Research Square

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Case Spectrum, Temporal Dynamics, and Free-Text–Coded Causes of Birth Defects and Stillbirths in a Tertiary Hospital in Northern China (2019–2025): A Dual-Registry Reanalysis

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Research Article

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Abstract

Background Hospital dual-registry series of birth defects and stillbirths are often reported only as annual aggregates. Individual registry rows with free-text diagnoses and delivery indications allow re-coding of clinical spectra, verification of demographic contrasts, and quantification of recorded prenatal exposures.

Methods We cleaned and de-identified institutional birth-defect registries (available years 2019–2020 and 2022–2025; n = 492 after removal of exact duplicate rows; 2021 unavailable) and stillbirth registries (2020–2025; n = 1416) at a tertiary hospital in Northern China. Maternal age, gestational age and residence were derived from structured fields. Defect names and stillbirth indications were mapped with rule-based free-text coding. Annual counts, dual-phase stillbirth trends, composition tests and exposure prevalences were computed from the cleaned files.

Results Mean maternal age was 29.9 ± 5.1 years among birth-defect cases and 29.6 ± 5.9 years among stillbirth cases (Welch $p = 0.262$). Advanced maternal age (≥ 35 years) accounted for 16.7% versus 19.9% (age-category χ^2 $p < 0.001$). Mean gestational age was higher in birth-defect than stillbirth records (26.8 ± 7.4 vs 21.8 ± 6.0 weeks; $p < 0.001$). Text-coded congenital heart defects led the birth-defect spectrum (103/492, 20.9%). Stillbirth counts rose from 177 (2020) to 304 (2024) (rising-phase $\beta = 28.8$/year, $p = 0.004$) and were 202 in 2025. Free-text coding assigned fetal malformations to 276 stillbirths (19.5% overall; 49.1% of 562 classifiable records); 60.3% of indication fields lacked a classifiable etiology string. Folic acid use was documented in 88.9% of birth-defect records with complete exposure fields, and termination after defect diagnosis in 83.0%.

Conclusions Individual dual-registry cleaning confirms a dual-phase stillbirth case-count trajectory and a heart-defect–led anomaly spectrum in this Northern China tertiary hospital. Free-text re-coding sharpens clinical categories but leaves a large stillbirth indication residue that is unclassifiable from registry wording alone, prioritising standardised cause attribution alongside cardiac and malformation-focused pathways.

Background

Birth defects and stillbirths concentrate the joint effects of baseline risk, prenatal detection, referral organization, and the intensity of perinatal investigation [1, 3–5, 11]. Globally, stillbirth remains a major contributor to perinatal loss, with large geographic inequalities in rates and in the completeness of cause attribution [3–6, 21, 22]. In China, hospital- and population-based surveillance continues to document a substantial burden of congenital anomalies and fetal deaths, with cardiac defects frequently leading the recorded spectrum [9, 11–16, 19, 20].

Two institutional registries at a tertiary maternal and child health hospital in Hebei Province—birth-defect registration forms and stillbirth registration forms—contain structured maternal fields and free-text diagnoses or delivery indications. Hospital-based birth-defect surveillance series in China have shown

that free-text diagnoses can be reorganized into clinically actionable categories and that annual case mixes are informative for local service planning even without population denominators [11–16, 30]. Rebuilding the analytic file from individual rows supports transparent inclusion counts after de-duplication, rule-based coding of defect names and stillbirth indications, and quantification of recorded exposures such as folic acid use [17, 23, 24].

This reanalysis aimed to: (1) clean and de-identify dual-registry rows for 492 birth-defect and 1416 stillbirth records spanning 2019–2025 (with birth-defect year 2021 unavailable); (2) recompute demographic contrasts and annual case dynamics, including a dual-phase reading of stillbirth counts; (3) map free-text defect names and stillbirth indications to clinical categories; and (4) summarize documented prenatal exposures and post-diagnosis pregnancy termination among birth-defect records.

Methods

Study setting and design

We conducted a retrospective dual-registry reanalysis at a tertiary maternal and child health hospital in Hebei Province, Northern China (approximate catchment 5 million; 8,000–10,000 deliveries annually). Reporting follows STROBE guidance for observational studies adapted to a case-only dual-registry design without population denominators.

All data extraction, cleaning and statistical analyses were implemented in accordance with the approved research protocol issued by the Medical Ethics Committee of Xingtai People's Hospital, and all patient personal information was completely de-identified prior to analysis.

Data sources and cleaning

Birth-defect annual workbooks (2019, 2020, 2022–2025) and stillbirth annual workbooks (2020–2025) were ingested. Year 2021 birth-defect documentation was not available. Header rows were reconciled across years (including damaged 2023–2025 birth-defect headers, which were mapped positionally). Exact duplicate rows were removed. Personal identifiers (name, address, hospital ID, telephone) were replaced by irreversible hashed record IDs before analysis. No imputation was performed.

Variables and coding

Maternal age was analyzed continuously and as < 20, 20–34, and ≥ 35 years, consistent with evidence linking advanced maternal age to adverse perinatal outcomes including stillbirth [7, 8]. Gestational age was parsed from mixed notations (decimal weeks and "weeks+days"). Residence was classified as urban or rural from address strings using local administrative keywords. Birth-defect free-text names were coded first to a detailed clinical set (cardiac; neural-tube/CNS; cleft; chromosomal; gastrointestinal/abdominal wall; limb; urinary; other) and then collapsed to six reporting categories

aligned with Chinese hospital-based surveillance practice [11–16]. Stillbirth free-text indications (□□□□□□ / □□□□) were coded to fetal malformations, placental/cord complications, maternal hypertensive disorders, chromosomal abnormalities, infections, or unknown/unspecified when the string lacked classifiable etiology, drawing on the logic of perinatal death classification systems such as ICD-PM [6, 18, 21, 25, 27–29].

Statistical analysis

Continuous variables are summarized as mean ± standard deviation; categorical variables as n (%). Between-series contrasts used Welch t tests and chi-square tests. Annual counts were regressed on calendar year; stillbirths were summarized with a rising-phase model (2020–2024) and a full-period model (2020–2025). Year × category chi-square tests and Cramer's V described composition stability. Analyses used Python 3.11 (pandas, SciPy). Two-sided α = 0.05.

Results

Analytic cohorts

After cleaning, 492 birth-defect records and 1416 stillbirth records entered analysis (total 1908). Birth-defect annual counts were 2019: 75, 2020: 59, 2022: 68, 2023: 97, 2024: 121, 2025: 72. Stillbirth annual counts were 2020: 177, 2021: 230, 2022: 239, 2023: 264, 2024: 304, 2025: 202 (Table 1; Fig. 1A). Hashed identifiers overlapped for 299 records across the two registries, consistent with shared clinical pathways (for example anomaly-related fetal death or indicated termination), but linkage was not required for the primary spectrum analyses.

Table 1
Demographic characteristics of the cleaned dual-registry case series

Characteristic	Birth defects (n = 492)	Stillbirths (n = 1416)	p-value
Maternal age (years), mean ± SD	29.9 ± 5.1	29.6 ± 5.9	0.262
Maternal age category, n (%)			0.000
< 20 years	10 (2.0)	91 (6.4)	
20–34 years	400 (81.3)	1041 (73.5)	
≥ 35 years	82 (16.7)	282 (19.9)	
Gestational age (weeks), mean ± SD	26.8 ± 7.4	21.8 ± 6.0	< 0.001
Residential area, n (%)			0.132
Urban	301 (61.2)	803 (56.7)	
Rural	190 (38.6)	599 (42.3)	

p-values from Welch t tests (continuous) or chi-square tests (categorical) on cleaned individual-level data.

Annual dynamics and dual-phase stillbirth trajectory

Birth-defect counts across available years ranged from 59 to 121, without a sustained linear trend (β = 4.84 cases/year, p = 0.323; Fig. 1A; Table 4). Stillbirth counts increased from 177 in 2020 to 304 in 2024 (relative change 71.8%), then were 202 in 2025 (– 33.6% from the 2024 peak). The rising-phase slope was β = 28.8 cases/year (p = 0.004; R^2=0.953), whereas the full-period linear fit was non-significant (β = 10.63, p = 0.379; Fig. 5A).

A Annual counts with stillbirth rising-phase fit (2020–2024). B Text-coded birth-defect category stacks. C Text-coded stillbirth indication proportions.

Maternal demographic contrasts

Mean maternal age did not differ significantly between series after cleaning (29.9 vs 29.6 years; p = 0.262), but the age-category distribution did (p < 0.001), with a higher share of adolescent mothers and of women ≥ 35 years among stillbirths (Table 1; Fig. 2). Gestational age remained sharply lower in stillbirth records, as expected from clinical definitions. Urban–rural mix was similar (p = 0.132).

All values recomputed from de-identified registry rows.

Birth-defect spectrum from free-text coding

Rule-based coding of defect names assigned congenital heart defects as the leading six-category group (103, 20.9%), followed by other/residual defects (215, 43.7%), cleft lip/palate (73, 14.8%), neural-tube/CNS defects (37, 7.5%), gastrointestinal/abdominal-wall defects (33, 6.7%), and limb defects (31, 6.3%) (Fig. 3A; Table 2). At finer resolution, chromosomal abnormalities (n = 80) and nonspecific “fetal malformation” strings inflated the residual bin (Fig. 3B). Year × category composition testing did not indicate a strong re-mix across available years (χ^2=34.42, p = 0.099, Cramer’s V = 0.118; Fig. 1B).

Table 2
Text-coded birth-defect categories in the cleaned cohort

Category	n	% of birth-defect cases
Congenital heart defects	103	20.9
Neural tube defects	37	7.5
Cleft lip/palate	73	14.8
Gastrointestinal defects	33	6.7
Limb defects	31	6.3
Other defects	215	43.7
Total	492	100.0

Categories derived by rule-based coding of free-text defect-name fields; chromosomal and urinary anomalies are folded into "Other defects" in the six-category collapse.

A Six-category reporting collapse. B Detailed coding categories before collapse.

Stillbirth indications from free-text coding

Across 1416 stillbirth rows, free-text indications were classifiable for 562 records (39.7%). Fetal malformations were the leading classifiable cause (276 overall, 19.5% of all stillbirths; 49.1% of classifiable records), followed by placental/cord complications (119), chromosomal abnormalities (100), and maternal hypertensive disorders (66) (Fig. 4; Table 3). Infections were rarely explicit in the indication string (n = 1). The large unknown/unspecified share (854, 60.3%) mainly reflects generic wording (for example isolated mid-trimester induction or scarred uterus without an etiology phrase) rather than a coded "other" clinical entity. Composition across years showed modest association with calendar year (χ^2=36.28, p = 0.067, V = 0.072), driven more by changing absolute volumes than by a single dominant re-mix.

Table 3
Text-coded stillbirth indications in the cleaned cohort

Indication category	n	% of all stillbirths	% of classifiable
Fetal malformations	276	19.5	49.1
Placental/cord complications	119	8.4	21.2
Maternal hypertensive disorders	66	4.7	11.7
Chromosomal abnormalities	100	7.1	17.8
Infections	1	0.1	0.2
Unknown causes	854	60.3	—
Total	1416	100.0	—

Coding applied to free-text delivery indication / induction-reason fields; records without classifiable etiology strings are labeled Unknown causes.

A All stillbirths including unclassifiable strings. B Distribution restricted to classifiable records.

Recorded exposures and post-diagnosis termination

Among birth-defect rows with non-missing exposure fields, folic acid supplementation was recorded in 434/488 (88.9%), early-pregnancy medication in 3.7%, fever in 2.4%, virus-related history in 2.4%, and diabetes history in 0.8% (Fig. 5B). Family history of birth defects and harmful-exposure flags were almost never affirmative in these forms. Termination of pregnancy after defect diagnosis was documented in 400/482 (83.0%) of records with a usable yes/no entry, underscoring that the birth-defect registry captures a high proportion of prenatally managed anomalies rather than solely live-born infants.

Table 4
Linear regression of annual cleaned case counts on calendar year

Outcome	Years	β	SE	t	p	R^2	Interpretation
Birth defects	available years	4.84	4.31	1.13	0.323	0.24	No sustained linear trend
Stillbirths (full)	2020–2025	10.63	10.77	0.99	0.379	0.196	Non-linear after 2025
Stillbirths (rising)	2020–2024	28.8	3.69	7.81	0.004	0.953	Significant rise

β is the ordinary-least-squares slope of annual counts on calendar year using cleaned individual-level yearly totals.

A Linear-trend β with 95% confidence intervals. B Prevalence of selected structured exposure/action fields among birth-defect records.

Discussion

Three results organize this reanalysis. First, stillbirth case volume shows a clear rising phase through 2024 and a lower 2025 total, while birth-defect annual counts lack a sustained linear drift—even after restoring the 2022 workbook that prior aggregate narratives had treated as missing alongside 2021. Similar single-centre and nationwide Chinese series have emphasized that stillbirth case counts and cause profiles are sensitive to referral intensity and documentation completeness [9, 19, 20]. Second, free-text coding keeps congenital heart defects at the head of the anomaly spectrum and places fetal malformations at the head of classifiable stillbirth indications, in line with hospital-based birth-defect surveillance reports from other Chinese provinces [11–16]. Third, structured exposure fields document high folic acid recording and frequent post-diagnosis termination, while stillbirth indication strings remain unclassifiable in a large fraction of rows—an observation that mirrors international concerns about incomplete perinatal cause-of-death coding [6, 18, 21, 25–29].

Working from source workbooks changes inclusion counts slightly (exact duplicate removal; year assignment from dates; header repair) and replaces pre-summarized category percentages with auditable coding rules. Demographic means for maternal age converged between series after cleaning, whereas age-category and gestational-age contrasts remained informative, consistent with the broader literature on age-related perinatal risk [7, 8]. These shifts are expected when moving from hand-curated yearbooks to row-level files; they do not erase the dual-phase stillbirth signal or the cardiac lead in the defect spectrum [11, 15, 16].

The high unclassifiable share is itself a finding about documentation. Many indication fields record procedures or background obstetric states without an etiology phrase. International experience with ICD-PM and related frameworks shows that standardized cause assignment improves comparability and prevention targeting, but only when local records contain explicit clinical detail [6, 18, 21, 25, 27–29]. Placental and cord pathways, and hypertensive disorders of pregnancy, are particularly important stillbirth mechanisms that are easy to under-specify in free text [10, 26]. Strengthening stillbirth review packages so that malformation, placental/cord, hypertensive, chromosomal, and infectious pathways are explicitly named would shrink the unknown bin [3–5, 21, 22].

Cardiac-focused prenatal pathways remain the organizing priority for anomaly services in this hospital, with cleft and neural-tube/CNS conditions as secondary concentrations, consistent with Chinese surveillance spectra in which congenital heart defects predominate [11–16]. The high post-diagnosis termination rate among coded birth-defect rows indicates that counseling and perinatal decision pathways are already central to local practice. Folic acid documentation was common in these forms; population evidence from China continues to support periconceptional folic acid for neural-tube defect prevention [17, 23, 24]. Stillbirth prevention work should retain attention to malformation-associated deaths while improving capture of placental, cord, and hypertensive mechanisms in the written indication [9, 10, 19, 26].

This is a single-center dual-registry case series without birth denominators, so incidence and stillbirth rates cannot be estimated—an inherent limit of hospital case series relative to population surveillance [11, 15, 30]. Free-text coding is rule-based and conservative; alternative dictionaries or full ICD-PM application would reassign some residual strings [6, 18, 21]. Birth-defect year 2021 remains unavailable. Address-based urban–rural classification is approximate.

Conclusions

Cleaned individual dual-registry data from a Northern China tertiary hospital support a dual-phase stillbirth case-count trajectory, a heart-defect–led anomaly spectrum, frequent documentation of folic acid use and post-diagnosis termination, and a large stillbirth indication residue that free text cannot classify. Service planning can anchor on cardiac and malformation pathways while registry quality work targets explicit etiology wording, alignment with perinatal death classification standards, and future denominator-linked rates [3–6, 11, 18, 21, 22, 30].

Abbreviations

AMA
Advanced maternal age
CHD
Congenital heart defects
CNS
Central nervous system
ICD-10
International Classification of Diseases, 10th Revision
ICD-PM
International Classification of Diseases – Perinatal Mortality
NTD
Neural tube defects
SD
Standard deviation
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
TOP
Termination of pregnancy

Declarations

Ethics approval and consent to participate

This retrospective registry reanalysis strictly complies with the ethical principles laid down in the World Medical Association Declaration of Helsinki and national regulations on biomedical research involving human beings. This study (Grant-related research project: Construction and empirical study of an information support program for women experiencing fetal loss) was reviewed and fully approved by the Medical Ethics Committee of Xingtai People's Hospital on November 10, 2023, with ethical approval number 2023□094□.

Consent for publication

Not applicable. The manuscript does not contain individual person's data in any form that would require consent for publication after de-identification.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

Author contributions were not fully specified in the source materials. Provisional roles for submission completion: XW and PZ contributed equally to data curation and drafting; NK and NL contributed to registry interpretation; HZ supervised the study and is the corresponding author. All authors should read and approve the final manuscript before submission.

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Not applicable.

Data Availability

De-identified analytic datasets derived from the institutional registries are available from the corresponding author on reasonable request, subject to institutional policies and patient privacy

regulations. Intermediate cleaned files used for analysis are archived in the project data_clean directory for internal verification.

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Figures

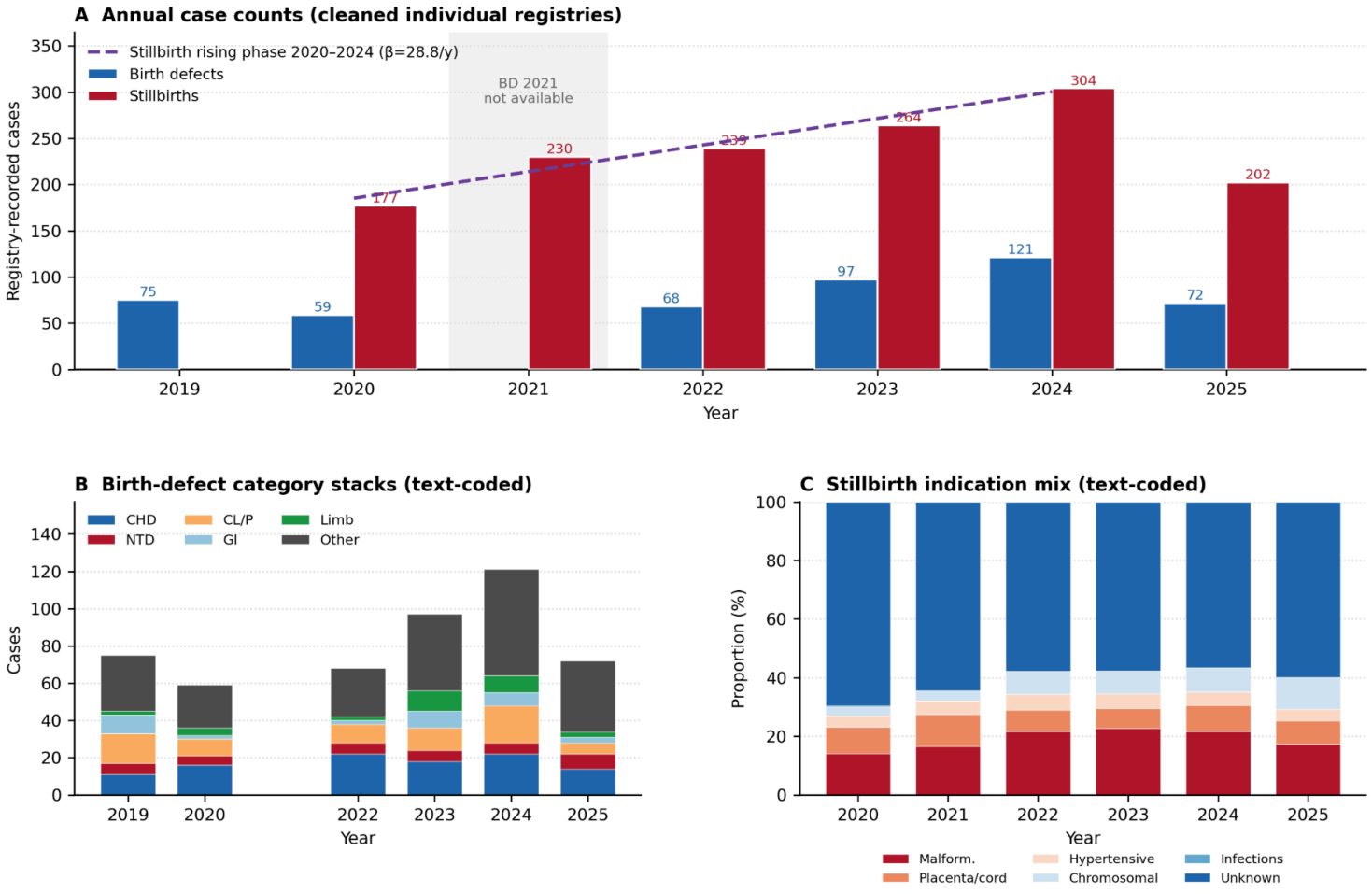

Figure 1

Temporal dynamics from cleaned dual-registry rows (2019–2025).

A Annual counts with stillbirth rising-phase fit (2020–2024). B Text-coded birth-defect category stacks. C Text-coded stillbirth indication proportions.

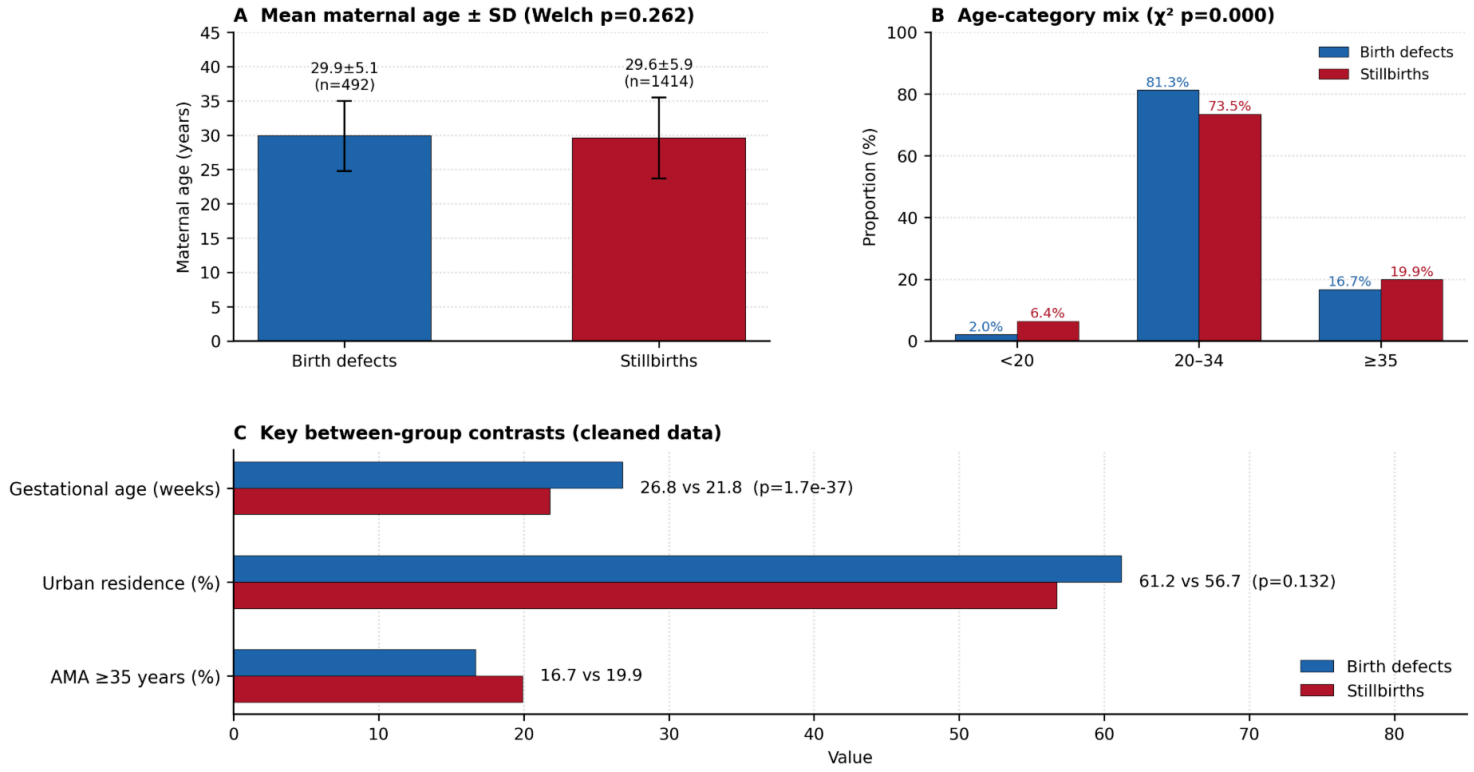

Figure 2

Maternal demographic contrasts on cleaned individual data.

All values recomputed from de-identified registry rows.

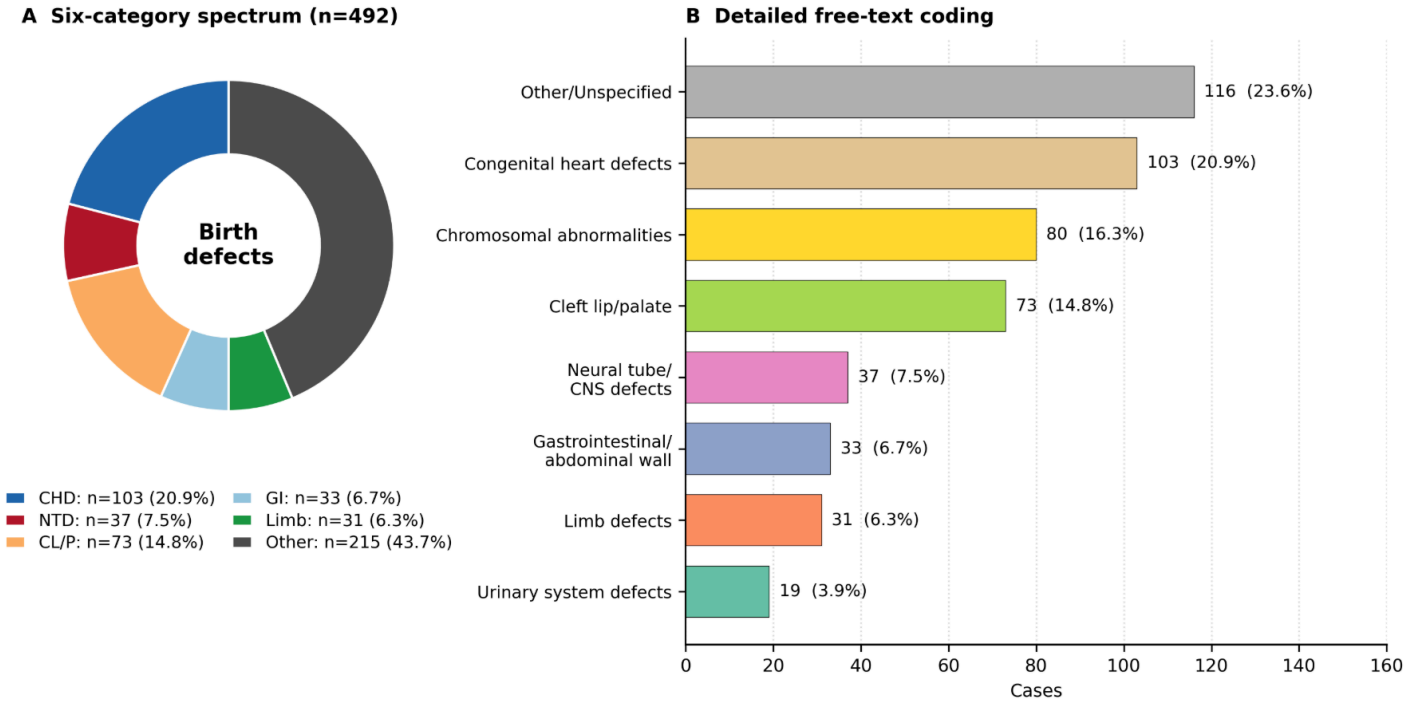

Figure 3

Birth-defect spectrum after free-text coding.

A Six-category reporting collapse. B Detailed coding categories before collapse.

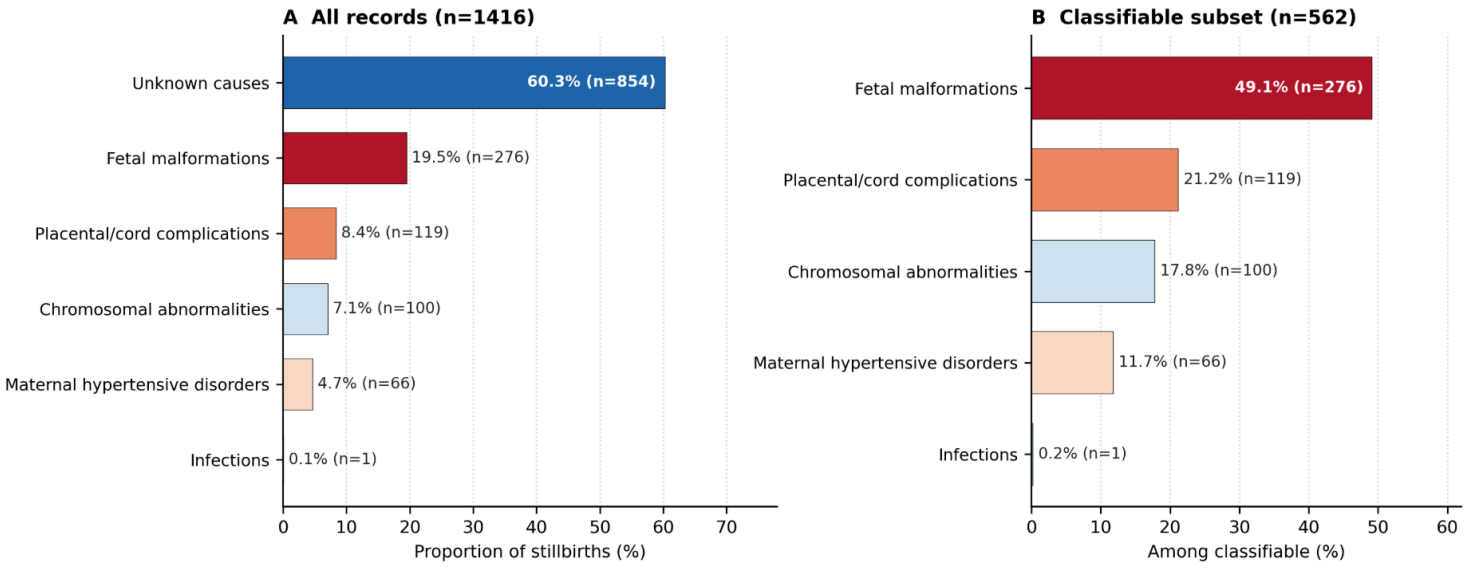

Figure 4

Stillbirth indication structure after free-text coding.

A All stillbirths including unclassifiable strings. B Distribution restricted to classifiable records.

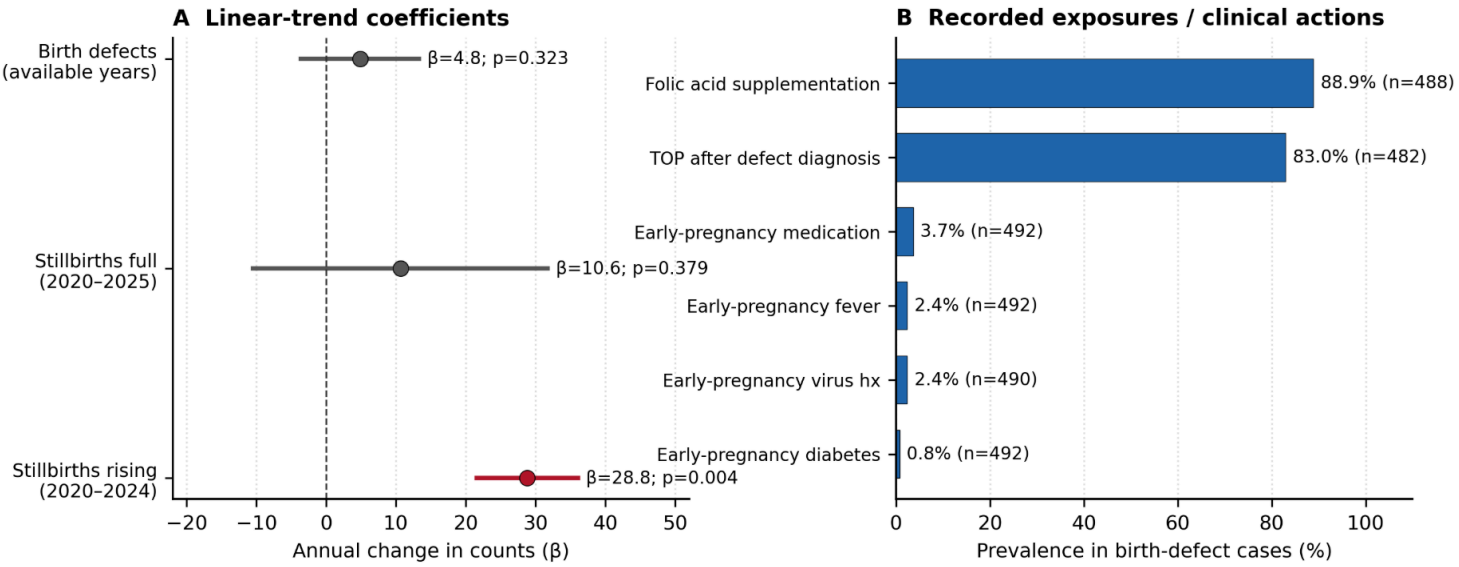

Figure 5

Trend coefficients and recorded prenatal exposures/actions.

A Linear-trend β with 95% confidence intervals. B Prevalence of selected structured exposure/action fields among birth-defect records.