Phased Comparative Analysis of Neonatal Asphyxia Mortality in Rugao City

Authors: Ding Yan, Li Hongbin, Huang Wenmei, Jie Wang, Li Hongbin

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Abstract

Abstract [Objective] To evaluate the effectiveness of comprehensive intervention measures in controlling neonatal asphyxia mortality. [Methods] A retrospective analysis and phased comparison of neonatal asphyxia mortality data from 2011-2016 and 1991-2010 was conducted. [Results] Compared with 1991-2010, the difference in neonatal asphyxia mortality rate in 2011-2016 was statistically significant (²=36.935, P=0.000). The difference in neonatal asphyxia mortality rates between secondary and tertiary hospitals was not statistically significant (²=1.371, P=0.242). The difference in constituent ratios of neonatal asphyxia deaths between 0-day and over-1-day groups was not statistically significant (²=0.336, P=0.562). The difference in constituent ratios among different birth places was statistically significant (²=40.468, P=0.000). The difference in constituent ratios among different death places was statistically significant (²=7.505, P=0.017). The average annual increase in neonatal asphyxia mortality was 0.07 per 100,000 in 1991-2010, and -1.64 per 100,000 in 2011-2016. [Conclusion] The rising trend of neonatal asphyxia mortality in Rugao City has been reversed, with comprehensive intervention measures demonstrating certain effectiveness. It is recommended to continue strengthening resuscitation training and establishing a post-resuscitation treatment system. Keywords: Neonatal asphyxia; Neonatal resuscitation; Infant mortality rate; Retraining

Full Text

A Comparative Analysis of Neonatal Asphyxia Mortality Rates in Rugao City by Time Period

Ding Yan, Li Hongbin*, Huang Wenmei, Wang Jie
(Maternal and Child Health Care and Family Planning Service Center of Rugao, Jiangsu Rugao, 226500, China)

Abstract:
[**Objective**] To evaluate the effectiveness of comprehensive interventions in controlling neonatal asphyxia mortality.
[**Methods**] A retrospective analysis and phase comparison of neonatal asphyxia mortality data was conducted between 2011-2016 and 1991-2010.
[**Results**] Comparison between 2011-2016 and 1991-2010 revealed a statistically significant difference in neonatal asphyxia mortality rates ($X^2 = 36.935$, $P = 0.000$). No statistically significant difference was found in neonatal asphyxia mortality rates between births in secondary and tertiary hospitals ($X^2 = 1.371$, $P = 0.242$). The composition ratios of neonatal asphyxia deaths at 0 days versus over 1 day showed no statistically significant difference ($X^2 = 0.336$, $P = 0.562$). However, the composition ratios across different death locations differed significantly ($X^2 = 7.505$, $P = 0.017$). The average annual increase in neonatal asphyxia mortality was 0.07 per 100,000 during 1991-2010, compared to -1.64 per 100,000 during 2011-2016.
[**Conclusions**] The rising trend in neonatal asphyxia mortality in Rugao City has been reversed, with comprehensive interventions demonstrating effectiveness. Continued strengthening of resuscitation training and post-resuscitation treatment systems is recommended.

Keywords: neonatal asphyxia; neonatal resuscitation; infant mortality rate; retraining

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Corresponding Author: Li Hongbin, Email: 2249903906@qq.com

Neonatal asphyxia represents one of the leading causes of perinatal and infant mortality. While studies have demonstrated that neonatal resuscitation techniques can effectively reduce both the incidence and mortality of neonatal asphyxia, regional studies show inconsistent statistical significance, and the quality of evidence from systematic reviews remains suboptimal. Consequently, regional implementation of neonatal resuscitation technology requires exploration of effective measures to maximize its impact. In Rugao City, neonatal asphyxia mortality exhibited negative growth during the first decade of 1991-2010 but reversed to positive growth in the second decade. During 2011-2016, comprehensive intervention measures were implemented to establish a regional resuscitation training and treatment system. Whether these efforts reversed the positive growth trend warrants investigation. This study conducts a retrospective analysis and phase comparison of neonatal asphyxia mortality data in Rugao City to evaluate the effectiveness of these regional comprehensive measures and provide decision-making references for more effective interventions during the "13th Five-Year Plan" period.

1.1 Data Sources

Data for infant deaths and neonatal asphyxia deaths from 1991-2010 were obtained from published literature, while corresponding data for 2011-2016 were

derived from the "three-network" monitoring system. Annual live birth numbers were sourced from birth monitoring reports, with the statistical period defined as January-December each year. Supplemental death data were categorized according to the year of death. The 2011-2016 data on infant mortality and neonatal asphyxia mortality are presented in Table 1 . Data collection, collation, and quality monitoring for the three-network surveillance were conducted according to the Jiangsu Provincial Maternal and Child Health Three-Network Monitoring Work Standards.

1.2 Methods

We retrospectively analyzed infant death and neonatal asphyxia death data from 2011-2016 and compared them with data from 1991-2010. Annual infant mortality rate was calculated as (number of infant deaths in a given year ÷ number of live births in that year) × 1000‰, while phase infant mortality rate was calculated as (total infant deaths during a phase ÷ total live births during that phase) × 1000‰. Annual neonatal asphyxia mortality rate was calculated as (number of neonatal asphyxia deaths in a given year ÷ number of live births that year) × 10 /100,000, with phase rates calculated similarly using phase totals.

To determine average levels of infant or neonatal asphyxia mortality rates during a phase, we first constructed a dynamic series where x , x , ···x , x corresponded to mortality rates in years 1, 2, ···n-1, n. The average growth quantity was calculated as (x - x)/(n - 1), reflecting the average annual increase. The average development speed was computed as the nth root of (x /x), and the average growth speed equaled average development speed minus 1, indicating the average rate of change over an extended period (positive values indicating upward trends, negative values indicating downward trends). All calculations were performed in Excel.

Comparisons of mortality rates or composition ratios between the two phases were conducted using chi-square tests for categorical data. Fisher' s exact probability method was employed when sample sizes were less than 5. Statistical analyses were performed using SPSS 17.0 software, with $P < 0.05$ considered statistically significant.

2 Results

2.1 Phase Comparison of Neonatal Asphyxia Mortality Rates

Statistically significant differences were observed when comparing infant mortality rates and neonatal asphyxia mortality rates between 1991-2010 and 2011-2016 (see Table 2). During 2001-2010, there were 97,951 live births and 749 infant deaths, yielding an infant mortality rate of 7.65‰ and 75 neonatal asphyxia deaths for a neonatal asphyxia mortality rate of 76.57 per 100,000. Comparison with 2011-2016 data showed a statistically significant difference in infant mor-

tality rates ($X^2 = 131.909$, $P = 0.000$) but no significant difference in neonatal asphyxia mortality rates ($X^2 = 1.535$, $P = 0.215$).

2.2 Changes in Average Growth Quantity of Neonatal Asphyxia Mortality

Across the three phases of 1991-2000, 2001-2010, and 2011-2016, the average growth quantity of infant mortality rates increased progressively by phase, demonstrating a consistent negative growth trend with gradually decreasing magnitude. In contrast, the average growth quantity of neonatal asphyxia mortality rates fluctuated across phases, showing negative growth in the first and third phases but positive growth in the second phase (see Table 3).

2.3 Phase Comparison of Neonatal Asphyxia Death by Age

During 1991-2010, deaths within the first 24 hours (0 days) accounted for 51.25% of total neonatal asphyxia deaths, while deaths after 24 hours (1 day) comprised 48.75%. In 2011-2016, these proportions were 46.67% and 53.33%, respectively. The difference in age composition between the two phases was not statistically significant ($X^2 = 0.336$, $P = 0.562$). However, comparisons of neonatal asphyxia mortality rates for both 0-day and 1-day categories between the two phases showed statistically significant differences (see Table 2).

2.4 Phase Comparison of Birth and Death Locations for Neonatal Asphyxia

During 1991-2010, 78.95% of neonatal asphyxia deaths occurred among infants born in primary-level hospitals, 20.50% in secondary or tertiary hospitals, and 0.55% at home. In 2011-2016, these proportions shifted to 33.33% in primary-level hospitals and 66.67% in secondary or tertiary hospitals, with no home births. The difference in birth location composition between phases was statistically significant ($X^2 = 40.468$, $P = 0.000$). Comparisons of neonatal asphyxia mortality rates by birth location showed statistically significant differences for primary-level hospitals but not for secondary/tertiary hospitals or home births (see Table 2).

Regarding death locations, during 1991-2010, 85.87% of neonatal asphyxia deaths occurred in hospitals, 5.54% during transport, and 8.59% at home. In 2011-2016, 100% of deaths occurred in hospitals. The difference in death location composition between phases was statistically significant ($X^2 = 7.505$, $P = 0.017$). Comparisons of neonatal asphyxia mortality rates by death location showed statistically significant differences across all locations (see Table 2).

3 Discussion

3.1 The Necessity of Phase Comparison for Neonatal Asphyxia Mortality

According to 2005 WHO statistics, approximately 1 million of the 4 million annual neonatal deaths worldwide were attributable to neonatal asphyxia. Mastery of neonatal resuscitation techniques is crucial for reducing neonatal mortality, minimizing disabilities, and improving population health outcomes. In the early 21st century, Rugao City implemented property rights system reforms in township hospitals, converting all primary-level hospitals to private ownership and creating challenges in obstetric construction and management. When the anomalous positive growth trend in neonatal asphyxia mortality during 2001-2010 was identified, health administrative authorities conducted investigations revealing that only 36.59% of private primary-level hospitals passed on-site resuscitation competency assessments. Consequently, comprehensive intervention measures were implemented during the "12th Five-Year Plan" period to establish regional resuscitation training and post-resuscitation treatment systems. Evaluating the effectiveness of these interventions holds practical significance for adjusting prevention and control strategies during the "13th Five-Year Plan" period.

3.2 Comprehensive Interventions During 2011-2016

The intervention strategy comprised two primary components: enhanced management and quality control, and systematic development of resuscitation training and post-resuscitation treatment infrastructure.

Management and Quality Control Measures: Health authorities convened two obstetric construction and management conferences, conducted four "Baby-Friendly Hospital" re-evaluation campaigns, performed two renewal inspections of maternal and child health care service licenses for obstetric institutions, and launched one special rectification campaign for standardized obstetric practice in medical institutions. The Nantong City Standards for Standardized Construction of Primary Medical and Health Institutions for Women' s Health and Obstetrics (Trial) were implemented, with institutional neonatal resuscitation training, hardware provision, and operational skills serving as key quality control components. The number of obstetric service institutions decreased from 50 at the beginning of 2011 to 31 by the end of 2016, as 19 private primary-level institutions lost their delivery qualifications due to inadequate obstetric staff credentials or insufficient annual delivery volumes, concurrently forfeiting their "Baby-Friendly Hospital" designations.

Resuscitation Training and Treatment System Development: First, a long-term municipal resuscitation training mechanism was established. Over six years, the city organized one comprehensive "three basics" training and assessment for obstetric and pediatric staff, five specialized training sessions for obstetric personnel, one "Maternal and Child Health Service Year" knowl-

edge competition, and one maternal and neonatal critical care emergency skills competition, with neonatal resuscitation as a core training component to promote knowledge updates among obstetric and pediatric medical staff. Additionally, one municipal neonatal resuscitation technology training program was conducted in 11 batches (limited to 30 participants per batch, divided into six study groups), featuring theoretical instruction in the morning and practical drills in the afternoon, taught by provincial neonatal resuscitation trainers from Nantong Maternal and Child Health Hospital. A total of 298 obstetric, pediatric, and related technical professionals participated, focusing on enhancing practical resuscitation skills.

Second, institutional development was strengthened through the formulation and implementation of several key policies: the Critical Maternal and Neonatal Rescue Plan (Revised), the Reduced Cesarean Section Rate Project Implementation Plan, the Maternal and Child Health Project Hierarchical Service Implementation Plan, and the Maternal and Neonatal Critical Care Referral and Treatment Work Implementation Plan (Trial). These documents clarified the responsibilities and service scopes of different medical institutions to standardize service delivery.

Third, a regional transport system and critical care treatment center were established. A regional 120 emergency rescue command center was created with unified city-wide dispatching, where all relevant personnel received resuscitation training and professional equipment was provided. Relying on the obstetrics and pediatrics departments of the Municipal People' s Hospital, a municipal-level critical maternal and neonatal care treatment center was established and passed evaluation by Nantong City authorities.

3.3 Main Strategies for the "13th Five-Year Plan" Period

Although the rising trend in neonatal asphyxia mortality during 2001-2010 was reversed during 2011-2016, mortality rates remained at similar levels between the two phases. Therefore, continued strengthening of regional resuscitation training and post-resuscitation treatment systems is essential during the "13th Five-Year Plan" period. All obstetric service institutions should enhance long-term institutional resuscitation training to develop well-coordinated resuscitation teams as a key "13th Five-Year Plan" objective. At the municipal level, a resuscitation technology expert group should be established to conduct case review and analysis, regular 巡回演练 [circuit training drills], and irregular inspection and guidance to identify problems in primary-level hospital neonatal resuscitation work and strengthen corrective implementation. Supervision and regulation should be intensified, with strict enforcement of the hierarchical maternal diagnosis and treatment system to prevent private hospitals from retaining high-risk pregnant women. Relying on the municipal 120 emergency rescue command center and critical infant treatment center, regular post-resuscitation rescue drills should be organized to strengthen capacity building and improve emergency response effectiveness. Research indicates that global economic growth correlates

negatively with infant mortality rates, necessitating increased health investment and policy support to establish an "ultra-growth support" operational mechanism, applying appropriate technologies to benefit children' s lives and health.

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Author Contributions Statement:
Ding Yan: Designed the research protocol, collected data, drafted and revised

the manuscript;
Li Hongbin: Conceived the research idea, performed statistical analysis, revised the final manuscript;
Huang Wenmei, Wang Jie: Conducted three-network monitoring, collected and collated data.

Note: Figure translations are in progress. See original paper for figures.