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Analyzing the Risk Factors of Early Neonatal Deaths in Kupang District, Rural Eastern Indonesia

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Abstract

The neonatal mortality rate in East Nusa Tenggara (NTT) remains high, with 80% of neonatal deaths occurring in the early period. This study aims to analyze the risk factors contributing to early neonatal death in Kupang District. A retrospective case-control study was conducted, involving 31 cases of early neonatal death and 69 controls from medical records from January 2023 to June 2024. Multinomial logistic regression analysis was used to identify the influence of maternal health, birth, neonatal factors, and healthcare facility readiness. The results showed that birth weight, frequency of antenatal visits, and the completeness of medical equipment were significant predictors of early neonatal death. More frequent antenatal visits were found to reduce the risk of death by 24%, while low birth weight increased the risk by 30%. In conclusion, interventions focusing on preventing low birth weight, ensuring compliance with minimum antenatal visits, and improving the readiness of basic healthcare facilities could reduce early neonatal death in this region.

Keywords: early neonatal death, risk factors, antenatal care, low birth weight.

Introduction

One of the indicators of Public Health Status is the maternal mortality ratio (MMR) and infant mortality rate (IMR), including the neonatal mortality rate (NMR). According to the 2017 Indonesia Demographic and Health Survey (SDKI), Indonesia's NMR is 15 per 1000 live births. East Nusa Tenggara (NTT) province is one of the provinces with high MMR, IMR, and NMR in Indonesia. The number of maternal deaths reached 181 cases and neonatal deaths reached 694 cases or 72.6% of total infant deaths in 2021 (Indonesia, 2022) (Ningsih et al., 2021). Neonatal deaths are further divided into early neonatal deaths (deaths occurring within the first 7 days) and late neonatal deaths (neonatal deaths occurring between the ages of 8-28 days). Data from the East Nusa

Tenggara Provincial Health Office states that the proportion of early neonatal deaths reached 80% in 2018.

The most common causes of neonatal death globally are asphyxia and prematurity. (Bhutta et al., 2008) (Darmstadt et al., 2014), while in NTT, the most frequent causes are asphyxia, low birth weight, and infection (4). Numerous factors could contribute to early neonatal deaths, including maternal factors, birth factors, and neonatal factors. Early neonatal death and stillbirth are closely linked to the mother's condition during and before pregnancy, as well as during childbirth. These conditions include mothers with high-risk 4T factors (too young, too old, too frequent, and too many pregnancies), complications during pregnancy and childbirth, and a history of poor pregnancy or childbirth outcomes.

A study conducted by Putri, Yunita, & Viridula, (2021) A scoring system for risk factors of early neonatal death related to maternal factors during pregnancy and childbirth found that risk factors for early neonatal death include: pregnant women aged <20 years or >35 years, with less than 4 antenatal care (ANC) visits, a history of stillbirth or previous history of high-risk pregnancy, and a threat of preterm labor. Intrapartum risk factors include meconium-stained amniotic fluid, prolonged labor, and gestational age <37 weeks at delivery. (Addisu et al., 2018; Latifah, 2024)

In addition to internal factors, there are several external factors beyond the condition of mother and baby are also believed to be determinants of early neonatal death. An audit of maternal and neonatal deaths in NTT found that the level of community knowledge, difficulties in accessing healthcare services, lack of healthcare provider competence, incomplete healthcare equipment at health centers, and suboptimal referral systems, had contributed to maternal and neonatal deaths. (Ulfah, 2021).

High-risk pregnancies and deliveries require prompt and appropriate care from competent healthcare providers. Delayed care could potentially increase maternal and infant morbidity and mortality. The ability to provide quick and prompt treatment is not always possessed by all healthcare workers, it requires skills and experiences that must be continuously honed. In NTT, where a large portion of the region is remote, and relatively low number of obstetric and neonatal emergencies encountered in health centers can lead to healthcare workers potentially losing their clinical skills in managing such cases.

Research by Abdullah, Hort, Butu, & Simpson, (2015) On the transfer and retention of midwifery knowledge and skills in NTT, found that only about 2% of midwives had a knowledge retention level and 20% had a skill retention level above the national minimum standard (85) after attending APN, PPGDON, PONED, and BBLR training. Another study by (Trisno et al., 2015)The identification and management of obstetric and neonatal complications in health centers in NTT showed that 30% of obstetric emergencies and 46% of pre-referral obstetric management were not by service standards. (Trisno et al., 2015).

This study provides new insights by focusing not only on maternal and neonatal factors but also on the readiness of healthcare facilities in rural areas, which is often

overlooked in previous research. The study highlights the need for improved healthcare infrastructure and training for healthcare workers in managing neonatal emergencies, offering a comprehensive analysis of the risk factors that contribute to early neonatal death in NTT.

Based on the above description, it can be concluded that: neonatal mortality rates and the proportion of early neonatal deaths in NTT are still high, an analysis of risk factors for early neonatal deaths in the context of healthcare readiness is needed, risk factors for early neonatal deaths include maternal factors, birth factors, neonatal factors, and healthcare readiness factors; studies on maternal and birth factors related to early neonatal deaths have been conducted, a more comprehensive study on neonatal factors and healthcare readiness factors, which can be determinants of early neonatal death, is needed. Therefore, this study is considered necessary to provide a more comprehensive picture of the risk factors for early neonatal death, so that it can be developed into a policy brief as a reference in developing local health department strategies to reduce neonatal mortality.

Given the high rates of early neonatal deaths in NTT, this research is urgently needed to inform policy changes and interventions that can reduce neonatal mortality. The findings of this study will be crucial in shaping strategies to improve antenatal care, increase the availability of essential healthcare equipment, and enhance the skills of healthcare providers in rural areas.

The main objective of this research is to analyze the risk factors contributing to early neonatal deaths in Kupang District. This includes identifying the maternal, birth, neonatal, and healthcare system factors that are most strongly associated with early neonatal mortality. The study also aims to provide recommendations for improving healthcare services to reduce neonatal mortality in rural settings. The findings from this research will benefit public health efforts by providing evidence-based recommendations for reducing early neonatal deaths. Healthcare policymakers can use the results to design targeted interventions that address the specific risk factors identified in this study. Additionally, the research will help improve healthcare delivery in remote areas by highlighting the importance of healthcare facility readiness and maternal healthcare practices.

Research Methods

This study is a retrospective cross-sectional study, measuring the exposure to risk factors and the incidence of early neonatal death in the period of January 2023 to June 2024, and analyzing the relationship between the two. The study was conducted in 6 health centers in Kupang district that had cases of early neonatal death. Respondents were all cases of early neonatal death recorded in the health center reports (cases), and live births in the same period (controls) with a minimum number of 2 times the number of early neonatal death cases. The total number of respondents obtained from the medical record review was 32 cases of early neonatal death and 80 controls (live births), resulting in a total of 111 respondents.

We included in our study: babies born alive who died within the first 6 days, and both the mother and baby had information on the specific factors that we needed for our study. For the babies who lived (control), we included those who survived the first 7 days and had information on the studied factors. We did not include babies who died from severe breathing problems at birth (severe asphyxia), infections (neonatal sepsis), birth defects, or if we deal with incomplete data.

Data collection

Data were collected through a review of medical records to identify risk factors for early neonatal death in both groups of respondents. This study examined maternal factors, birth factors, and neonatal factors. Additionally, to assess healthcare facility readiness, an interview with the Head of The Health Centre and direct observation using a checklist on the input aspects of healthcare services were performed.

Data collected for each factor group were as follows: maternal factors, including maternal age, nutritional status, parity, spacing between pregnancies, history of hypertension during pregnancy, anemia, and antenatal care frequency. Birth factors included: place of birth, mode of delivery, prolonged labor, and meconium-stained amniotic fluid. Neonatal factors included: gestational age, birth weight, presence of asphyxia, and essential neonatal care received (early initiation of breastfeeding, exclusive breastfeeding, and kangaroo mother care). Healthcare facility readiness factors included: human resource readiness (presence of a birth attendant team and regular case simulations at the health center), availability of essential health equipment for neonatal emergencies, referral facility readiness (availability of a driver and ambulance 24 hours a day), and managerial readiness (completeness of Standard Operating Procedures and regular supervision available).

Statistical Analysis

We looked at maternal child health reports from January 2023 to March 2024 in the District Health Office of Kupang district, which recorded 64 cases of early neonatal death at the 6 research health centers' sites. (Pathirana et al., 2016). After reviewing patient medical records, the complete data for all neonatal deaths were only found in 31 cases (48% of the total deaths), so this study took all of this data as the case group (total sampling). The sample size for the control group was 62 (doubling the number of cases). Thus, the minimum sample size that includes cases and controls was 93 cases, however for convenience issues the sample size was set at 100 respondents in this study.

A descriptive analysis was conducted to describe the readiness of health centers to provide neonatal healthcare, the characteristics of maternal risk factors, birth risk factors, neonatal risk factors, and the incidence of early neonatal death and IUFD in health centers.

Multivariate analysis was used to determine the relationship between various variables, namely independent variables consisting of 4 variables: health center readiness, maternal factors, birth factors, neonatal factors, and one dependent variable, namely birth

outcome (live birth or death). Since this study used nominal and ordinal data scales, multinomial logistic regression was used to examine the influential risk factors and the magnitude of their contribution to the newborn's condition. We ran the model using the stepwise method and odds ratio (OR) as the regression coefficient with a 95% confidence interval. All tests were conducted using the computer software JASP (Version 0.16.1)

Results and Discussion

Results

Health Centre Readiness

The readiness of health centers in providing neonatal healthcare was assessed based on several aspects, including human resource readiness (presence of a birth attendant team and regular case simulations at the health center), availability of essential health equipment for neonatal emergencies, referral facility readiness (availability of a driver and ambulance 24 hours a day), and managerial readiness (completeness of Standard Operating Procedures and regular supervision). The results of direct observation using a checklist are presented in Table 1.

Table 1. Aspects of Health Centre Readiness in Providing Neonatal Healthcare

Aspects of Health Centre Readiness	Good	Fair	Deficient	Total
Human resource readiness	19	44	37	100
Availability of essential health equipment	25	0	75	100
Referral facility readiness	34	0	66	100
Managerial readiness	69	31	0	100

Managerial aspects are the strongest, with no deficiencies identified. However, the completeness of medical equipment and referral facilities is still lacking in over 60% of cases. The human resource aspect mostly falls into the fair category, only good in 19% of cases, and 37% of cases categorized as deficient, which is related to the unavailability of regular case simulation at health centers.

Maternal Factors

Table 2 described maternal factors in this study, as follows: maternal age, nutritional status, parity, birth spacing, history of hypertension in previous pregnancy, anemia, and frequency of antenatal care visits.

Table 2. Maternal Factors

Maternal Factors	n	%
Total	100	100.00
Maternal Age		
< 21 years	8	
21 – 35 years	79	

Maternal Factors	n	%
>35 years	13	
Nutritional Status		
Good	34	
Poor	66	
Parity		
primary	37	
2-4	53	
>4	10	
Birth spacing		
<2 years	7	
>2 years	56	
Primi	37	
Anemia		
Anemia	5	
No anemia	95	
Frequency of ANC visit		
<4x	10	
4 -5 x	53	
>=6x	37	

Based on the table, most respondents have a low pregnancy risk. Here's a breakdown: 79% of respondents are between 21-35 years old, 53% have had 2-4 pregnancies with a safe interval (2 years or more) in 56% of cases, and 95% are not anemic. The frequency of antenatal care (ANC) checks among respondents is mostly between 4-5 times (53%), with only 10% having less than 4 ANC visits and 37% having 6 or more ANC visits. However, 66% of respondents have poor nutritional status, categorized as underweight (BMI <18.5), overweight (BMI 25-29.9), or obese (BMI >30).

Birth Factors

In this study, the birth factors examined include place of birth, mode of delivery, prolonged labor, and meconium-stained amniotic fluid, as described in Table 3. The majority of respondents (67%) delivered in hospitals, followed by primary healthcare facilities (30%) and home births (3%). Vaginal birth was the most common mode of delivery (68%), with cesarean section rates at 32%. Complications, such as meconium-stained amniotic fluid (12%) and prolonged labor (7%), were reported in less than 15% of cases.

Table 3. Birth Factors

Birth Factors	n	%
Total	100	100.00
Place of Birth		
Primary Health Centre	30	
Hospital	67	
Others	3	
Mode of Delivery		
Per vaginal	68	
Sectio Caesarea	32	
Prolonged Labour		
Yes	7	
No	93	
Meconium stained amniotic fluid.		
Yes	12	
No	88	

Neonatal Factors

The neonatal variables analyzed in this study were: gestational age, birth weight, asphyxia, and the provision of essential neonatal care, such as early initiation of breastfeeding, exclusive breastfeeding, and kangaroo mother care. As indicated in Table 4, a significant proportion of newborns (61%) were exclusively breastfed, while 49% were breastfed within the first hour of life. However, only 2% received kangaroo mother care (KMC). Given that KMC should be provided to preterm infants (less than 37 weeks) or low birth weight infants (less than 2500 grams), it is notable that in this study, not all preterm infants (9%) and low birth weight infants (18%) had received that essential care.

Table 4. Neonatal Factors

Neonatal Factors	n	%
Total	100	100
Gestational Age		
<37 weeks	9	
37 – 41 weeks	85	
>41 weeks	6	
Birth Weight		
<2500 g	18	

Neonatal Factors	n	%
2500 – 3000 g	40	
3000 – 3500 g	36	
>3500 g	6	
Presence of Asphyxia		
Yes	7	
No	93	
Early Initiation Breastfeeding		
Provided	49	
Not provided	51	
Exclusive Breastfeeding		
Provided	61	
Not provided	39	
Kangaroo Mother Care (KMC)		
Provided	2	
Not provided	98	

Early Neonatal Death

This study examined four risk factors that influenced early neonatal death, namely health center readiness, maternal factor, birth factor, and neonatal factor. Using logistic regression, we analyzed the effect of each predictor variable of every risk factor towards early neonatal death. The results are described in Table 5.

Table 5. Risk Factors Towards Early Neonatal Death

Risk Factors	p-value	Nagelkerke R^2
Health Centre Readiness	0.068	0.118
Maternal Factor	0.251	0.090
Birth Factor	0.315	0.065
Neonatal Factor	<0.001*	0.828

The results show that of the four types of risk factors, only neonatal factors had a significant contribution to early neonatal death, with a p-value <0.001. A Nagelkerke R^2 of 0.828 suggests that the model can explain approximately 82.8% of the variability in neonatal mortality that can be accounted for by the predictor variables included in the model, which are: gestational age, birth weight, asphyxia, exclusive breastfeeding, and KMC. We exclude early initiation of breastfeeding to correct multicollinearity with exclusive breastfeeding. While the overall model was found to be significant, none of the individual neonatal factors reached statistical significance at the 0.05 level based on Wald tests. This discrepancy might be attributable to factors such as interaction effects among the predictors, multicollinearity, overfitting, or insufficient sample size.

Although the other three types of risk factors were not statistically significant in predicting early neonatal death on their own, two predictor variables reached the level of significance <0.05 using the Wald test. Those predictor variables were: health equipment (p-value = 0.023), and ANC (p-value = 0.042). There is a significant negative correlation between the completeness of health equipment in community health centers and the risk of early neonatal mortality. Each unit increase in the completeness of health equipment is associated with a 28.8% decrease in the risk of early neonatal mortality (Odds Ratio of 0.288). A coefficient estimate of -1.244 indicates that the addition of one type of maternal and neonatal emergency equipment or medication significantly reduces the risk of early neonatal mortality by 1,2 times. The Wald test revealed that antenatal care (ANC) visits had a significant impact on early neonatal mortality with an odds ratio (OR) of 0.468. This indicates that a higher frequency of ANC visits is associated with a 46.8% reduction in the risk of neonatal death.

Risk Factors of Early Neonatal Mortality

We used logistic regression to identify the main factors affecting the risk of early infant death. Overall, birth-related factors didn't significantly influence the outcome, so they were removed from the model. Among maternal factors, only the number of antenatal care (ANC) visits was significant. For health center readiness, the availability of medical equipment was significant. Neonatal factors were significant overall, but only birth weight was included in the final model as its p-value was close to the significance threshold (p=0.087). Table 4.6 shows that 31.2% of the risk of early neonatal death was explained by the frequency of ANC, the completeness of medical equipment, and birth weight (p<0.001; Nagelkerke R2=0.312).

Table 6. Early Neonatal Mortality

Model	Deviance	AIC	BIC	df	ΔX^2	p	McFadden R^2	Nagelkerke R^2	Tjur R^2	Cox & Snell R^2
M_0	123.820	125.820	128.425	99			0.000		0.000	
M_1	98.815	106.815	117.236	96	25.005	< .001	0.202	0.312	0.238	0.221

Note. M_1 includes ANC, health equipment, and birth weight.

Coefficients

Model		Estimate	Standard Error	Odds Ratio	Wald Test z	Wald Statistic	df	p	95% Confidence interval Lower bound	Upper bound
M_0	(Intercept)	-0.800	0.216	0.449	-3.700	13.694	1	< .001	-1.224	-0.376
M_1	(Intercept)	0.943	1.216	2.568	0.775	0.601	1	0.438	-1.441	3.327
	ANC	-0.867	0.410	0.238	2.114	4.469	1	0.035	0.063	1.671
	ALKES	-0.285	0.291	0.752	-0.980	0.960	1	0.327	-0.856	0.286
	BBL	-1.208	0.346	0.299	-3.485	12.147	1	< .001	-1.887	-0.528

Note. Early Neonatal Death level '2' coded as class 1.

The Wald test indicated that birth weight ($p<0.001$) and frequency of antenatal care (ANC) ($p=0.035$) were significant risk factors for early neonatal mortality. Infants with low birth weight had a 30% higher risk of death compared to those with normal birth weight (Odds Ratio = 0.299). For every 1-gram increase in birth weight, the risk of neonatal death decreased by 1.2 times (coefficient estimate = -1.208). Similarly, with the frequency of ANC, the more frequently a mother had ANC, the risk of early neonatal death decreased by 24% (Odds Ratio = 0.238).

Discussion

Early neonatal death is a serious global health problem, specifically in developing countries. Various risk factors contribute to the high neonatal mortality rate. Analysis of these risk factors is crucial in designing effective interventions to reduce neonatal mortality. This study examined risk factors associated with early neonatal mortality in a rural setting and Primary Health Centre (PHC) in Eastern Indonesia. Factors that significantly contribute to early neonatal deaths were: frequency of antenatal care, completeness of health equipment at PHC, and birth weight of the newborn.

Antenatal Care (ANC) or prenatal care is a series of health examinations conducted during pregnancy. These examinations are crucial for monitoring the health of both the mother and fetus, as well as for early detection of any problems that could threaten the safety of both. Adequate and regular frequency of ANC during pregnancy has been proven to have a very strong correlation with a decrease in the risk of early neonatal death. Numerous studies have demonstrated that sufficient and regular ANC frequency can significantly reduce the risk of early neonatal death. Some studies show that mothers who have at least 4 ANC visits during pregnancy have a lower risk of neonatal death compared to mothers who have less than 4 ANC visits. However, the

newest ANC guideline published by the Indonesia Ministry of Health mentions a minimum of 6 ANC visits including a USG examination and 2 times visits should be provided by a physician (Kemenkes, 2020). Routine ANC visit is required for early detection of complications during pregnancy, prevention, and treatment of danger signs in the pregnancy, monitoring of fetal growth, and ensuring proper birth preparedness. Early detection of pre-eclampsia, gestational diabetes, or infection enables prompt treatment, thus preventing more serious conditions that can lead to neonatal death. USG examination could measure uterine fundus height and discover abnormalities, proper intervention can be provided if needed. Less ANC visits might hinder the danger signs during the pregnancy and increase the risk of fetal or neonatal deaths (Titaley et al., 2008) (Abdullah et al., 2016).

While the frequency of antenatal care (ANC) visits is very important, other factors can also affect the risk of early infant death, including the quality of ANC Services: It's not just how often a woman visits for ANC, but also the quality of care she receives. Good quality ANC includes a thorough physical exam, laboratory tests, counseling, and vaccinations. Access to healthcare services is also an important part, especially in rural settings. Having healthcare facilities that are nearby and affordable is essential for women to attend ANC more often. Socioeconomic and cultural factors also play an important role, people with lower incomes often have limited access to PHC, including ANC, meanwhile, certain community customs and beliefs can also influence a woman's decision to seek ANC. Other studies indicated that poverty, less educated and less empowered women, might be associated with low ANC attendance and and early neonatal death. (Adedokun & Yaya, 2020; Ali et al., 2018; Simkhada et al., 2008; Yego et al., 2014).

Besides the frequency and quality of ANC, the timing of the visit is also considered an essential part of ANC, especially in detecting complications. (Kisuule et al., 2013). As stated in the ANC guideline of Indonesia MoH, the first ANC visit should be provided in trimester 1 and USG examination should be provided by a physician during that visit. Failure to comply with this timing could potentially lead to a higher risk of maternal and neonatal mortality if serious conditions remain undetected during the pregnancy. This study confirmed that the more frequent a mother had ANC visits, the risk of early neonatal death decreased by 24%. Most respondents in this study attended 4-5 ANC (53%), however, the timing of ANC was not investigated in this study.

Another significant predictor of early neonatal death was the weight of the newborn. Birth weight is a crucial indicator of a newborn baby's health. Babies born with low birth weight (LBW) have a significantly higher risk of early neonatal death compared to babies born with normal birth weight. This association could be attributed to immature organ systems, limited energy reserves, and birth complications. Low birth weight (LBW) babies generally have underdeveloped organ systems, especially the lungs, liver, and kidneys. This makes them more susceptible to infections, respiratory problems, and other health issues. LBW babies also have fewer fat reserves, making it harder for them to maintain their body temperature and giving them limited energy to fight infections. Lastly, LBW babies are often born prematurely or experience difficulties during birth,

which can lead to brain or other organ injuries that potentially lead to early neonatal death. This study found that LBW newborns had a 30% higher risk of death compared to those with normal birth weight. The risk of neonatal death could be reduced by 1.2 times for each 1-gram increasing birth weight. Thus, ensuring babies are born at normal weight is a very important strategy to decrease early neonatal death significantly.

Maternal death, early neonatal death, and stillbirth are closely linked, with nearly half of all maternal, stillbirth, and early neonatal deaths occurring within the critical 48-hour period from the onset of labor to birth. This underscores the need for an integrated intrapartum approach to save both the lives of mothers and babies. (Wang et al., 2014) (Sharrow et al., 2022) (Pathirana et al., 2016) (Engmann et al., 2020). Babies born with LBW and or without prematurity carry significant risks during or shortly after the delivery process, and timely intervention is required by doctors in an adequate health facility. However, the majority of Primary Health Centers (PHCs) in Eastern Indonesia are categorized as limited resource settings. There is a lack of health workers and lack of proper health equipment to provide basic emergency neonatal care, thus increasing the risk of early neonatal death for LBW newborns. This study also revealed that, in the observed PHC, the completeness of medical equipment and referral facilities is still lacking in over 60% of cases, and 37% of health workers lack of skills to provide emergency neonatal cases. Further analysis shows that a lack of essential health equipment in PHC could increase the risk of early neonatal death. Each unit increase in the completeness of health equipment is associated with a 28.8% decrease in the risk of early neonatal mortality.

The findings of this research are important for the Health Office and other related stakeholders, highlighting the areas for improvement. For example, strategies to reduce neonatal mortality due to low birth weight include: improving the quality of antenatal care through early detection of pregnancy complications and providing adequate nutrition to pregnant women, preventing infections during pregnancy by providing immunizations and timely treatment of infections., increasing access to adequate healthcare service, especially in a rural area, and increasing public awareness regarding the importance of maintaining the health of pregnant women and infants.

There are some limitations of this study. First, there was potential selection bias because only 6 PHCs in the districts, therefore it might not represent all births in the district, because mothers with predicted pregnancy complications might give birth in hospitals. Another potential limitation is that information in the patient records was not able to give more comprehensive knowledge of the mother and infant's surrounding condition that might lead to early neonatal death.

Conclusion

In conclusion, the most significant risk factors for early neonatal death were: birth weight, frequency of antenatal visits, and completeness of essential health equipment to provide emergency maternal neonatal care in PHC. Interventions that focus on preventing LBW babies and promoting the importance of complying with a minimum of 6 ANC visits, as well as ensuring PHC readiness in providing basic maternal and neonatal care, could help reduce early neonatal death. This study provides new findings that highlight the important role of the readiness of health center facilities in determining neonatal outcomes, which has been underpaid in rural contexts such as in NTT. Therefore, this study supports the need for policy changes that improve health infrastructure in remote areas to reduce neonatal mortality rates.

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