	868 (0.38%)
Obesity	10,116 (35.9%)	70,489 (30.7%)
Substance use and mental health		
Opioid use in pregnancy	2,108 (7.5%)	9,950 (4.3%)
Cocaine use in pregnancy	757 (2.7%)	2,867 (1.3%)
Methamphetamine use in pregnancy	780 (2.8%)	3,531 (1.5%)
Cannabis use in pregnancy	4,010 (14.2%)	25,401 (11.1%)

Cocaine use in pregnancy	2,972 (6.2%)	13,273 (3.8%)
Maternal smoking	12,861 (27%)	81,394 (23%)
Diagnosis of anxiety in prenatal period	11,822 (25%)	68,619 (20%)
Diagnosis of depression in prenatal period	8,774 (18%)	49,048 (14%)
Pregnancy related diagnoses		
Diagnosis of gestational diabetes in prenatal period	2,966 (10.5%)	13,494 (5.9%)
Vaginal bleeding during current pregnancy	7,599 (26.9%)	42,747 (18.6%)
Pregnancy with twins	2,853 (10.1%)	1,755 (0.76%)
Poor fetal growth	3,326 (11.8%)	11,350 (5.0%)
Gonorrhea during pregnancy	354 (1.3%)	2,347 (1.0%)
Trichomonas during pregnancy	1,108 (3.9%)	6,117 (2.7%)
Bacteriuria or UTI during pregnancy	5,819 (20.6%)	36,794 (16.0%)
Diagnosis of hypertensive disorder of pregnancy	3,021 (10.7%)	4,866 (2.1%)
Diagnosis of anemia during prenatal period	12,952 (27%)	70,672 (20%)
Area-level vulnerability indices		
Ohio Opportunity index (zip code level)	68 (60, 77)	69 (62, 78)
Area deprivation index (ADI) National Rank (zip code level)	84 (67, 93)	83 (66, 92)
ADI State Rank (zip code level)	7 (5, 9)	7 (4, 9)

[1] Categorical variables are presented as n (%) and continuous variables are presented as median (IQR).

Optimized PTB models

The final models included demographic, pregnancy-related, and medical-history-related variables, and one interaction between short cervix and prior preterm birth. See Table 3. Each

of the models contains the same variables to simplify implementation of these models into the clinic.

Table 3: Final PTB model variables and performance

Variable	Model 1 OR (95% CI)	Model 2 OR (95% CI)	Model 3 OR (95% CI)
Age >35	1.36 (1.30, 1.41)	1.35 (1.30, 1.40)	1.33 (1.28, 1.39)
OI (ten-unit increase)	0.95 (0.94, 0.96)	0.96 (0.95, 0.97)	0.96 (0.95, 0.97)
Twins *	15.3 (14.3, 16.3)	14.7 (13.8, 15.7)	14.1 (13.2, 15.1)
Poor fetal growth	1.57 (1.44, 1.70)	1.90 (1.79, 2.02)	1.95 (1.86, 2.04)
Hypertensive disease of pregnancy	2.42 (2.20, 2.65)	3.21 (2.99, 3.45)	4.41 (4.12, 4.65)
Vaginal bleeding during pregnancy	1.39 (1.35, 1.44)	1.39 (1.35, 1.44)	1.41 (1.36, 1.45)
Gestational diabetes	1.86 (1.72, 2.02)	1.81 (1.70, 1.93)	1.49 (1.42, 1.56)
UTI	1.19 (1.15, 1.24)	1.20 (1.15, 1.24)	1.17 (1.13, 1.21)
Short cervix x previous preterm birth (PPB)			
First pregnancy; No short cervix	Reference	Reference	Reference
First pregnancy; Short cervix	3.98 (3.40, 4.67)	3.58 (3.09, 4.15)	2.92 (2.52, 3.38)
No PPB; No short cervix	0.85 (0.83, 0.88)	0.86 (0.83, 0.88)	0.89 (0.85, 0.91)
No PPB; Short cervix	3.13 (2.84, 3.46)	2.79 (2.54, 3.07)	2.54 (2.31, 2.79)
PPB; No short cervix	3.32 (3.17, 3.47)	3.26 (3.12, 3.41)	3.24 (3.09, 3.39)
PPB; Short cervix	5.97 (5.34, 6.68)	5.80 (5.21, 6.45)	5.71 (5.14, 6.35)

Short cervix x previous preterm birth (PPB) continued			
Developmental AUROC	0.66	0.67	0.69
Validation AUROC	0.67	0.67	0.68
Developmental H-L (10 group) p-value	0.05	0.17	0.08
Validation H-L (10 group) p-value	0.51	0.55	0.61

*Pregnancies with more than two fetuses were excluded from the cohort as almost all pregnancies with more than two fetuses delivered preterm.

The models performed well in both the developmental dataset and the validation dataset, with areas under the receiver operating characteristic (AUROC) near 0.7. When assessing calibration, a high p-value in the Hosmer-Lemeshow GOF test is desired, and all of the validation GOF p-values are high, suggesting no evidence of lack of fit.

The IMRP research team assessed whether these models showed any bias or residual confounding after the removal of race and ethnicity. The Research Team ran PTB Model 3 separately on individuals who were listed as Black or African American and non-Hispanic (NHB) and on those who were listed as White and non-Hispanic (NHW) as there is a known disparity in PTB outcomes between these groups. The model run on only NHW individuals had an AUROC of 0.69 and performed similarly well in the NHB individuals with an AUROC of 0.70. The models were well calibrated in both groups.

Finally, using this model, the predicted probabilities in NHB individuals had a mean of 0.12 and median of 0.08 (0.06,0.11) and those in NHW individuals had a mean of 0.11 and median of 0.07 (0.06,0.09).

2.3 Key Findings

The work to produce the updated PTB models resulted in the following key findings:

1. The models continue to perform well in both NHB and NHW individuals even after the replacement of race and ethnicity as an independent predictor.
2. Variables included in the final model included demographics (age), pregnancy-related diagnoses, history of prior preterm birth, and the Ohio Opportunity Index.

3. Variables related to substance use, mental health, and medical history appeared to be less important in predicting the outcome and were not retained in the final models.
4. The AUROC improved slightly from model 1 to 3, most likely because the Research Team continues to obtain additional information throughout the pregnancy that informs risk.

Section 3: Development of New Pre-delivery SMM Models

3.1 Introduction and Objectives

The composite definition for severe maternal morbidity (SMM) includes 21 separate indicators defined by the CDC,[10] including acute myocardial infarction, acute renal failure, sepsis, and shock. Receiving a transfusion is one of the indicators, and previous work recommends separating these outcomes into SMM with transfusion included (i.e., all 21 indicators included in the definition) and SMM with transfusion-only indicators excluded (i.e., only 20 indicators included in the definition).[11]

The incidence of severe maternal morbidity (SMM) has been steadily increasing over time. In 2017, 71.5 of every 10,000 deliveries in the US were identified as having SMM excluding transfusion-only indicators, compared to 88.2 per 10,000 deliveries in 2020.[12] In Ohio, the SMM rate (excluding transfusion-only indicators) was relatively stable from 2016-2019 with a rate of 71.1 per 10,000 deliveries over that time period.[13] This is above the healthy people 2030 goal of 64.4 per 10,000.[12] The incidence of SMM including transfusion-only SMM is significantly higher, with US rates increasing from 146.8 in 2008 to 179.8 per 10,000 in 2021.[14]

SMM can have short and long-term consequences in pregnant individuals and, like in preterm birth, there are known disparities in outcomes. In Ohio, the overall SMM without transfusion rate was 71.1/10,000 deliveries from 2016-2019. Deliveries covered by Medicaid had a SMM rate of 85 per 10,000 deliveries, compared to 58.7/10,000 for privately insured deliveries. Over the same time period, NHB individuals had the highest rate of SMM at 112.2 per 10,000, compared to 60.5 for NHW individuals.[13]

The IMRP had previously developed preliminary SMM models. In updating these models, the team has made the following changes:

1. Based on clinical subject matter expert feedback:
    a. Only one pre-delivery timeframe will be included, as most SMM risk factors occur later in pregnancy, so models including variables from earlier in pregnancy are not as clinically useful;

   b. Models for both SMM with transfusion as well as SMM without-transfusion-only codes will be created; however, only the SMM model with transfusion will be implemented into MPRT as that is the most clinically actionable;
   c. The Research Team examined SMM and mortality, as both are clinically relevant outcomes the team seeks to avoid.
2. For risk factors that occur during pregnancy, the dates of the diagnosis were considered to ensure that the diagnosis had occurred at the relevant point in pregnancy to be included in that model.
3. Race and ethnicity were removed from previous models, and the team evaluated the addition of ADI, SVI, and OI.

3.2 Methods

To create the dataset used for model development, birth certificates were linked with Medicaid claims and eligibility data. Pregnancy-Associated Mortality Review (PAMR) data were also joined to this dataset to identify episodes of pregnancy-related mortality during this period. PAMR data does not currently have adjudicated data for 2019, so for that year a board-certified maternal fetal medicine specialist reviewed and adjudicated the deaths as pregnancy-related or not.

These SMM models are intended to be used at 32 weeks and beyond to help identify patients who might benefit from delivery at a hospital that provides a higher level of care. Because of this, patients were excluded from the dataset if they delivered or had SMM prior to 32 weeks. The main outcome of interest for SMM model 1 was SMM excluding transfusion-only SMM during the delivery hospitalization or maternal mortality after 32 weeks gestation. The main outcome of interest for SMM model 2 was SMM including transfusion-only SMM, during the delivery hospitalization or maternal mortality after 32 weeks gestation.

Individuals were included in the dataset if they had a delivery hospitalization that occurred from 2018-2022 or a maternal mortality after 32 weeks of gestation during the same period. Individuals who had a delivery or maternal death prior to 32 weeks were excluded, as the model is intended to be used between 32 weeks and delivery. Two SMM models were created to be used at a single time-period during pregnancy (Table 4). Only billing codes that had a billing date prior to the end of the period were used to define variables in each of the models.

Variables were created based on prior literature[15], clinical experience, and availability as discrete data elements in both claims data and EHR data.

Table 4: SMM models at delivery hospitalization

Model	When model should be used	Exclusions	Included variables	Outcome
SMM model I	32w0d to labor and delivery admission	Births + maternal deaths prior to 32w0d	Billing codes with dates prior to admission	SMM during delivery admission, excluding transfusion-only indicators +maternal mortality after 32 weeks
SMM model II	32w0d to labor and delivery admission	Births + maternal deaths prior to 32w0d	Billing codes with dates prior to admission	all SMM during delivery admission including transfusion-only indicators + maternal mortality after 32 weeks

3.3 Results

The final analytic file consisted of 228,621 individuals with 4,016 (1.8%) or 176/10,000 having the outcome of SMM with transfusion-only SMM or mortality. Of those, 2,553 (1.1%) had an outcome of SMM without transfusion only indicators or mortality or 112 per 10,000 having the outcome. Thirty-three pregnancy-related maternal mortalities were identified in the dataset.

Table 5 shows summary findings of this cohort.

Table 5: Summary data on SMM with transfusion-only SMM + maternal mortality cohort

Pregnancy-related diagnoses	**N (%)** **[Total = 228,621]**	**No SMM** **[Total = 224,605]**	**SMM with transfusion-only SMM + mortality** **[Total = 4,016]**
Cardiac disease during pregnancy	12,286 (5.4%)	11,712 (5.2%)	574 (14%)
Hypertensive disease of pregnancy	16,312 (7.1%)	15,762 (7.0%)	550 (14%)
Placenta accreta	229 (0.1%)	172 (<0.1%)	57 (1.4%)
Placenta abruption	1,119 (0.5%)	1,072 (0.5%)	47 (1.2%)
Placenta previa before delivery	2,008 (0.9%)	1,874 (0.8%)	134 (3.3%)
Transfusion during the prenatal time period	**345 (0.1%)**	**303 (0.1%)**	**42 (1.0%)**
Multiples (pregnancies with more than one fetus)	3,727 (1.6%)	3,565 (1.6%)	162 (4.0%)
Anemia	34,426 (15%)	33,447 (15%)	979 (24%)
Bleeding disorder	6,204 (2.7%)	5,903 (2.6%)	301 (7.5%)
Indicator of diagnosis of pregestational diabetes	7,176 (3.1%)	6,905 (3.1%)	271 (6.7%)
pre-existing hypertension complicating pregnancy	18,916 (8.3%)	18,254 (8.1%)	662 (16%)
Sickle cell disease	710 (0.3%)	640 (0.3%)	70 (1.7%)

Pregnancy-related diagnoses continued	N (%) [Total = 228,621]	No SMM [Total = 224,605]	SMM with transfusion-only SMM + mortality [Total = 4,016]
Chronic kidney disease	580 (0.3%)	538 (0.2%)	42 (1.0%)
Previous C-Section	42,606 (19%)	41,489 (18%)	1,117 (28%)
Parity 0	73,426 (32%)	71,982 (32%)	1,444 (36%)
Parity 1-4	146,081 (64%)	143,761 (64%)	2,320 (58%)
Parity 5+	9,114 (4.0%)	8,862 (3.9%)	252 (6.3%)
Previous C-Section	42,606 (19%)	41,489 (18%)	1,117 (28%)
Opiate use during pregnancy	10,358 (4.5%)	10,028 (4.5%)	330 (8.2%)

The final model is shown in Table 6. Mothers age was included in the model as both as a continuous variable, squared, and cubed, and therefore has a complex relationship shown in table 7. The IMRP team also created a model without transfusion-only indicators. That model uses the same variables but performed slightly better. See table 8 for model performance.

Table 6: Final SMM with transfusion-only SMM + maternal mortality model (SMM model II)

Variable	OR	95% CI
Cardiac disease	2.17	1.97-2.39
Hypertensive disease of pregnancy during prenatal period	1.50	1.36-1.66
Placenta accreta	7.44	5.29-10.46
Placenta abruption	1.78	1.32-2.42
Opportunity index	0.94	0.92-0.97

Variable	OR	95% CI
Placenta previa	2.71	2.22-3.29
Transfusion during prenatal period	3.03	2.11-4.36
Indicator of diagnosis of pregestational diabetes	1.37	1.19-1.56
pre-existing hypertension complicating pregnancy	1.38	1.25-1.52
Sickle cell disease	3.40	2.6-4.45
chronic kidney disease	1.98	1.41-2.77
Opioid use during pregnancy	1.70	1.51-1.92
Mom age	No Data	No Data
Multiples (pregnancies with more than one fetus)	2.31	1.96-2.72
Anemia	1.46	1.36-1.58
Bleeding disorder in the prenatal period	2.32	2.05-2.63
Prior C-section	1.74	1.61-1.89
Parity 0	reference	reference
Parity 1-4	0.55	0.51-0.60
Parity 5+	0.72	0.61-0.84

Table 7: Mother's age relationship within the SMM with transfusion-only SMM model

Mother's age at birth	Odds ratio	95% Confidence interval
20 vs 15	0.80	0.67-0.94
25 vs 20	0.99	0.93-1.05
30 vs 25	1.13	1.08-1.19
35 vs 30	1.21	1.16-1.27
40 vs 35	1.20	1.10-1.30

Table 8. Performance of SMM model without transfusion-only indicators

Category	SMM model I (excluding transfusion-only indicators)	SMM model II (including transfusion-only indicators)
Developmental AUROC	0.70	0.68
Validation AUROC	0.71	0.68
Developmental H-L (10 group) p-value	0.47	0.04
Validation H-L (10 group) p-value	0.02	0.35

3.4 Key Findings

The work to produce the updated SMM at delivery models resulted in the following key findings:

1. The SMM model with transfusion-only SMM did not perform as well as the SMM model removing transfusion-only indicators.

2. Mother's age at birth shows a complex relationship with the outcome. At younger ages, a 5-year increase in age is protective, whereas at older ages a five-year increase in age is a risk factor for SMM.
3. Risk factors with the highest odds ratios in the model, even after adjusting for all other variables include, placenta accreta (OR 7.44), sickle cell disease (3.40), and transfusion during the prenatal period (OR 3.03).
4. Any prior live birth (parity >0) shows a protective association with SMM.
5. Every 10-point increase in the Ohio Opportunity Index appears to be protective in relation to SMM.

Section 4: Development and Field Testing of the Patient Facing Risk Calculator

4.1 Introduction and Objectives

MPRT's goals include facilitating patient-clinician communication and providing education to pregnant individuals that could lead to reduced risk of PTB and SMM. To support this goal, the IMRP has designed and developed an intervention called the patient-facing risk calculator (PFRC) that takes risk factors identified from the PTB risk calculator, pairs them with educational resources, and provides them as a handout to the patient after an office encounter.

4.2 Methods

Design Methodology

The PFRC has undergone multiple stages of design and subject matter expert feedback. This includes clinical subject matter experts evaluating and editing the educational materials to ensure that they are up to date and evidence-based. In addition, the IMRP solicited feedback from a health literacy expert who evaluated the tool to ensure that it followed health-literacy best practices. The IMRP is now planning a study that will gather feedback on the tool from pregnant individuals through surveys and a focus group session. This will be a mixed-methods observational exploratory design, which will include a qualitative focus group session and a mixed-methods questionnaire where patients provide ratings and unstructured feedback about various features of the tool.

The study will consist of 30-60 minute-sessions eliciting feedback about the educational tool to understand the needs and preferences of the population. First, participants will view the educational tool as a paper handout for 5 minutes. Next, a focus group session will be conducted where the researchers ask open-ended questions to the participants to elicit unstructured feedback. Finally, all the participants will be given a paper survey to complete. The question topics include understandability, visual appeal, necessary additions to the tool, ideal

timing to receive the tool, how the tool makes patients feel, and whether the tool would affect their behavior. These procedures will be sufficient to understand reactions to the educational tool among people in the target population and provide the researchers with the feedback necessary to modify the tool to better fit the needs and desires of the population.

The participants will include adults and pregnant individuals recruited from prenatal and parenting classes at Moms2B. Pregnancy status will not be identified as part of this research; however, recruitment will take place in classes with high numbers of pregnant attendees. Participants will provide verbally informed consent and will be given a gift card for participating. The project team plans to recruit up to 30 participants over multiple sessions.

Results from these sessions will inform changes to the PFRC design.

Implementation into MPRT

The IMRP team has implemented the PFRC in MPRT in a non-production environment and is undergoing testing and review. Once it is delivered to MPRT-using health systems, the PFRC will appear as a button titled "view patient-facing summary" for clinicians to select when using the PTB risk calculator as part of MPRT. Selecting this option will load in a new tab within the web application. The clinician will then be able to facilitate shared decision making with the patient, print a handout with the included information, and provide the printout to the patient to take home, if desired.

4.3 Results

The preliminary design of the PFRC is seen in Figure 1. It will show the patient's name, date of birth, and weeks' gestation as well as the patient's risk score visualized as the number of people out of 100 with this patient's characteristics who would be expected to have a PTB. This will be presented in a visualization that compares the patient's risk score to the number of people out of 100 in the US who, without such risk factors, would be expected to have a PTB. Finally, each of the patient's risk factors for PTB will be listed with specific educational resource links and QR codes to assist patients in better understanding their individual risks and what can be done to mitigate them.

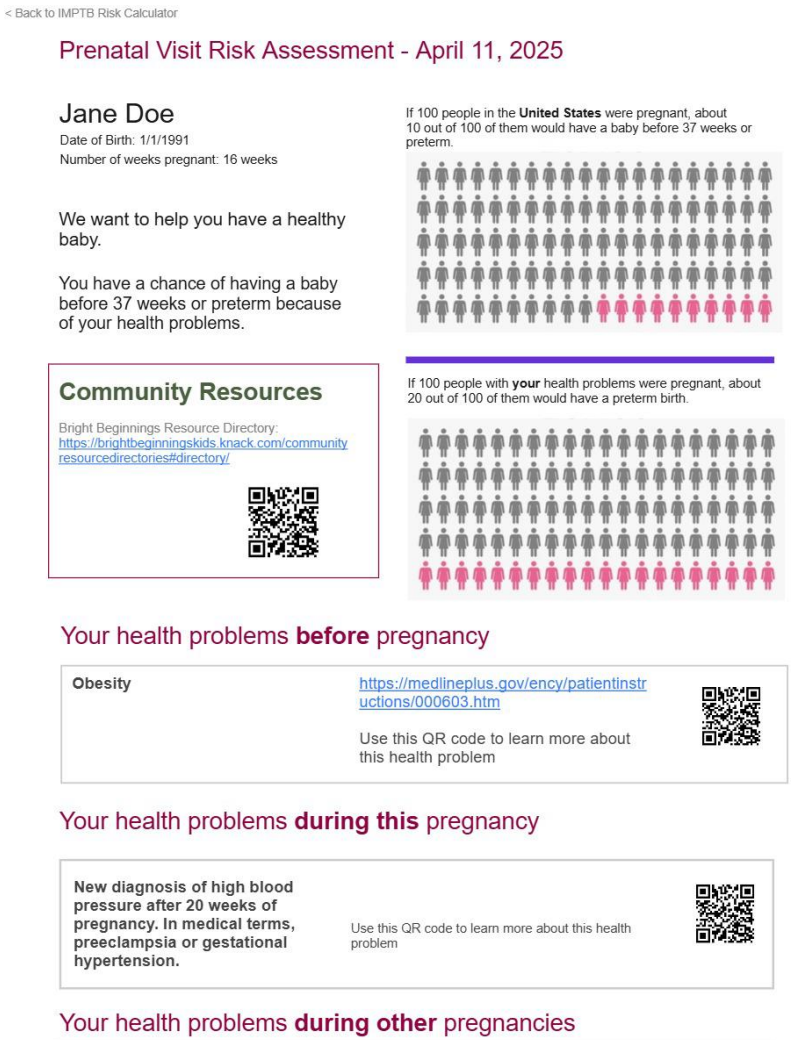

Figure 1: Mock-up of planned PFRC

4.4 Key Findings

Feedback from the clinical subject matter experts and health-literacy experts include:

1. Endorsement for using a risk visualization strategy in the PFRC that utilizes people-icons to communicate magnitude of risk. In addition, it was suggested a comparison of an individual's personal level of risk to the US rate of PTB, rather than the Ohio or Medicaid population level of risk also be visualized.
2. QR codes are provided in the paper handout to provide convenient access to educational resources available online.

Additional findings from the planned focus groups and surveys with users (patients and clinicians) will inform future versions of the PFRC.

Section 5: Medicaid Perinatal Risk Tool Updates

Commented [DN2]: If the MPRT is treated as a proper noun in this report, maybe these should be capitalized.

5.1 Introduction and Objectives

MPRT includes the PTB risk calculator, the patient-facing risk calculator, and the Electronic-PRAF. MPRT has been in the production environment at OSUMC since 2023. Over the previous year, the IMRP team has made multiple changes and updates to MPRT in response to feedback from users and experts and to expand functionality.

Changes to the MPRT in this cycle of IMRP include:

1. Updating and simplifying models as part of the risk calculator.
2. Updating the user interface of MPRT based on clinical subject matter expert feedback.
3. Technical integration of the Electronic PRAF 2.0.
4. Preparing the user interface to include the SMM and post-partum models and the PFRC.

5.2 Methods

Updating and simplifying models in MPRT and updating user interface

Based on feedback from subject matter experts and experience with the clinical trial, several models were removed from MPRT. These included the very preterm birth and one-day mortality models, as feedback indicated the rarity of these outcomes made it difficult for clinicians to interpret. The infant mortality models were removed from MPRT, as clinicians preferred the PTB models as a point-of-care tool.

The IMRP collaborated internally to iteratively update the MPRT user interface to respond to clinical subject matter expert feedback and further automate functions within MPRT. This

required use of additional FHIR resources, specifically OB history, to be able to automatically pull in gestational age rather than requiring manual user to input.

Technical Integration of Risk Calculator with the PRAF 2.0

In addition to leveraging FHIR to automate the extraction of medical record data for populating MPRT's risk calculator, the team developed the PRAF-EHR tool within MPRT using FHIR protocols to extract PRAF variables directly from the EHR. In collaboration with the ODM and DeliverHealth Solutions ("Deliver" is a technology contractor for NurtureOhio, an online reporting and data repository platform for PRAF data), the team defined an application programming interface (API) implemented by Deliver that enables MPRT users to submit E-PRAF data directly to NurtureOhio from within the PRAF-EHR tool, eliminating the need for manual data-entry into external platforms. Additionally, the team worked closely with DeliverHealth to 1) implement a shared unique identifier linking each PRAF-EHR submission to a specific practice and user; 2) ensure structural alignment between PRAF-EHR and E-PRAF, and 3) maintain consistency in field values and formatting between the FHIR standard and the PRAF data model.

5.3 Results and Key Findings

The impact of the MPRT user interface changes can be seen in Figures 2 and 3. Figure 2 shows the new interface for the landing page for MPRT. There is a new tab for post-partum period alongside preterm birth. The new landing page also automatically populates the gestational weeks without need for additional user interaction.

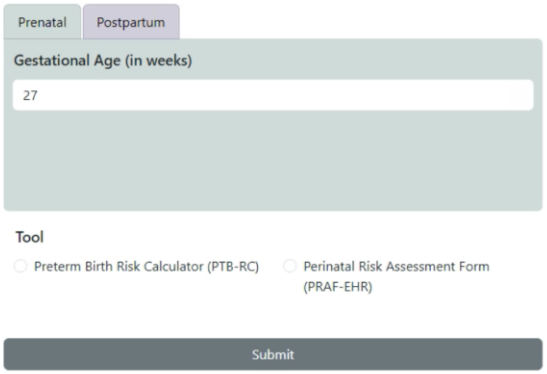

Figure 2: Addition of post-partum tab to MPRT and automatic population of gestational weeks

In Figure 3, the changes include:

1. Updates to key: The A1 label in Figure 2 shows the previous design of the key, with a small key that was challenging to interpret. In B1, the key has been made larger, with an option to enlarge it even more if clicked. The key has additional information for the user, and a diagram to help interpret it more easily.
2. Automatically populated fields: A2 shows the prior design which required manual entry of all pink highlighted fields. In B2, all fields are automatically populated, and the gauge is visualized as soon as the page is opened.
3. Gauge updates: A3 shows the previous version of the gauges, and B3 shows the updated version. The changes include:
    a. Simplifying the gauge by removing minimum and maximum probabilities;
    b. Increasing the size and readability of the patient's risk, removing the line indicating the mean risk in the population;
    c. Simplifying to only one gauge (i.e., removing very preterm birth);
    d. Adding a detailed interpretation of the probability to help the user understand and explain it to their patients;
    e. Adding a comparison of the patient's probability to the national preterm birth rate, which experts felt was a more meaningful comparison than to the mean of the population of patients in the model.

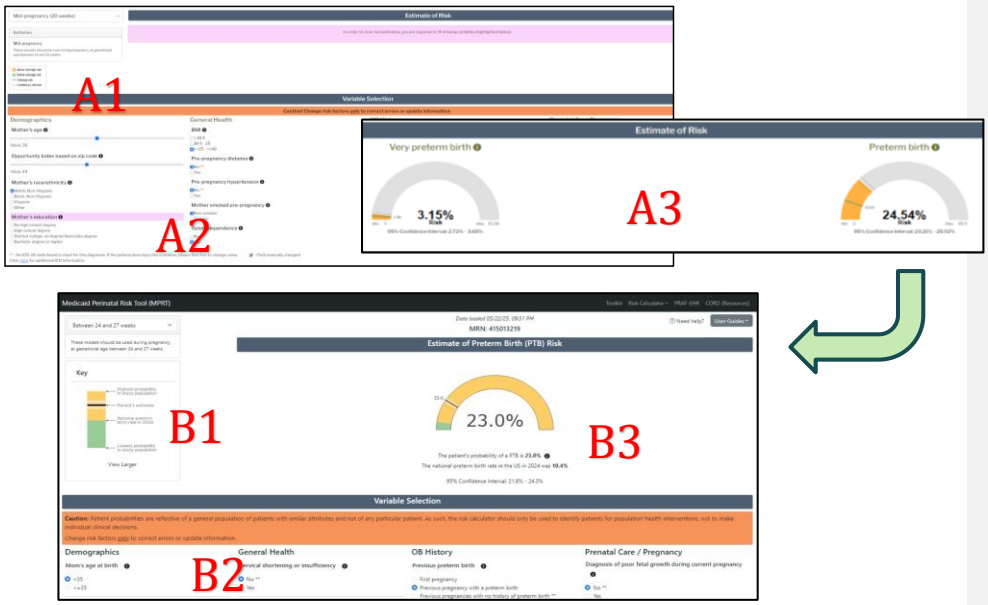

Figure 3: Comparison of previous user interface (A) to updated user interface (B).

Figure 4 shows the updated PRAF-EHR, which includes editable fields, instructional text to guide the user, links to user guides, and a way for users to reach out to the support team for assistance.

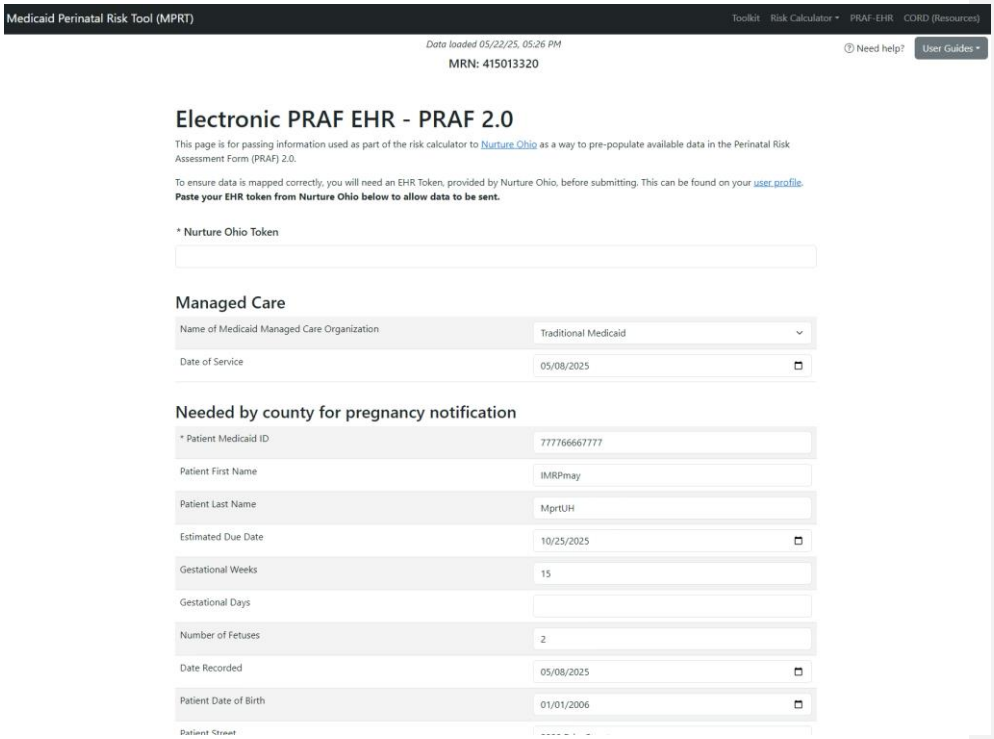

Figure 4: PRAF-EHR 2.0 User interface

Section 6: Clinical Trial of Test Feasibility of the Clinical Use of MPRT

6.1 Introduction and Background

The purpose of the clinical trial was to test the feasibility and acceptability of the PTB risk calculator as part of MPRT and a patient facing mobile app for preterm birth and infant mortality prevention in a high-risk OB clinic population. As the scope of work of the project shifted away from the mobile app, this section will report on the results of the PTB risk calculator implementation. There were two aims that assessed the feasibility and acceptability of the PTB risk calculator: (1) validate the predictive models in a prospective cohort; (2) test the acceptability and usefulness of a risk calculator for use as a risk communication tool as compared to usual care within a clinic visit.

6.2 Methods

6.2.1 Study design

The clinical trial was a randomized trial which proceeded over two clinical visits. The impact of the PTB risk calculator was assessed in two ways. The first was by comparing actual birth outcomes to the estimated probability of birth outcomes from the PTB risk calculator at 20 weeks. The second was by surveying patients about their risk perception, understanding of risks, and worry about the pregnancy before and after seeing the risk calculator or having a usual visit depending on the group into which they were randomized.

6.2.2 Participants and recruitment

Participants were recruited at the OSU East OB clinic during one of their perinatal encounters. Participants were consented to be part of the study and given a baseline demographic and OB history survey. On the second visit, participants were randomized to either usual care or to a group shown the risk calculator during their visit. Each participant filled out a survey before and after the visit with their clinician.

The surveys asked the following three questions, once before and then once again after the visit:

1. My baby's risk of preterm birth is:
    a. Less than average
    b. Average
    c. More than average
2. I understand the risks associated with my pregnancy:
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
3. How worried are you about this pregnancy?
    a. Not worried at all
    b. Not very worried
    c. Somewhat worried
    d. Very worried
    e. Extremely worried

6.2.2 Statistical analysis

Baseline survey results were summarized overall and by groups. The primary outcomes were compared between groups using Fisher's Exact tests. For the before-after surveys, baseline answers were compared between groups, as well as percent change in response between groups. Relationships between risk, worry, and understanding were evaluated with the Fisher's Exact test.

For the validation of the PTB risk model, data from the surveys and from chart review are used to run the predictive model and calculated probability is being compared to actual outcome (PTB vs full term delivery). Once data collection is complete, the performance of the model will be assessed by AUC and by comparing the proportion of patients with PTB in each decile of probability.

6.3 Results

Eighty individuals were recruited to the study and filled out the demographic and OB history survey. Only 50 individuals were able to be contacted for a second visit prior to delivery. Two individuals did not complete follow-up surveys, so before/after surveys from 48 individuals were analyzed, 23 who viewed the risk calculator, and 25 who had usual care. See Figure 5.

Demographics of these individuals are shown in Tables 9.1-9.13. Overall, individuals in both groups were similar. Although not statistically significant, there were two notable differences between the groups. This was the first pregnancy for 28.0% of the risk calculator group compared to 8.3% of the usual care group. In addition, there was a slight difference in race between the two groups: the risk calculator group had a higher percentage of Black participants, and a lower percentage of White participants compared to the usual care group.

The gestational age at which the second visit occurred was similar between groups with a median of 27 weeks.

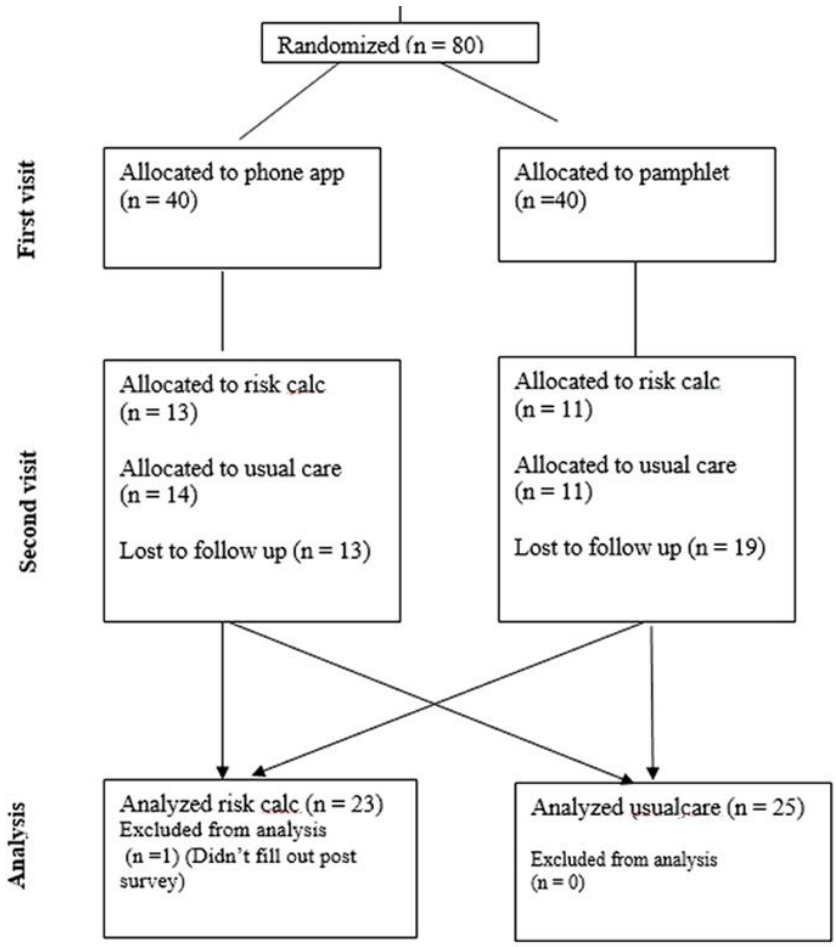

Figure 5: Randomization details of Clinical Trial (Due to a change in project scope, this document is focusing only on the results of the baseline survey from the first visit and randomization in the second visit)

Table 9.1 Summary of Patients Randomized to the Risk Calculator or Usual Care - Android v. Apple

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
Do you have an Android or Apple smartphone?, n (%)				0.15731
Android	7 (28.0%)	3 (12.0%)	10 (20.0%)	
Apple	18 (72.0%)	22 (88.0%)	40 (80.0%)	

Table 9.2 Summary of Patients Randomized to the Risk Calculator or Usual Care - Race

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
What is your race?, n (%)				0.25721
Asian	1 (4.2%)	0 (0.0%)	1 (2.0%)	
Black or African American	14 (58.3%)	20 (80.0%)	34 (69.4%)	
White	6 (25.0%)	2 (8.0%)	8 (16.3%)	
I choose not to answer this question	3 (12.5%)	3 (12.0%)	6 (12.2%)	
Missing	1	0	1	

Table 9.3 Summary of Patients Randomized to the Risk Calculator or Usual Care - Ethnicity

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
What is your ethnicity?, n (%)				0.15351
Hispanic or Latino or Spanish origin	2 (8.3%)	4 (16.0%)	6 (12.2%)	
Not Hispanic or Latino or Spanish origin	19 (79.2%)	21 (84.0%)	40 (81.6%)	
I choose not to answer this question	3 (12.5%)	0 (0.0%)	3 (6.1%)	
Missing	1	0	1	

Table 9.4 Summary of Patients Randomized to the Risk Calculator or Usual Care - Education

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
What is the highest level of school that you have finished?, n (%)				0.38671
No/some high school	2 (8.3%)	2 (8.0%)	4 (8.2%)	
High school or GED	12 (50.0%)	16 (64.0%)	28 (57.1%)	
Some college	8 (33.3%)	5 (20.0%)	13 (26.5%)	
2 years of college/Associate's Degree	0 (0.0%)	1 (4.0%)	1 (2.0%)	
4 years of college/Bachelor's Degree	2 (8.3%)	0 (0.0%)	2 (4.1%)	
I choose not to answer this question	0 (0.0%)	1 (4.0%)	1 (2.0%)	
Missing	1	0	1	

Table 9.5 Summary of Patients Randomized to the Risk Calculator or Usual Care – First Pregnancy

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
Is this your first pregnancy?, n (%)				0.07551
No	18 (72.0%)	22 (91.7%)	40 (81.6%)	
Yes	7 (28.0%)	2 (8.3%)	9 (18.4%)	
Missing	0	1	1	

Table 9.6 Summary of Patients Randomized to the Risk Calculator or Usual Care – Weeks Gestation

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
What week of this pregnancy were you in when you started prenatal care?				0.71052
N	25	25	50	
Mean (SD)	9.5 (5.29)	8.8 (3.42)	9.2 (4.42)	
Median	9.0	8.0	8.5	
Range	1.0, 27.0	4.0, 17.0	1.0, 27.0	

Table 9.7 Summary of Patients Randomized to the Risk Calculator or Usual Care – Multiples

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
Are you currently pregnant with multiple babies (e.g.: twins, triplets)?, n (%)				0.63741
No	22 (88.0%)	23 (92.0%)	45 (90.0%)	
Yes, twins	3 (12.0%)	2 (8.0%)	5 (10.0%)	

Table 9.8 Summary of Patients Randomized to the Risk Calculator or Usual Care – Diabetes Before Pregnancy

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
Before this pregnancy, were you diagnosed with diabetes or high blood pressure? (choice=Diabetes (before this pregnancy)), n (%)				0.31241
Unchecked	24 (96.0%)	25 (100.0%)	49 (98.0%)	
Checked	1 (4.0%)	0 (0.0%)	1 (2.0%)	

Table 9.9 Summary of Patients Randomized to the Risk Calculator or Usual Care – High Blood Pressure Before Pregnancy

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
Before this pregnancy, were you diagnosed with diabetes or high blood pressure? (choice=Hypertension (before this pregnancy)), n (%)				0.47951
Unchecked	21 (84.0%)	19 (76.0%)	40 (80.0%)	
Checked	4 (16.0%)	6 (24.0%)	10 (20.0%)	

Table 9.10 Summary of Patients Randomized to the Risk Calculator or Usual Care – No Diabetes or High Blood Pressure Before Pregnancy

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
Before this pregnancy, were you diagnosed with diabetes or high blood pressure? (choice=None), n (%)				0.73281
Unchecked	5 (20.0%)	6 (24.0%)	11 (22.0%)	
Checked	20 (80.0%)	19 (76.0%)	39 (78.0%)	

Table 9.11 Summary of Patients Randomized to the Risk Calculator or Usual Care – Pregnancy Interval

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
When did your last pregnancy end?, n (%)				0.94811
Less than 18 months ago (less than 1.5 years)	6 (33.3%)	7 (31.8%)	13 (32.5%)	
Between 18-59 months ago (1.5 - 5 years)	9 (50.0%)	12 (54.5%)	21 (52.5%)	
More than 59 months ago (more than 5 years)	3 (16.7%)	3 (13.6%)	6 (15.0%)	
Missing	7	3	10	

Table 9.12 Summary of Patients Randomized to the Risk Calculator or Usual Care – Previous Pregnancy Smaller Baby than Expected

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
Have any of your babies been smaller than expected for the number of weeks of pregnancy when they were born?, n (%)				0.16511
No	15 (83.3%)	14 (63.6%)	29 (72.5%)	
Yes	3 (16.7%)	8 (36.4%)	11 (27.5%)	
Missing	7	3	10	

Table 9.13 Summary of Patients Randomized to the Risk Calculator or Usual Care – Delivery before 37 Weeks

	RiskCalc (N=25)	UsualCare (N=25)	Total (N=50)	P-value
Did you deliver any of your babies before 37 weeks?, n (%)				0.38641
No	13 (72.2%)	13 (59.1%)	26 (65.0%)	
Yes	5 (27.8%)	9 (40.9%)	14 (35.0%)	
Missing	7	3	10	

(Tables 9.1-9.13 - [1]Chi-Square p-value; [2]Kruskal-Wallis p-value)

Aim 1: Survey results

The sample size of this study was too small to detect even substantial differences, so the focus of these results is on the observable calculated differences among the sample. The majority of patients in both the risk calculator group and usual care group had no change in their risk perception from before to after the visit (table 10). However, 22% of patients in the risk calculator group had a decrease in their perception of risk (e.g., "average" risk before and "less than average" risk after), compared to only 12% in the usual care group. Similarly, 26% of the risk calculator group reported an increase in their understanding compared to only 4% in the usual care group. Finally, in terms of worry about the pregnancy, the usual care group appeared to be less worried at baseline with 11/25 (44%) saying they were not at all worried, compared to 21.7% in the risk calculator group (Figure 6). In the usual care group, 68% had no change in worry and 24% had a decrease in worry after talking to their physician. In contrast, in the risk calculator group, fewer than half of the patients had no change in worry with 21.7% having an increase in worry and 34.8% a decrease in worry.

Table 10: Results of surveys

Change in answer to "My baby's risk of preterm birth is:"				
	Risk Calculator	Usual Care	Total	p-value
No Change in risk perception	17 (73.9%)	19 (76.0%)	36	
Decrease in risk perception	5 (21.7%)	3 (12.0%)	8	
Increase in risk perception	1 (4.4%)	3 (12.0%)	4	p=0.557
Change in answer to "I understand the risks associated with my pregnancy"				
	Risk Calculator	Usual Care	Total	
No change in understanding risk	15 (65.2%)	23 (92.0%)	38	
Increase in understanding risk	6 (26.1%)	1 (4.0%)	7	
Decrease in understanding risk	2 (8.7%)	1 (4.0%)	3	p=0.053
Change in answer to "How worried are you about this pregnancy?"				
	Risk Calculator	Usual Care	Total	
No change in worry	10 (43.5%)	17 (68.0%)	27	
Increase in worry	5 (21.7%)	2 (8.0%)	7	
Decrease in worry	8 (34.8%)	6 (24.0%)	14	p=0.205

*Note, one subject in the risk calculator group had missing post survey results

Commented [DN3]: Maybe nothing to do here. But I'm always worried about how non-technical audiences read "no significant difference" particularly with a small study like this. It could be advantageous to open with a statement that the sample size was too small to detect even substantial differences, and so the focus is on observable calculated differences among the sample. And then not mention tests and statistical significance after that.

Depending on how the audience thinks of "statistical significance", they might read this to mean that it doesn't work. In truth, we don't have enough evidence to know if it works.

Commented [DJ4R3]: @Doogan, Nathan think mentioning the small sample size is important, especially if this ever gets posted publicly. I am going to add in what you suggested so we are covering all our bases.

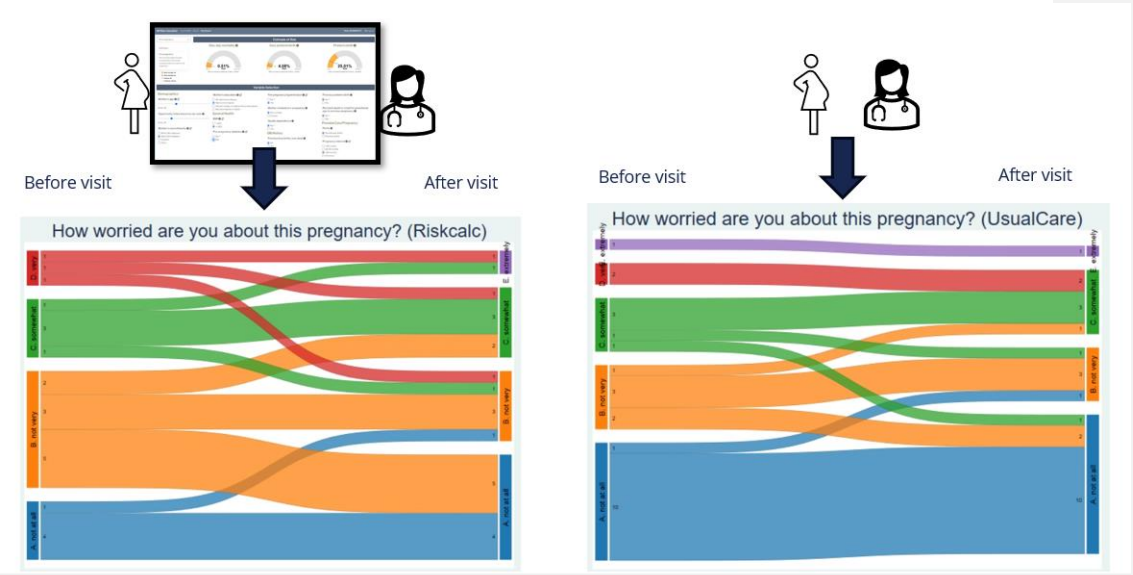

Figure 6: Changes in levels of worry, before and after visit, for risk calculator (left side) and usual care (right side) (Blue: Not at all; Orange: Not very; Green: Somewhat; Red: Very; Purple: Extremely)

Aim 2: Model validation results

The validation of the PTB risk model is ongoing and will be reported early in the next year of the project timeline.

6.3 Key Findings and Next Steps

The clinical trial was designed to help determine the feasibility of implementing MPRT within a clinical setting, the performance of the tool and its impact on patients in terms of risk perception, understanding, and worry. Data continues to be analyzed, but the preliminary findings are as follows:

1. Of the 80 patients initially recruited to be part of the trial, only 48 patients were re-contacted at their second visit and provided data. This was due to the complexities of

following patients in the second half of their pregnancy. Some of the patients delivered before their next visit, went to a different clinic, or missed scheduled appointments due to hospitalizations.

2. Forty-eight patients were assigned to either see the risk calculator or have a usual visit with their provider. Patients in these groups had similar demographics and baseline pregnancy risks, although more patients in the risk calculator group were pregnant for the first time.
3. The majority of patients in the usual care group had no change in their survey answers from before to after the visit, potentially suggesting that the risk calculator had more of an impact on risk perception, understanding, and worry than did a usual visit. Although the differences were not statistically significant, this is a small trial and was not adequately powered to detect clinically meaningful changes, at least in part due to attrition of the sample.

The next step for analysis is to compare risk perception, as measured by the survey, to predicted probability, as measured by the PTB risk calculator, to actual pregnancy outcome (i.e., PTB or full-term delivery). This will allow the research team to assess the performance of the PTB risk calculator as well as better understand how risk perception relates to actual risk. The research team will also be able to evaluate if the risk score on the risk calculator changed the participants' perception of their risk.

Section 7: Recruitment and Expansion of MPRT

7.1 Introduction and Objectives

The core objective of deploying the Medicaid Perinatal Risk Tool (MPRT) to Epic-using health systems across Ohio is to enable those health systems to benefit from use of the Risk Calculators and PRAF-EHR.

7.2 Methods

IMRP's MPRT Dissemination Team has followed project sponsors' prioritization for engaging health systems across the State to deploy MPRT in their Epic EHR environments. This includes working with both clinical and information technology staff at each site to identify and resolve challenges to dissemination. The team's choice of a cloud-native multi-tenant architecture for MPRT avoids most of the per-site technology build required for successful deployment. MPRT's use of the FHIR standard also reduces the implementation and data exchange overhead borne by each site. Notwithstanding, the integration of any tool in a health system's IT environment is a multifaceted process spanning many technology departments and involving IT governance and risk and security protocols.

The MPRT Dissemination Team completes an extensive risk assessment required by each site prior to implementation. This includes meetings with clinical informatics, architecture, networking, security, compliance, and IT governance personnel as part of the IT approval and implementation process at each site. The team developed an MPRT Implementation Bundle for sites' use that includes an Epic Implementation Guide, IT security and technical documentation, system and data diagrams, user guides, and a demonstration video. The team has provided training and training materials adaptable to each site's standards, as well as ad hoc consultation to site personnel. The team also provides ongoing technical support to all hospital partners and monitors for issues or errors associated with using MPRT.

The team maintains a roster of contacts at the sites for communications about changes, planned and unplanned downtime, and other updates. These communications are via the team's shared imrp@osumc.edu mailbox.

Simultaneously with expanding MPRT's reach, the application was updated six times in FY24 and (as of June 1, 2025) seven times in FY25. These updates have included: changes to align with updates made to the PRAF; auto-population of additional form fields; an updated preterm birth risk calculator; and the enablement of postpartum PRAFs. Behind the scenes, improvements were made to better monitor and audit code contributions and other application changes, enhance alerting to proactively address issues, and refine error messaging to help hospital system IT departments troubleshoot integration challenges.

In FY25, the team recognized the need to improve efficiency, compliance, and robustness. To support these goals, the team implemented automated accessibility, software component dependency, and security scanning within its software build pipelines. These enhancements were designed to strengthen the MPRT technical team's self-review process and ensure digital conformance and compliance with accessibility, security, and robustness policies and standards. The automated accessibility scans evaluate each page against the Web Content Accessibility Guidelines (WCAG) 2.1 Level AA standards. Security and dependency scanning is powered by Azure Advanced Security, which identifies vulnerabilities based on the OWASP Top 10, the Common Vulnerabilities and Exposures (CVE) database, and the National Vulnerability Database (NVD), ensuring comprehensive coverage of known security risks.

7.3 Key Findings

After engaging five pilot sites for MPRT dissemination in FY23, an additional three sites were engaged in FY24 and six sites in FY25, for a grand total of 14 sites, as of June 1, 2025. The dissemination team worked with each of the pilot sites and, as part of implementation at each site, has identified and employed enhancements and refinements to the overall implementation process. The IMRP team has presented its works and findings and has requested partnerships

with various Ohio health entities approximately thirty times.

In FY23, institutions that agreed to partner with the IMRP in integration efforts included University of Cincinnati, MetroHealth, Cleveland Clinic Fairview Health System, Ohio State University (OSU) and OSU affiliated hospital, Avita Health.

In FY24, integration continued with MetroHealth and Cleveland Clinic Fairview/Akron General; and six new sites began the integration process: ProMedica and ProMedica affiliates Bay Park and Toledo Hospital, University of Toledo, TriHealth and Good Samaritan. MPRT went live at four sites in FY24: OSU, Adena, Heart of Ohio, and University of Cincinnati.

MPRT has gone live at 10 sites in FY25: MetroHealth; Cleveland Clinic Fairview and its affiliates Akron General; ProMedica and its affiliates Bay Park and Toledo Hospital; University of Toledo; TriHealth and its affiliate Good Samaritan; and Mercy Bon Secours. In addition, new sites have begun the integration process: University Hospitals, Genesis Health Systems, Mt. Carmel Health System, Wilson Health, and OhioHealth.

Section 8: Testing PTB Models on Ohio Electronic Health Data

8.1 Introduction and Objectives

All of the IMRP predictive models have been developed using linked Medicaid Claims (Women of Reproductive Age (WRA) file) and vital records data. When deployed in real time within an EHR, EHR data is used to populate the model. Therefore, there was a need to determine if the models created using administrative data would perform adequately using EHR data.

8.2 Methods

The objective of this study was to evaluate how the IMRP models perform on EHR data compared to their performance on the WRA file data, and to evaluate if there was any evidence of bias. To obtain a large and representative enough validation sample Epic Cosmos (Epic, Inc, Verona WI) was leveraged. Cosmos is a research tool that combines deidentified data from Epic-using hospitals across the US and internationally and makes them available in an online portal for approved researchers.

The Cosmos cohort was created by identifying all births with Medicaid coverage from 1/1/2022-12/31/2024. Variables were defined in the same way as in the PTB models. The only variable that was not able to be included was the Ohio Opportunity Index, as it was not available in Cosmos. To account for this, separate PTB models were created for validation without OI

included. Models created using the linked WRA file were then fit to the Cosmos dataset. AUROC and H-L GOF tests were calculated.

Because Cosmos is considered a de-identified dataset it does not require separate IRB approval to use but does require approval from Epic prior to analyzing data. All analysis must be done within a secure portal and only summary data can be downloaded.

8.3 Results

Overall, 85,394 patients met criteria for inclusion in the analytic sample. Of these 10,439 had birth prior to 37 weeks (12.2%). Summary statistics by PTB status are in table 11. In comparing these to the WRA file cohort, there was a slightly higher rate of preterm birth in the Cosmos dataset. The frequency of risk factors in the Cosmos cohort differed compared to the linked WRA analytic file. For example, 10.5% of patients with a preterm birth in the WRA file cohort had gestational diabetes while only 6.6% in the Cosmos dataset had an indicator for gestational diabetes. Conversely, 10.7% of those with preterm birth in the WRA file had hypertensive disorder of pregnancy vs 19% in Cosmos.

Some variables are very similar in their proportions. For example, 10.1% of preterm births were pregnant with twins in WRA file data compared to 11% in Cosmos.

Table 11: Summary Statistics from Cosmos Cohort

Characteristic	**PTB N = 10,439**[1]	**No PTB N = 74,955**[1]	**Overall** N = 85,394[1]
Short cervix	455 (4.4%)	599 (0.8%)	1,054 (1.2%)
Gestational diabetes	691 (6.6%)	4,403 (5.9%)	5,094 (6.0%)
Hypertensive disease of pregnancy	2,020 (19%)	4,613 (6.2%)	6,633 (7.8%)
Poor fetal growth	1,188 (11%)	3,952 (5.3%)	5,140 (6.0%)
Vaginal bleeding	870 (8.3%)	2,577 (3.4%)	3,447 (4.0%)
Urinary tract infection	804 (7.7%)	5,350 (7.1%)	6,154 (7.2%)
Short cervix x previous preterm birth (PPB)			
Twins*	1,121 (11%)	581 (0.8%)	1,702 (2.0%)

Age>35	1,408 (14%)	6,724 (9.0%)	8,132 (9.5%)
Mom's Age in Years	Median[IQR]: 27 [23, 31],	median[IQR]: 28 [23, 33]	median[IQR]: 27 [23, 31]
PPB	No data	No data	No data
First Pregnancy	2,899 (28%)	23,108 (31%)	26,007 (30%)
No PPB	4,465 (43%)	43,773 (58%)	48,238 (56%)
PPB	3,075 (29%)	8,074 (11%)	11,149 (13%)

*Pregnancies with >2 fetuses were excluded due to the high likelihood of preterm birth in these pregnancies

Model validation results are in table 12.

Table 12: Results of validation of PTB models on Cosmos cohort

Category	Model 1	Model 2	Model 3
AUROC	**0.68**	**0.68**	**0.69**

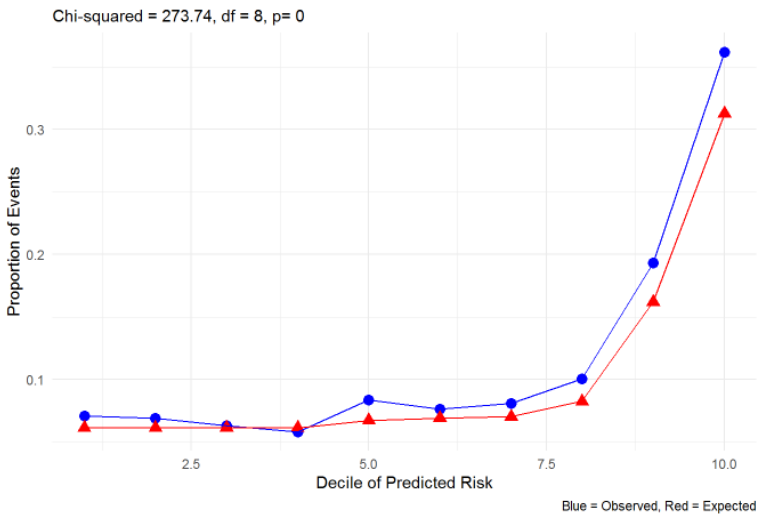

Figure 7: Hosmer-Lemeshow Goodness-of-Fit Plot

Table 13: 32 Week PTB Model: Summary of Predicted Probability by Preterm Birth

Predicted probability	No PTB N = 74,963[1]	PTB N = 9,851[1]	Overall N = 84,814[1]
[0.0,0.1]	63,622 (92%)	5,231 (7.6%)	68,853 (100%)
(0.1,0.2]	7,822 (79%)	2,060 (21%)	9,882 (100%)
(0.2,0.3]	2,218 (70%)	966 (30%)	3,184 (100%)
(0.3,0.4]	493 (61%)	319 (39%)	812 (100%)
(0.4,0.5]	329 (45%)	407 (55%)	736 (100%)
(0.5,0.6]	248 (40%)	379 (60%)	627 (100%)
(0.6,0.7]	56 (26%)	156 (74%)	212 (100%)
(0.7,0.8]	56 (27%)	155 (73%)	211 (100%)
(0.8,1]	20 (13%)	129 (87%)	149 (100%)
Unknown	99	49	148

[1] median[IQR]: Median [Q1, Q3], mean(sd): Mean (SD) ,sum: Sum; n (%)

8.3 Key Findings

Evaluation of the findings from the Cosmos validation continues. Preliminary findings include:

1. The frequency of some risk factors within the cohort was different compared to the WRA file, but not in a consistent direction (i.e., some were more frequent, some less, and some the same). This could relate to multiple factors. Cosmos includes data only from health systems who have agreed to contribute data and have Epic as their EHR. Although Epic is common in Ohio, it is not universally used and there may be important differences in patient populations of Epic and non-Epic hospitals. Also, these cohorts did not overlap in time, so this was a different patient population which could account for some of the differences. For example, the impact of the COVID pandemic could possibly have been responsible for some differences. Perhaps most importantly, there are differences in how data are captured in claims vs. EHR data. The project team define

variables using the problem list when working with EHR data (both in Cosmos and when implementing within MPRT), which is known to be an unreliable source for some diagnoses since it requires a clinician to enter the diagnosis.

2. The models created using data from the WRA file had similar AUROC when validated on Cosmos data
3. There is a large group of patients in the Cosmos data with very low predicted probability (Table 13). Most patients (81%) had a predicted probability less than 10%. Among this group, only 7.6% had a preterm birth with 92% not having a preterm birth; however, because of the large numbers, this amounts to half of all preterm births in the cohort. As a next step, the project team is evaluating whether those patients who had a low predicted probability but had a PTB are significantly different than those with higher predicted probabilities and had a preterm birth. The IMRP is specifically looking at whether these patients may have reduced healthcare access with lower likelihood of their risk factors being reliably documented.

Section 9: Post-Partum Model Progress and Next Steps

9.1 Introduction and Objectives

The objective of Phase V is to develop three new post-partum predictive models which can be used at the time of delivery to identify individuals at high risk of poor post-partum outcomes so that interventions can be put in place. These include models for post-partum SMM, post-partum depression, post-partum missed postpartum OB visit, and post-partum opioid use disorder (OUD) treatment.

9.2 Methods

The post-partum SMM model is based on the model by Dr. Heather Frey, MD and her colleagues at The Ohio State University[16]. An updated dataset was created using the same methodology, and validation of this model on a new cohort is in progress.

An analytic file is being generated for the post-partum depression model, using the current SMM dataset. The population of interest is all individuals with a delivery hospitalization. The outcome of interest is a composite variable including a diagnosis of post-partum depression, or depression in the year after delivery and/or poor mental health outcomes including suicide, psychiatric hospitalization or ED visits in the year after delivery. Literature review has suggested inclusion of additional risk factor variables including post-traumatic stress disorder, and excessive vomiting during pregnancy as those have been associated with post-partum depression. SMM indicators, stillbirth, and gestational age at birth as risk factor variables will also be used, as trauma during birth and obstetrical outcomes have been associated with post-partum depression.

9.3 Next steps

Post-partum modeling is ongoing. Once the post-partum SMM model is validated it will be integrated into MPRT. Development of a quality improvement study to test the implementation of the post-partum SMM model during a delivery hospitalization is also in progress. To better understand their current needs and capacity, the project team will begin by meeting with those involved in the fourth trimester clinic at The Ohio State University.

As each of the post-partum models is completed, work to identify potential interventions which could be implemented for high-risk patients and test these in short PDSA cycles within participating clinics will take place.

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Abbreviations: GRC: Ohio Colleges of Medicine Government Resource Center; OSU: The Ohio State University; PI: Principal Investigator; PM: Project Manager.