

Appendix 1: Variable definitions, model equation, and diagnostic analyses

WMI prediction model developed in the 201-case complete-case analysis cohort

Logistic regression equation

The logistic regression model estimated the probability of MRI-defined WMI using the following equation. Binary predictors were coded as 1 for the presence of the characteristic and 0 for the reference category.

$$\begin{aligned}
 P(\text{WMI} = 1) &= \exp(\eta) / [1 + \exp(\eta)] \\
 \eta &= -1.053252 \\
 &+ 1.002986 \times \text{Vaginal_delivery} \\
 &+ 0.195203 \times \text{Cesarean_delivery_count} \\
 &+ 0.458636 \times \text{Apgar_1min} \\
 &+ 0.319439 \times \text{Female} \\
 &- 0.012461 \times \text{Maternal_age} \\
 &- 0.159198 \times \text{Gestational_age} \\
 &+ 0.000694 \times \text{Birth_weight} \\
 &- 0.433713 \times \text{PROM} \\
 &+ 0.874203 \times \text{NRDS} \\
 &- 0.683820 \times \text{Maternal_height_squared} \\
 &- 0.894758 \times \text{Parity} \\
 &+ 0.011765 \times \text{Maternal_weight} \\
 &+ 0.469255 \times \text{Gravidity} \\
 &+ 0.262036 \times \text{Neonatal_pneumonia}
 \end{aligned}$$

Note. Vaginal_delivery was coded as 1 for vaginal delivery and 0 for cesarean delivery; Female was coded as 1 for female and 0 for male; PROM, NRDS, and Neonatal_pneumonia were coded as 1 for yes and 0 for no. Maternal_height_squared represents maternal height entered as height (m)², with no separate linear height term. WMI was predicted when $P(\text{WMI} = 1) \geq 0.50$.



Participant flow for the revised complete-case analysis

The revised models used all 201 complete cases with bootstrap internal validation

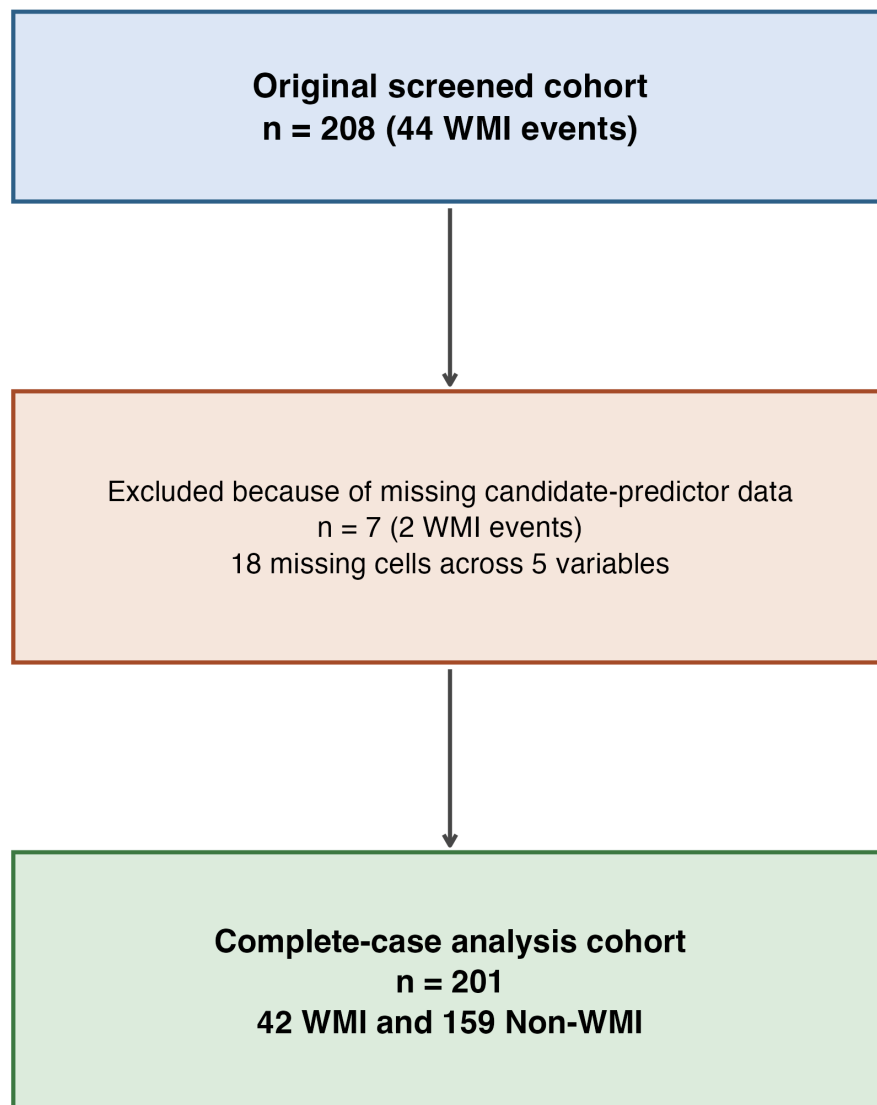


Figure S1 Participant flow diagram. The flow diagram shows the derivation of the complete-case analysis cohort. Among 208 screened participants, seven were excluded because of missing candidate-predictor data, leaving 201 complete cases for model development and bootstrap internal validation.

Calibration plots

Blue: apparent grouped calibration; orange: optimism-corrected calibration line

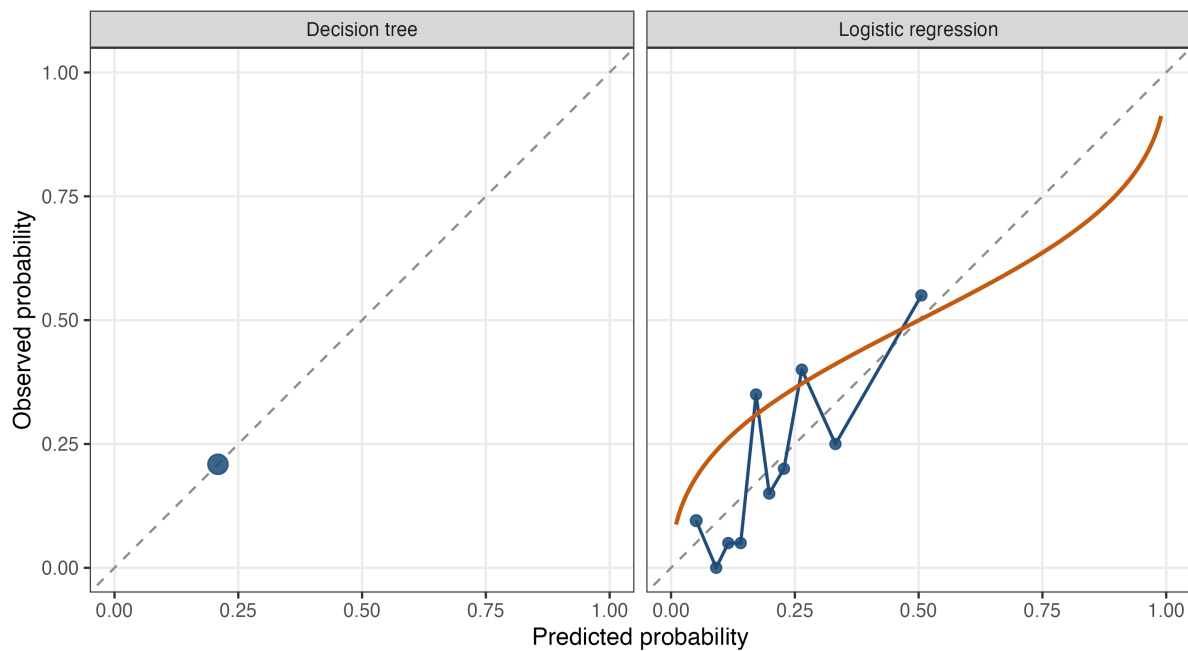


Figure S2 Calibration plots. Blue points and lines show apparent grouped calibration by predicted-risk groups; the orange curve shows the bootstrap optimism-corrected calibration line. The diagonal dashed line represents perfect calibration.

Table S1 Variable definitions and availability

Variable	Operational definition	Unit or coding	Data source	Collection time	Missingness	Available before prediction
Sex	Sex recorded in the birth record.	Male/Female	Delivery or neonatal medical record	At birth	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Gestational age	Completed gestational age determined from the last menstrual period, early-pregnancy ultrasound, and obstetric assessment.	weeks	Delivery or neonatal medical record	At birth	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Birth weight	First body weight measured after birth.	g	Delivery or neonatal medical record	Immediately after birth	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Mode of delivery	Mode of delivery documented in the delivery record.	Cesarean/ Vaginal	Delivery or neonatal medical record	At delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
1-min Apgar score	Apgar score recorded at 1 minute after birth.	0-10 points	Delivery or neonatal medical record	1 minute after birth	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
5-min Apgar score	Apgar score recorded at 5 minutes after birth.	0-10 points	Delivery or neonatal medical record	5 minutes after birth	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Neonatal pneumonia	Clinical-author verification required: insert the exact clinical, laboratory, and radiographic diagnostic criteria and guideline reference used in this cohort.	No/Yes	Neonatal medical record before MRI	Diagnosed before MRI	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Neonatal respiratory distress syndrome	Clinical-author verification required: insert the exact clinical and chest-imaging diagnostic criteria and guideline reference used in this cohort.	No/Yes	Neonatal medical record before MRI	Diagnosed before MRI	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
10-min Apgar score	Apgar score recorded at 10 minutes after birth.	0-10 points	Delivery or neonatal medical record	10 minutes after birth	Screened cohort: 2/208 (1.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Multiple pregnancy	More than one fetus in the index pregnancy, based on obstetric records.	No/Yes	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Maternal age	Maternal age at delivery.	years	Maternal obstetric history or antenatal record	At delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Maternal height	Maternal height from the first antenatal-care record; entered in the final model only as height squared.	m	Antenatal-care record	First antenatal visit	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Maternal weight	Maternal prepregnancy weight from the first antenatal-care record.	kg	Antenatal-care record	First antenatal visit	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Gravidity	Total number of pregnancies including the index pregnancy.	count	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Parity	Number of pregnancies reaching the locally defined viable delivery stage.	count	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Number of cesarean deliveries	Number of cesarean deliveries documented in the obstetric history.	count	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Previous intrauterine fetal death or stillbirths	Number of previous intrauterine fetal deaths or stillbirths documented in the obstetric history.	count	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Assisted reproductive technology	Use of assisted reproductive technology, including in-vitro fertilization and embryo transfer.	No/Yes	Maternal obstetric history or antenatal record	Before conception/ delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Single umbilical artery	Single umbilical artery documented by prenatal ultrasound or delivery records.	No/Yes	Hospital medical record	Before or at delivery	Screened cohort: 3/208 (1.4%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point

Table S1 (continued)

Variable	Operational definition	Unit or coding	Data source	Collection time	Missingness	Available before prediction
Placental or uterine rupture	Placental or uterine rupture documented in the obstetric record.	No/Yes	Hospital medical record	Before or at delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Chorioamnionitis	Clinical-author verification required: insert the exact clinical and/or histopathological diagnostic criteria and guideline reference used in this cohort.	No/Yes	Maternal obstetric history or antenatal record	Before or at delivery	Screened cohort: 4/208 (1.9%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Premature rupture of membranes	Spontaneous rupture of membranes before the onset of regular labor, documented in the obstetric record.	No/Yes	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Neuropsychiatric abnormality	Maternal neuropsychiatric abnormality documented in the medical history.	No/Yes	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Autoimmune disease	Maternal autoimmune disease documented in the medical history.	No/Yes	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 5/208 (2.4%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Bacterial vaginosis	Bacterial vaginosis documented in the obstetric record.	No/Yes	Maternal obstetric history or antenatal record	Before delivery	Screened cohort: 4/208 (1.9%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
Fetal distress	Fetal distress documented in the obstetric or delivery record.	No/Yes	Delivery or neonatal medical record	Before or at delivery	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	Yes; recorded before the pre-MRI prediction point
WMI outcome	MRI-defined white matter injury recorded as the model outcome.	No/Yes	Brain MRI report and neonatal medical record	At MRI examination	Screened cohort: 0/208 (0.0%); analysis cohort: 0/201 (0.0%)	No; outcome assessed at MRI and not used as a predictor.

The prespecified prediction time was immediately before MRI evaluation. All candidate predictors were assessed for whether they were available before that prediction point. Yellow-highlighted definition cells require final verification by the clinical authors before submission. WMI, white matter injury; MRI, magnetic resonance imaging; PROM, premature rupture of membranes; NRDS, neonatal respiratory distress syndrome.

Table S2 Functional-form assessment for continuous predictors

Continuous predictor	Linear AIC	Spline AIC	Δ AIC	LRT χ^2	df	P for nonlinearity	Conclusion
Maternal age	216.06	219.31	3.26	0.74	2	0.690	No clear evidence of nonlinearity
Gestational age	216.06	214.09	-1.97	5.97	2	0.051	No clear evidence of nonlinearity
Birth weight	216.06	216.82	0.76	3.24	2	0.198	No clear evidence of nonlinearity
Maternal height	216.00	212.94	-3.06	7.06	2	0.029	Evidence of nonlinearity
Maternal weight	216.06	219.66	3.60	0.40	2	0.820	No clear evidence of nonlinearity

Linear and natural-spline functional forms were compared for each continuous predictor. Δ AIC was calculated as spline AIC minus linear AIC; negative values indicate a lower AIC for the spline model. P values were derived from likelihood-ratio tests comparing the linear and spline models. Maternal height was entered in the final model only as a squared term according to the prespecified modeling decision.

Table S3 Multicollinearity diagnostics for the final logistic regression model

Model term	Auxiliary R ²	VIF	Tolerance
Vaginal delivery vs cesarean delivery	0.620	2.63	0.380
Number of cesarean deliveries	0.688	3.21	0.312
1-min Apgar score	0.174	1.21	0.826
Female vs male	0.107	1.12	0.893
Maternal age	0.226	1.29	0.774
Gestational age	0.529	2.12	0.471
Birth weight	0.445	1.80	0.555
PROM: yes vs no	0.103	1.12	0.897
NRDS: yes vs no	0.300	1.43	0.700
Maternal height squared	0.210	1.27	0.790
Parity	0.748	3.97	0.252
Maternal weight	0.185	1.23	0.815
Gravidity	0.775	4.44	0.225
Neonatal pneumonia: yes vs no	0.166	1.20	0.834

Variance inflation factor (VIF) and tolerance were calculated from the final model matrix. Tolerance was calculated as 1/VIF. Higher VIF and lower tolerance indicate stronger linear dependence among predictors.

Table S4 Bootstrap optimism-corrected calibration and overall error estimates

Model	Metric	Apparent estimate	Mean optimism	Optimism-corrected estimate (95% CI)	Valid bootstrap resamples
Logistic regression	Brier score	0.15	−0.03	0.18 (0.15-0.22)	1000
Logistic regression	Calibration intercept	0.00	0.00	−0.00 (−0.42-0.44)	1000
Logistic regression	Calibration slope	1.00	0.49	0.51 (0.27-0.81)	1000
Decision tree	Brier score	0.17	−0.01	0.18 (0.14-0.23)	1000
Decision tree	Calibration intercept	0.00	−0.02	0.02 (−0.34-0.37)	1000
Decision tree	Calibration slope	Not estimable	0.63	Not estimable	0

Corrected estimates and percentile 95% confidence intervals were obtained from 1,000 bootstrap resamples. Brier score is an overall prediction-error measure, with lower values indicating smaller prediction error. The final pruned decision tree classified all participants as Non-WMI; therefore, its calibration slope was not estimable.