深圳市卫生健康发展研究和数据管理中心
Shenzhen Health Development Research and Data Management Center

Cost-Effectiveness Analysis of First-Trimester Ultrasound Screening for Fetal Structural Abnormalities in China

Ao C[1], Jiang L[1], Xia X[2], Li J[2], Zeng H[1], Wu B[1],Wu L[1]
[1] Shenzhen Health Development Research and Data Management Center, Shenzhen, China
[2] Shenzhen Nanshan Maternity & Child Healthcare Hospital, Shenzhen, China

EE379

Background

- Birth defects denote structural, functional, or metabolic abnormalities occurring in infants prior to birth, constituting a primary cause for early miscarriages, stillbirths, perinatal mortality, infant mortality, and congenital disabilities, with their etiology yet to be fully expounded.
- The overall incidence rate of birth defects is approximately 5.60% in China[1]. Based on the total national annual birth count in 2022, an estimated 540,000 new cases of children born with birth defects were reported that year, with approximately a quarter of them presenting noticeable clinical manifestations at birth.
- The economic burden resulting from the treatment of children with birth defects, disabilities, or fatalities is substantial. In 2014, the treatment costs for birth defect diseases in Jilin Province amounted to 600 million RMB, with an average cost per case of ¥10,914.05[2].
- Prenatal screening and diagnosis serve as secondary preventive measures against birth defects, with approximately 75% of fetal structural anomalies currently being diagnosable prenatally[3-4].
- With the advancement and widespread adoption of fetal anomaly ultrasound screening technology, coupled with the continual improvement in ultrasound machine resolution, many fetal anomalies can now be diagnosed in the early stages of pregnancy.
- In 2013, the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) issued guidelines for the application of early pregnancy ultrasound scans, categorizing fetal anatomical assessment as one of the components of early pregnancy (11-13^{+6} weeks) ultrasound examinations [5].
- In accordance with the prenatal ultrasound screening guidelines issued in 2012 and 2022 in China, the examination of fetal anatomical structures in our country is typically conducted during the mid-term of pregnancy (20-24^{+6} weeks) [6-7].

Objective

Our study aims to determine the cost-effectiveness of first-trimester fetal structural abnormalities ultrasound screening compared to mid-trimester fetal structural ultrasound screening in China, providing evidence-based support for optimizing clinical pathways.

Methods

Model Design

- A decision tree model with 18-week horizon(from early pregnancy at 12 weeks gestation to late pregnancy at 30 weeks gestation) was developed from society perspective in China (Fig 1).
- The model has three outcomes: 1) termination of pregnancy for fetal abnormality (TOPFA)in early pregnancy; 2) TOPFA in mid-pregnancy; 3) continuation of pregnancy into late pregnancy.
- The model is based on the following assumptions: 1) Assuming that, under the current level of ultrasound screening, fetal abnormalities detectable before the end of mid-pregnancy can be identified, and the incidence of fetal abnormalities can be adjusted according to the incidence of birth defects; 2) Considering the exceptional precision of the ultrasound equipment employed in this study and the uniformity and expertise of the medical personnel conducting the ultrasound examinations, it is assumed that the sensitivity and specificity of the two groups undergoing structural ultrasound screening are consistent.
- The model was constructed and analyzed using Microsoft Excel 2019.

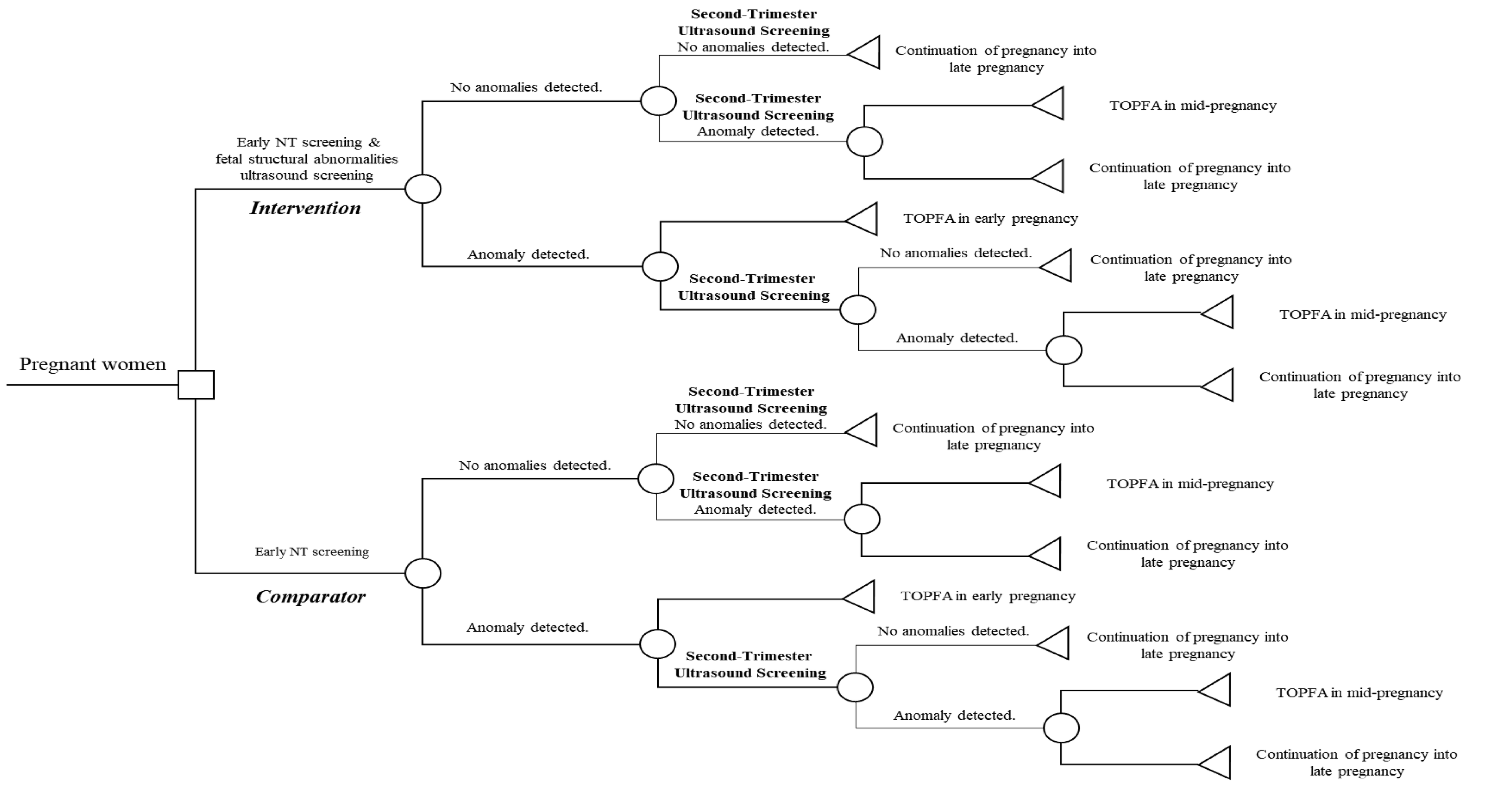

Fig 1. Decision tree model

Data Source & Baseline

- Given the standardized protocol[8] for early fetal abnormality ultrasound screening was implemented in the Shenzhen Nanshan Maternity & Child Healthcare Hospital starting in 2021, this study included pregnant women undergoing prenatal ultrasound screening in the early pregnancy (11-13^{+6} weeks) and mid-pregnancy (20-24^{+6} weeks) periods before and after the implementation point, namely 2020 (sample control group) and 2021 (sample intervention group) as data source to conduct a retrospective analysis.
- Following meticulous collection by researchers, the sample sizes for the two groups of pregnant women were 3,052 and 3,317 respectively. In the sample control group, the average age was (30.51±4.35) years, while in the sample intervention group, it was (30.50±4.26) years. There was no statistically significant difference in the mean age between the two groups (t=0.028, P=0.978).

Transition Probabilities

- Based on the clinical pathways of prenatal ultrasound screening, using the two groups of samples as the data source, the clinical transition probability parameters of each node in the decision tree model were collected.

Costs

- The costs incurred in this study encompass both direct and indirect components.
- Direct medical costs include expenses related to ultrasound examinations (such as early pregnancy ultrasound scans, mid-pregnancy ultrasound structural screening, Level II prenatal ultrasound examination, and Level III prenatal ultrasound examination), non-invasive prenatal screening costs, invasive diagnostic expenses, genetic counseling fees, TOPFA costs etc. were obtained from real-world hospital data.
- Indirect costs involve the loss of income for pregnant women and their accompanying family members during prenatal check-ups and pregnancy termination procedures. The indirect costs were calculated through the days of absence from work multiplied by the China's GDP per capita in 2021[9].

Utility

- The health utility in this study consists of early pregnancy, early pregnancy ultrasound abnormalities, TOPFA in early pregnancy, mid-pregnancy, mid-pregnancy ultrasound abnormalities, and TOPFA in mid-pregnancy, were from the published literatures[10-11].

Results

Base-Case Result

- Using decision tree model simulation, **the intervention group dominated the control group with lower unnecessary pregnancies**(TOPFA rate in first-trimester:0.59 versus 0.23; TOPFA rate in mid-trimester:0.41 versus 0.77).
- In the base-case analysis (Table 1), the average total cost per pregnant woman entering late pregnancy-related ultrasound screening in the intervention group is ¥ 2,085.09, with a total of 0.283857 QALYs. In comparison, the average total cost per pregnant woman entering late pregnancy-related ultrasound screening in the control group is ¥ 2,299.70, with a total of 0.282536 QALYs and resulting in an Incremental Cost-Effectiveness Ratio (ICER) of ¥-161,732.68/QALY, which **presented an absolute cost-effectiveness advantage**.

Table 1. Base case results

Items	Intervention	Comparator
Total costs	¥2,085.09	¥2,299.70
Total QALYs	0.283 857	0.282 536
Incremental cost	- ¥213.61	
Incremental QALYs	0.001 321	
ICER	-¥161,732.68/QALY	

Univariate sensitivity analysis

- Cost, transition probability, and other clinical parameters were considered in univariate sensitivity analysis. The parameters ranged within the upper and lower limits of the 95% confidence interval of the base case.
- Univariate sensitivity analysis showed that the three main factors were the proportion of structural abnormalities in abnormal mid-trimester ultrasound screenings of in the control group, the proportion of abnormalities detected in mid-trimester ultrasound screenings after no abnormalities were found in early pregnancy ultrasound screenings in the control group, and proportion of structural abnormalities in abnormal mid-trimester ultrasound screenings in the intervention group (Fig 2).

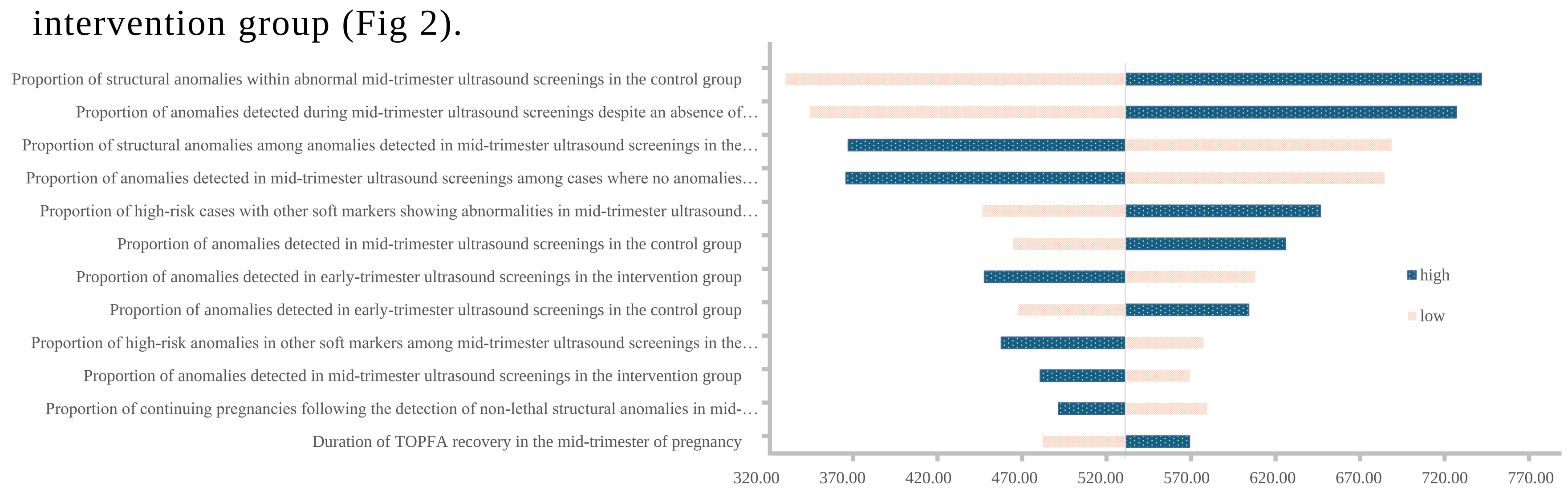

Fig 2. Tornado diagram (NMB)

Probabilistic sensitivity analysis

- All model parameters were simultaneously and randomly sampled from a predetermined set of parametric distributions to generate 5000 estimates of the cost and QALYs for each group. The gamma distribution was selected for cost parameters, and the beta distribution was selected for probability and quality of life value parameters (Fig. 3).
- At the cost-effectiveness threshold of 3 × GDP per capita, the probabilistic sensitivity analysis demonstrated the robustness of the results with the likelihood of the intervention group being cost-effective was 94.60% (Fig. 4).

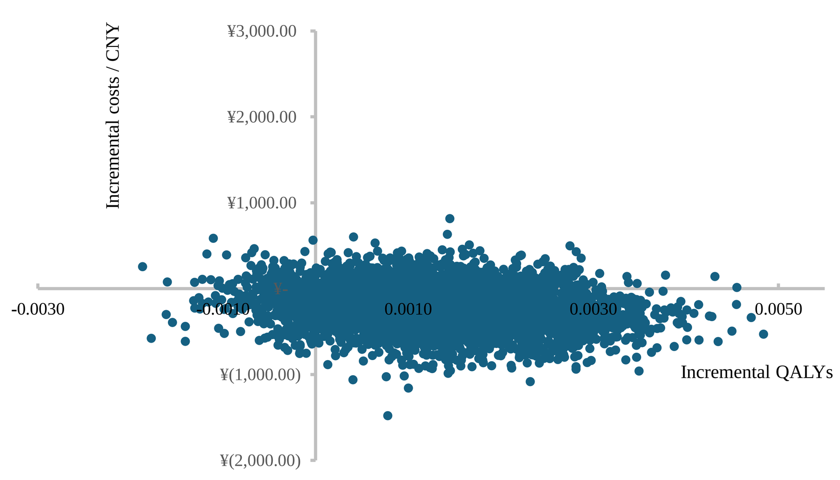

Fig 3. Probabilistic sensitivity analyses

Fig 4. Cost-effectiveness Acceptability Curve

Conclusion

From society perspective in China, first-trimester fetal structural abnormalities ultrasound screening is more effective and cost-saving compared with mid-trimester fetal structural ultrasound screening. It is recommended that ultrasound screening for structural abnormalities should be extended to the first trimester.

References

[1] China Birth Defects Prevention and Control Report (2012). https://www.gov.cn/gzdt/201209/12/content_222371.htm.
[2]Li T. Estimation analysis on curative care expenditure of birth defect Jilin province of 2014 based on the system of health accounts 2011.Jilin University,2018.
[3] Liu, Z., et al., Expert consensus on congenital defect prevention and control healthcare education. Maternal and Child Health Care of China, 2022, 37(5): 775-779.
[4] Neonatal Surgery Group, Pediatric Surgery Branch o f Chinese Medical Association. Pediatric surgical expert consensus on prenatal consultation for common fetal structural abnormalities. Chin J Pediatr Surg. 2022, 21(9): 805-810.
[5] SALOMON LJ, ALFIREVIC Z, BILARDO CM, et al. ISUOG practice guidelines: performance of first-trimester fetal ultrasound scan. Ultrasound Obstet Gynecol, 2013, 41(1):102-113.
[6] Chinese Medical Association, Ultrasound Physicians Branch. Prenatal Ultrasonography Guidelines (2012). Chinese Journal of Medical Ultrasonics (Electronic Edition). 2012, 9(7): 574-580.
[7] Group of Ultrasound in Obstetrics and Gynecology Ultrasound Branch of Chinese Medical Association, Medical Imaging Group of the National Prenatal Diagnosis Expert Group Department of Maternal and Child National Health Commission of the People's Republic of China. Practice guidelines for performance of prenatal ultrasound screening. Chin J Ultrasonogr. 2022, 31(1):12.
[8] Liao Y., et al., Routine first-trimester ultrasound screening using a standardized anatomical protocol. Am J Obstet Gynecol 224(4):396.e1-396.e15.
[9] Shenzhen City's Statistical Communique on National Economic and Social Development in 2021. http://www.sz.gov.cn/cn/xxgk/zfxxgj/tjsj/tjgb/content/post_9763161.html.
[10] WU H., et al. Health-related quality of life in different trimesters during pregnancy. Health Qual Life Outcomes, 2021, 19(1): 182.
[11] KUPPERMANN M., et al., Preferences regarding contemporary prenatal genetic tests among women desiring testing: implications for optimal testing strategies. Prenat Diagn, 2016, 36(5): 469-475.