A population-based study of neonatal deaths in Indonesia based on the Indonesian demographic health survey: what determinants play an essential role?

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Abstract

Background

Neonatal mortality appears to be one of the most concerning problems to fulfill Sustainable Developmental Goals globally. Indonesia, as a developing country with uneven distribution of standardized health facilities over the archipelago, has been reported to be the country with the highest fatality cases of the newborn in Southeast Asia. To address this problem, we evaluate how substantive the socioeconomic spectrum and proximate determinants as a substantial predictor of the neonatal mortality rate in advance to maximize the health policies' quality in reducing the rate of newborn death.

Method

The analysis was conducted using the data source of the 2017 Indonesia Demographic Health Survey from 11.965 live-born infants born from singleton pregnancy in the year of 2017. By using a hierarchical approach and logistic regression, the multilevel analysis was carried out to assess the possible contributing factors including socioeconomic, household, and proximate factors to neonatal mortality.

Results

At socioeconomic determinants, the odds of newborn death was significantly higher for those who born from mothers with poor education level (OR = 1.72, p = 0.03), insufficient antenatal visits (OR = 3.98, p = 0.01), and not being involved to postnatal care (OR = 6.60, p = 0.01). Regarding community factors, the variable of traditional birth attendants was significantly higher for the odds of newborn death (OR = 2.06, p = 0.01) as well as the delivery in government public hospitals (OR = 1.89, p = 0.01). In terms of proximate determinants, the odds of newborn death found to be higher for male infants (OR = 1.43, p = 0.03) and low birth (< 2.5 kg) weight infants (OR = 4.15, p = 0.01). After the adjustment of these covariates, the newborn death were associated to mothers with insufficient antenatal care (OR = 2.58, p = 0.01), not participating in postnatal care (OR = 5.66, p = 0.01), assisted by traditional birth attendants (OR = 1.46, p = 0.03), and neonatal factors such as male gender (OR = 5.66, p = 0.01 and low birth weight (OR = 4.37, p = 0.01).

Conclusion

In reducing neonatal death, public health interventions should be targeted to individual and community-level factors of socioeconomic determinants. Improving the quality and coverage of perinatal health services such as the utilization of either antenatal care or postnatal care, the availability of trained birth attendants, and the optimization in public hospitals' services have a significant meaning for better infants' lives.

Background

Based on data reported by the World Health Organization, approximately 2.4 million children die within 1 month after birth worldwide. Approximately, the 47 % of million children died have been contributed by around 7000 cases of neonatal deaths (1)]. Most neonatal deaths occur within the first week of life and are linked to various aetiologies [(1, 2). Complications of preterm birth (35%) and intrapartum-related events (24%) are the leading causes of neonatal deaths, whereas infections (15%) and congenital defects (11%) play a lesser role (1, 2). Although the rate of neonatal deaths has decreased by 2.6 million since 1990, the rate of decline in mortality is still slower than in children younger than 5 years. With 28 deaths per 1000 live births, countries in Central Asia and sub-Saharan Africa have the highest rates of neonatal mortality in last decade (1–3).

Sustainable developmental goals were implemented to reduce mortality rate of newborns to at least 12 deaths per 1000 live births by 2030. However, in 2016, the rate of deaths in Southeast Asia was still 14 per 1000 live births (2, 3). Indonesia ranks seventh place globally in the neonatal death rate, with 64,000 fatality cases of newborns and a rate of 14 deaths per 1000 live births. Among all Southeast Asian countries, Indonesia also has the highest number of neonatal mortality cases (1). A decrease in child mortality could be realised by organising an expanded and effective intervention for preventable diseases. The quality of care around the childbirth period is associated with diseases and conditions conducive to neonatal deaths. Thus, health services and skilled personnel who perform cost-effective interventions proven to treat and prevent such diseases and illnesses must be afforded. The greatest proportion of vulnerable children comes from poorer areas and households. To attain successful consistency in pursuing sustainable developmental goal targets, international communities should take decisive roles to stop preventable newborn deaths (2, 3).

Indonesia has a large population. Before becoming a middle-income country, in the early 1970s, Indonesia was included among the poorest countries in the world because of its low life expectancy rates and literacy, as compared with current years (4). In this high-population country, health facilities are not distributed well in rural and isolated areas that contain uneducated and pauper communities (5). With regard to health insurance, Indonesia has implemented a national health insurance scheme for all citizens (6). Well educated households have better knowledge that enables them to use antenatal care services during the mothers' pregnancy and therefore secure immunisation for their children (7, 8). Indonesia is a large archipelago, comprising more than 17,000 islands, and disparities between various communities living in different areas present a challenge to the government in their goal of equalizing health service determinants over all regions, including infrastructure, service quality and skilled personnel (9–12).

In this study, we use demographic health survey data to evaluate to what extent the equity of various diversifying factors can predispose the population to trends in the neonatal mortality rate. Learning from a previous study that assessed the determinants of neonatal deaths as a representative of Indonesian births from 1997 to 2002, we examine the characteristics of the socioeconomic spectrum as a

substantial predictor of the neonatal mortality rate (13). This examination allows for an extended evaluation of inequality among communities in achieving the sustainable developmental goal of reducing the neonatal mortality rate.

Methods

Data sources

This population-based study aims to examine the individual and community determinants that affect neonatal mortality. We identified the 2017 data set of the Indonesia Demographic Health Survey (IDHS) retrieved from all of Indonesia, including 26 provinces, and recorded all cases of neonatal deaths that occurred in Indonesia between July and September 2017. We classified the IDHS samples received from every province into either urban or rural areas.

Data collection

A multistage stratified random sampling technique was performed to clarify the population census over 3 consecutive months to determine the census blocks, the primary sampling unit expressed in each level. Beginning from the stratification, we divided households into those residing on Javanese Island and those living on the other islands or parts of Indonesia. We obtained information from the IDHS in 2017 using a standard designed commonly for countries with a high prevalence of contraception, the Demographic and Health Survey Model Questionnaires (14), to frame three questionnaires, including the Household Questionnaire, the Women's Questionnaire for married women, and the Men's Questionnaire for married men. The questionnaire covered personal information on age, education, occupational status, mother's demographic characteristics (such as full obstetric histories and antenatal care-receiving history) and neonatal characteristics (including age, sex, birth weight and postnatal care history). We used two-stage probability sampling to collect samples from the Demographic Health Survey and obtained the data randomly. To classify samples into subgroups or homogeneous strata to minimise sampling error, we performed stratification of samples based on geographical site and urban/rural areas.

Conceptual framework

We conducted our analysis based on the study by Mosley and Chen, which applied a conceptual framework to evaluate child survival in developing countries (15). Using this framework, we subdivided the information from the IDHS data sets containing the determinants into socioeconomic and proximate determinants (Table 1). We defined all variables that can have a direct impact on neonatal death, including maternal- and neonatal-derived factors, as proximate determinants.

Study variables

In this study, the death of neonates (i.e. newborns who lived for 1 month after delivery) is the primary outcome. The neonatal mortality rate is defined as the number of newborn deaths per 1000 live births. Using a model of descriptive analysis, we used a binary variable with a coding system to describe the

outcome. We recorded information on socioeconomic determinants, including individual-, household- and community-level variables and proximate determinants linked to maternal and neonatal factors contributing to neonatal death. Table 1 presents further descriptions of the variables evaluated in this study.

Study design

The design of this study was cross-sectional. We performed a univariate analysis using a table of distribution frequency to measure the distribution of data and thereafter carried out bivariate and multivariate approaches to determine the variables' significance to the outcome.

Statistical analyses

To present the true distribution of the country, the distribution of the sample first needed to be weighted. The weighting process for the sample was based on the statistical guidelines of the DHS. We had to perform the weighting process first because some states or regions were over-represented and some were under-represented. This unweighted distribution does not represent the population accurately. The frequency tabulation was carried out to describe the data distribution among the variables analysed and therefore used to measure the prevalence of neonatal mortality. This was followed by contingency table analysis, to elucidate how those variables could affect the predicted outcome, without adjusting them with the other covariates. We measured the association between the determinants and the outcome using an odds ratio (OR), 95% confidence interval (CI) and p-value.

To investigate the spread of data in our analysis, we carried out frequency tabulations. We further analysed the significance of the effects of possible determinants on neonatal mortality using a cross-table in the Statistical Package for the Social Sciences (SPSS) software. According to the conceptual framework that elucidated a systematic relationship among the tested variables, we conducted multilevel logistic regression using such approaches. First, we analysed the impacts on neonatal mortality of the variables from the socioeconomic and proximate determinants entered in the first model. Using SPSS version 16, we analysed the data set with a chi-square model. The variables analysed were then defined as significant if $p > 0.05$. In the first model, the correlation between the determinants and outcome was presented by ORs and 95% CIs and therefore weighted to illustrate sampling probability.

Variables that demonstrated a significant association with the outcome remained eligible for the second model. Through the second model, we computed the significant variables from both socioeconomic and proximate determinants, to examine the significant effects of certain variables on the outcome, against other variables that may act as an adjustment. We used the SPSS program to perform statistical analyses using binomial logistic regression. From the second model, the findings were recorded by measuring the p-value and adjusted OR (95% CI) that was obtained by estimating how strong the variable analysed was, as compared with other covariates in deciding in the study outcome.

Results

We recruited 11,965 newborns from singleton pregnancies within 3 years of the survey. With regard to geography, 6076 (50.8%) were from rural areas and 5889 (49.2%) were from urban areas. West Java, which accounted for a total of 1187 cases (9.9%), was the area in Indonesia with the highest number of neonatal deaths over the 3 years. Based on the 3-year analysis shown in Table 2, there was 148 cases (1.2%) of neonatal deaths. Nevertheless, as shown in Table 3, and as compared with Javanese regions with lower percentages of neonatal deaths, West Papua had the highest number of neonatal deaths, 7 of 165 cases (4.2%). Not far behind, North Sulawesi reported 5 of 126 (1.70%) newborn deaths, which was the second highest throughout the years. Most cases of foetal deaths were among mothers with a lower educational status, including 3067 uneducated women (25.6%) and 6722 undergraduates (56.2%), as compared with 2176 graduates (18.2%). In terms of attitude towards pregnancy, 10,571 women (88.3%) were aware of their pregnancy and attended at least four routine antenatal visits. Two months after delivery, 8068 women (67.4%) had received sufficient postnatal care. From the total family populations, up to 11,666 couples (97.5%) were employed, whether as either a single-earner or dual earners, whereas the other 299 households (2.5%) did not have a regular job.

With regard to childbirth status, 9960 parents (83.0%) reported that their pregnancy was planned, and they embraced their child, whereas 1079 (9.0%) of the total population reported the childbirth as an unwanted event. In addition, 926 parents (7.7%) did not show affection to their child and were not content with their infant's birth. Furthermore, in terms of the categorisation of the families' wealth index, a large number of families did not make an adequate living, with 3217 (26.9%) families being destitute and 2839 (20.0%) families being poor. Following this, 2224 families (18.6%) were classified in the middle wealth category, with the remainder being above average in wealth.

As shown in Table 3, which presents community-level factors including perinatal care during the pregnancy period, 357 women had undergone prenatal care not given by healthcare professionals, midwives or physicians. During labour, most women (8540; 72.1%) were assisted by midwives, whereas 2197 (18.6%) were aided by physicians. However, the other 832 women (7.1%) did not receive proper medical assistance and thus sought help from traditional birth attendants (TBAs). Surprisingly, 228 (2.2%) deliveries had not been assisted by anyone. After the delivery process, 554 mothers (4.6%) reported not receiving appropriate medical attention for postnatal care. Delivery events occurred mostly at public hospitals (4042; 33.8%), followed by private hospitals (4822; 40.2%). Approximately 259 women (2.2%) could deliver their babies at *unit kesehatan berbasis masyarakat* (UKBM), a health facility pioneered by communities, and 2842 women (23.8%) reported labouring in their homes.

Further analyses to compare neonatal deaths and neonatal live births revealed remarkable findings that clarified the assessed determinants (Table 4). With regard to socioeconomic determinants, infants born to mothers with no education were at a significantly higher risk of death (OR [95% CI] = 1.72 [1.03 – 2.86], p = 0.03). On the contrary, there was an opposite trend for infants born to mothers who had graduated (OR [95% CI] = 0.65 [0.46 – 0.91], p = 0.01). Women's negative attitudes towards checking their conditions routinely through antenatal care altered the risk of neonatal death significantly (OR [95% CI] = 3.98 [2.81 – 5.61], p = 0.01), and the same negative response to postnatal care also had a greater effect on the risk

of neonatal death (OR [95% CI] = 6.60 [4.52 – 9.63], p = 0.01). Family empowerment to make a living was not significant among families in which mothers and/or fathers had an occupation (OR [95% CI] = 1.09 [0.49 – 2.95], p = 0.78). Moreover, neonatal death was affected significantly by the person in charge of assisting the delivery process. Neonatal mortality cases could be reduced by the attendance of midwives (OR [95% CI] = 0.50 [0.30 – 0.83], p = 0.01) and physicians (OR [95% CI] = 0.22 [0.12 – 0.39], p = 0.01). In contrast, TBA care increased the risk of neonatal death significantly (OR [95% CI] = 2.06 [1.47 – 2.89], p = 0.01). Delivery in a public hospital increased the risk of newborns' deaths (OR [95% CI] = 1.89 [1.28 – 2.79], p = 0.01). However, in this study, the proximate determinants linked to maternal factors did not contribute significantly to the number of newborn deaths. As compared with the group of survivors, newborns who were reported to be unviable within the 1-month period after birth were generally male (OR [95% CI] = 1.43 [1.03 – 2.00], p = 0.03) and weighed less than 2.5 kg (OR [95% CI] = 4.15 [3.07 – 6.65], p = 0.01). From the results of the regression analysis to determine the significance of variables as compared with other covariates in inducing the outcome, the most important factors in the occurrence of neonatal deaths were the lack of participation in antenatal care (OR [95% CI] = 2.58 [1.79 – 3.72], p = 0.01) and in postnatal care (OR [95% CI] = 5.66 [3.86 – 8.29], p = 0.001). After adjustment, the variables attendance by a TBA (OR [95% CI] = 1.51 [1.07 – 2.12], p = 0.01) was found to increase the odds of neonatal deaths significantly. Neonatal factors of proximate determinants, namely, male in gender (OR [95% CI] = 1.46 [1.04 – 2.05], p = 0.02) and low birth weight (OR [95% CI] = 4.37 [2.92 – 6.53], p = 0.01), had their OR increased after adjusting for covariate. Conversely, the variables of uneducated mother (OR [95% CI] = 1.46 [0.87 – 2.44], p = 0.15) and delivery at a public hospitals (OR [95% CI] = 1.01 [0.71 – 1.45],p = 0.93) were not significantly increasing the OR for neonatal deaths after adjustment. As shown in Table 5, the regions of Papua and West Papua had the lowest percentages of antenatal care and postnatal care utilisation. Maluku Island had the highest probability of delivery being assisted by a TBA.

Discussion

In this analysis of the IDHS data in 2014–2017, fewer than four antenatal visits throughout pregnancy and the absence of postnatal care services had the most significant effects on increasing the odds of neonatal mortality. This result is in line with a study carried out by Laksono, which demonstrated that women with sufficient antenatal care (more than four visits) were at a lower odds of witnessing their newborn's death (16). Our findings also support the results of the previous study using 2017 IDHS data, in which the authors found that attending more than four antenatal care visits during the pregnancy period had a protective effect on neonatal death. However, the study conducted by Masruroh et al. did not detect other significant factors that prevent a rise in the odds of neonatal mortality incidence (17). The use of antenatal care varies among regions in Indonesia, with a low coverage of antenatal care (fewer than four visits) observed in the Maluku and Papua regions (18). Antenatal care services were reported to be underserviced in rural areas outside the Java–Bali region, which consists of families with a low household wealth index and low maternal education level. The other associated factors reported were the distance between the mother's residence and the health facility and the lack of obstetric complications before delivery (8). Based on a report by Suharmiati et al., this low utilisation of antenatal care visits in

the remote and border islands with extreme topography was affected by the low availability of healthcare services and facilities, non-optimised health infrastructure and inappropriate reward for healthcare providers (19). Furthermore, in urban areas of Indonesia, the constraints of actualising efficient antenatal care services are made worse by several factors, including poor laboratory and management records during antenatal care services, inadequate monitoring documentation and the fact that less than 5% of women receive all the routine measurements, consisting of urine tests, blood screening tests, iron supplementation, tetanus vaccination and information on pregnancy complications (20). Meta-analyses conducted in African countries have also implied that the benefits of antenatal care visits facilitated by skilled providers can reduce the incidence of neonatal deaths (21, 22). Another meta-analysis that investigated the effect of antenatal care visits in various developing countries revealed that the risk of neonatal death could be reduced by adequate antenatal care visits (23). With regard to postnatal care, delivery facilities that supply postnatal care might attenuate the risks of neonatal mortality and therefore improve the lives of newborns (24, 25). A study conducted in Garut, Sukabumi and Ciamis found that women who attended antenatal and postnatal care services experienced financial difficulties related to the cost of health services or transportation, the distance to the nearest facilities and the lack of awareness, as indicated by the need to use the services only if obstetric complications had already occurred (26). Based on a report from Titaley, the non-participant group of mothers in postnatal care services was related mostly to the low household wealth index, lack of understanding of pregnancy complications and low education levels (27). Furthermore, similar to our finding that postnatal care plays a significant role in reducing the risk of neonatal deaths, a nationwide case–control study in India reported an increase in the odds of neonatal death among women undergoing childbirth in delivery facilities who did not attend a postnatal check-up (25). In general, this study supports the previous studies of the IDHS 2002–2003 that revealed the association between inadequate utilisation of perinatal health services, either antenatal care or postnatal care, and the increased odds of neonatal mortality. Clusters of deliveries that received assistance by TBAs had a significant reduction in the odds of neonatal death (13)].

Nevertheless, this study also revealed varying factors that induce neonatal deaths as perinatal outcomes. The delivery process facilitated by a TBA caused the odds to increase. The absence of education in mothers was found to increase the OR of neonatal deaths significantly. This finding suggests, in line with another report in Brazil, that a low level of maternal education has a significant effect on the increase in newborn death. In other words, low levels of education can induce a lack of discipline and adherence of women to a beneficial health curriculum (28). Analyses of the Indian National Family Health Survey in 1994 found that low education levels, regardless of age (i.e. adolescents or older women), increased the odds of neonatal death (29). In addition to the effect of low education levels of mothers, a study in Gaza, Palestine, reported that fathers who had an educational certificate at the highest level of secondary school was associated significantly with neonatal mortality. The difference between the groups with low and high educational levels (diploma or a university degree) was associated with the mothers' adherence to antenatal visits and to breastfeeding their infants, whereby most parents with a lower educational level did not meet the required criteria (more than four antenatal care visits and exclusive breastfeeding) (30).

Andriano et al. conducted a demographic study in Malawi to evaluate the effects of education system reform (i.e. free primary education for individuals during the 1990s) and found that education quality resulted in a lower probability of death in infants and children younger than 5 years (31). In general, these studies suggest that knowledge barriers between healthcare professionals and families, because of low educational levels, reflect the mothers' attitudes to modern health services (28–31). However, after adjustment, the OR was not significant as compared with other covariates.

Our demographic study found that childbirths assisted by a TBA increased the risk of neonatal death significantly. With regard to the person assisting the childbirth, Titaley et al. analysed the effects of trained delivery attendance and place of delivery on early neonatal deaths. The results of that study further support our analyses by elucidating that women living in rural areas and experiencing home delivery with appropriate assistance from skilled healthcare professionals had a significantly reduced chance of having their newborns die. In addition, delivering in a healthcare facility or in the home without the assistance of trained delivery attendants could increase the risk of neonatal death (32). In another study on the IDHS data sets conducted by Badriah et al., labour facilitated by a skilled birth attendant was correlated with a higher risk of labour complications, namely, prolonged labour and postpartum fever. Besides this, there were no differences in stillbirths or neonatal deaths between women assisted by trained birth attendants and those assisted by untrained attendants (33). The use of services provided by TBAs among pregnant women in Indonesia is still inevitable, because of the traditional beliefs and recommendations from families that convince women in achieving a satisfying pregnancy and perinatal care (34, 35). Proximity to institutional healthcare, transportation problems and low financing within the family units are major constraints to accessing sufficient healthcare services, including delivery assistance from TBAs (34, 36). Ironically, based on reports in Bangladesh, some communities did not access a health facility because no proper facility was available in their area or the care available was of poor quality. Thus, women who do not want to attend a healthcare facility to manage their pregnancy and who prefer untrained birth attendants may fail to recognise early the alarming signs of dangers in pregnancy (36). In Indonesia, traditional beliefs affect women's preference between midwives and TBAs and therefore influence their adherence to antenatal care visits in several rural areas. Based on trends among communities in Indonesia, women believe that pregnancy is a part of their ordinary life cycle and is not a complexity that can appear as a risk factor for comorbidities and complications. This trend then influences women to be more active in seeking appropriate health facilities, including sufficient antenatal care services and delivery assistance from TBAs (35).

Our study found that delivering in public hospitals could increase the odds of neonatal death, although it was not significant. A meta-analysis assessing the effect of delivery at healthcare facilities on neonatal deaths showed that delivering in a health facility was effective in reducing the odds of neonatal death, especially in low- to middle-income countries (37). Our finding is in line with Titaley's report, which elucidated higher odds of women experiencing the death of their neonates in public hospitals than in private hospitals (32). Based on a report in Ethiopia, the rate of neonatal deaths in public hospitals was influenced mostly by preterm birth, birth asphyxia and neonatal infection (38). In addition, Adams et al. suggested that a disparity exists between the ability to alleviate the burden of the neonatal mortality rate

in public hospitals and private hospitals, in which public hospitals demonstrated a higher rate of neonatal deaths. This disparity was probably affected by different clinical practices, obstetrician-led care models and congenital anomalies experienced by babies born in public hospitals (39). Occasionally, the number of neonates died outside of hospitals could be higher that than in hospitals because communities cannot recognize the various life-threatening conditions in young babies, namely, birth asphyxia, prematurity and birth injuries. However, this phenomenon led to the late detection and treatment of babies whose condition was commonly complicated. For instance, a few reports from countries in the Middle East and South Asia found that prematurity with complications and sepsis were the most frequent contributing factors causing neonatal deaths in the hospital setting (40–42).

Proximate determinants including male gender and birthweight < 2.5 kg also increased the odds of neonatal deaths. This finding is in line with previous demographic studies, which indicated that the risk of neonatal death was higher in male infants and newborns who were smaller in size (32, 43, 44). Mostly, the disadvantage of the rising number of male infant deaths was attributed to perinatal conditions in the decades before improvements in obstetric practices. However, the innate biological differences between both gender groups turned out to be more significant in developing the risk of male newborn deaths (45). Reports from other countries indicated various trends. Based on multilevel analyses carried out in Brazil to determine the factors associated with neonatal mortality, maternal characteristics were not associated with neonatal deaths. Instead, neonatal characteristics, including foetal congenital anomaly, low Apgar score at 1 minute and low birthweight, presented a significant association (46). In Ethiopia, a few regions including Tigray, Omhara and Benishangul Gumz showed a significant association with neonatal deaths as the study outcome. Maternal age < 18 years was significant to the study outcome, whereas in terms of neonatal aspects, male gender and being born in the winter or rainy season were correlated significantly with the outcome (47).

Study limitations

Despite the strength of this study, which is related to its capability of forming a nationwide representation based on a survey and multilevel analyses to clarify the association between tested determinants and the outcomes specifically, this survey did not cover data on maternal deaths or all variables specific to neonatal aspects, such as genetic and environmental factors. In terms of maternal aspects, other complications, including vaginal bleeding, fever and convulsions, were not specified to minimise data distribution.

Recommendations

As a result of the disparities in perinatal care services, including antenatal care and postnatal care utilisation over various regions in Indonesia, healthcare providers and policymakers must refer to the findings of the IDHS to make a decision to maximise the utilisation of such services. Healthcare providers should implement a few interventions, such as education targeting mothers regarding the importance of antenatal care programmes for their condition, composed of screening, detection, management and monitoring, because these interventions can be effective in increasing mothers' awareness and can

provide integrated care starting from the pregnancy process to childbirth and the postnatal period. In the other words, mothers' awareness should not be limited to worrying about obstetric complications but should be focused on every second of the pregnancy period. To equalise the quality of antenatal care services in Indonesia, policymakers must establish a policy of implementing funding reallocation to improve the health infrastructure in regions with a low coverage of perinatal care services; otherwise, the standardised reward for healthcare workers should be guaranteed.

In addition, facilities and delivery attendants in public hospitals should be trained effectively to ensure that the delivery practice is safe. Traditional delivery attendants deemed to be unskilled must be encouraged to undergo training in perinatal self-care skills. In other words, to improve maternal and newborn care, public hospitals must be used efficiently by every pregnant woman who needs perinatal care and childbirth services, by establishing training for midwives and physicians working at such health facilities. In addition, TBAs must be empowered to work collaboratively with healthcare providers. An integrated system is needed that provides training for unskilled birth attendants, including midwives and TBAs, in every region of Indonesia that is still isolated from healthcare centres.

Conclusions

With regard to proximate determinants, notable factors associated with neonatal factors including male sex and low birth weight is likely to prompt neonatal deaths. Furthermore, a few socioeconomic determinants, namely, perinatal care services, either antenatal care or postnatal care, and TBA as birth attendants turned out to be the significant factors causing neonatal deaths. To reduce neonatal deaths, it is recommended that all pregnant women should be advised to attend the services offered by healthcare facilities, in the form of sufficient antenatal visits (more than four times throughout the pregnancy) and postnatal care. A better integrated system with contributions by healthcare providers and policymakers should ensure that every mother can increase their awareness and be facilitated during their attempts to obtain routine perinatal care services, including antenatal visits and postnatal care. In addition, unskilled birth attendants should receive adequate training to ensure that delivering babies will be safer.

Abbreviations

CI
confidence interval
IDHS
Indonesia Demographic Health Survey
OR
odds ratio
TBA
traditional birth attendant

Declarations

Ethics approval and consent to participate

We downloaded data from the DHS after presenting our project proposal and receiving permission from the DHS Program (132989.0.000). The original data sets of the IDHS were collected in accordance with international and national ethical guidelines. The datasets from 2017 IDHS have already obtained ethical clearance approved by the National Institute for Health Research and Development of the Indonesian Ministry of Health to be generally used for demographic study purposes.

The National Institute for Health Research and Development of the Indonesian Ministry of Health also gives the approval for informed consent stated by study participants to be waived for this study purpose. The utilization of 2017 IDHS data in this demographic study has already confirmed by ICF International through the website as follows: https://dhsprogram.com/data/new-user-registration.cfm after reporting and communicating the study purposes and the analysis method.

Consent for publication

Not applicable

Availability of data and materials

The dataset used during the current study are in the public domain and can be obtained from the DHS Program (http://dhsprogram.com/) or from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

MTAS brought the concept and designed the study, MTAS, MPM and MPM performed the data acquisition. MPM, MPM, and FE conducted the analysis and prepared the manuscript. MTAS, MTU, RE, DA, KDH, and AH provided the advice and validation for the final revision. All authors read and approved the manuscript.

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Tables

Table 1. Operational definition of assessed determinants

Socioeconomic Determinants	
Individual level variables	
Mother's educational status	1 = uneducated, 2 = undergraduate, 3 = graduate
Sufficient antenatal care visits (>4 visits)	0 = insufficient, 1 = sufficient
Earners in family	1 = single-earner fathers, 2 = single-earner mothers, 3 = dual earners, 4 = no earners
Childbirth status	1 = planned, 2 = unplanned, 3 = unwanted
Attending postnatal care 2 months after delivery	0 = no, 1 = yes
Household level determinants	
Household wealth index	1 = poorest, 2 = poorer, 3 = middle, 4 = richer, 5 = richest
Community-level factors	
Cluster type	0 = rural, 1= urban
Region	11= Aceh, 12 = North Sumatera, 13 = West Sumatera, 14 = Riau, 15 = Jambi, 16 = South Sumatera, 17 = Bengkulu, 18 = Lampung, 19 = Bangka Belitung, 21 = Riau, 31 = DKI Jakarta, 32 = West Java, 33 = Central Java, 34 = DKI Yogyakarta, 35 = East Java, 36 = Banten, 51 = Bali, 52 = West Nusa Tenggara, 53 = East Nusa Tenggara, 61 = West Kalimantan, 62 = Central Kalimantan, 63 = South Kalimantan, 64 = East Kalimantan, 65= North Kalimantan, 71 = North Sulawesi, 72 = Central Sulawesi, 73 = South Sulawesi, 74 = South-East Sulawesi, 75 = Gorontalo, 76 = West Sulawesi, 81 = Maluku Island, 82 = North Maluku, 91 = West Papua, 94 = Papua
Prenatal care assisted by healthcare professionals	0 = no, 1 = yes
Delivery assistance	0 = traditional, 1 = midwives, 2 = self-assisted, 4 = physician
Postnatal care assisted	0 = no, 1 = yes

by healthcare professionals	
Delivery place	1 = home, 2 = community-based care facility, 3 = public hospitals, 4 = private hospitals
Proximate determinants	
Maternal variables	
Delivery method	1 = Caesarean section, 0 = vaginal delivery
Delivery complications	1 = no complications, 2 = prolonged labour, 3 = other complications
Neonatal variables	
Infants' gender	0 = male, 1 = female
Infants' birthweight	0 = <2.5 kg, 1 = >2.5 kg

Table 2. Distribution frequency of data

VARIABLE	n	n (%)*
Socioeconomic Determinants		
Individual level variables		
Maternal educational status		
Uneducated	3067	25.6
Undergraduate	6722	56.2
Graduate	2176	18.2
Sufficient antenatal care visits, at least four times during pregnancy		
No	1394	11.7
Yes	10,571	88.3
Earners in family		
Mothers and/or fathers employed	11,666	97.5
Mothers and fathers unemployed	299	2.5
Childbirth status		
Planned childbirth	9960	83.3
Unplanned childbirth	1079	9.0
Unwanted childbirth	926	7.7
Attending postnatal care during 2 months after delivery		
No	3897	32.6
Yes	8068	67.4
Household level determinants		
Household wealth index		
Destitute	3217	26.9
Poor	2839	20.0
Middle	2224	18.6
Rich	2127	17.8
Wealthy	2008	16.8
Community-level factors		
Cluster type		
Urban	6076	50.8
Rural	5889	49.2
Region		
Java	8390	70.1
Non-Java	3575	29.9
Antenatal care assisted by healthcare professionals		
No	357	3.0
Yes	11,608	97.0
Delivery assistance		
Physicians	2197	18.6
Midwives	8540	72.1
TBA	832	7.1
None	228	2.2
Postnatal care assisted by healthcare professionals		
No	554	4.6

Yes	11,411	95.4
Delivery place		
Home	2842	23.8
Government public hospitals	4042	33.8
UKBM (community facilities)	259	2.2
Private healthcare facility	4822	40.2
Proximate Determinants		
Maternal level variables		
Delivery complications		
No complications	3559	29.7
Prolonged labour	927	7.8
Other complications	7479	62.5
Delivery method		
Vaginal delivery	9866	82.5
Caesarean section	2099	17.5
Neonatal level variables		
Infants' gender		
Female baby	5823	48.7
Male baby	6142	51.3
Infants' birth weight		
2500–4000 grams	11,172	93.4
<2500 grams	793	6.6
Neonatal deaths		
Yes	148	1.2
No	11,817	98.8

Table 3. Probability of neonatal death in every province in Indonesia

Region	N (total)	n (neonatal death) /	n/N (%)
North Sumatera	630	11	1.70%
West Sumatera	254	1	0.40%
Riau	287	1	0.30%
Jambi	166	4	2.40%
Aceh	630	6	1.00%
South Sumatera	288	4	1.40%
Bengkulu	194	1	0.50%
Lampung	302	5	1.70%
Bangka Belitung	177	4	2.30%
Riau	245	3	1.20%
DKI Jakarta	377	4	1.10%
West Java	1187	8	0.70%
Central Java	756	7	0.90%
DKI Yogyakarta	121	2	1.70%
East Java	745	8	1.10%
Banten	389	7	1.80%
Bali	155	2	1.30%
West Nusa Tenggara	345	3	0.90%
East Nusa Tenggara	674	9	1.30%
West Kalimantan	261	2	0.80%
Central Kalimantan	138	3	2.20%
South Kalimantan	192	4	2.10%
East Kalimantan	312	3	1.00%
North Kalimantan	177	3	1.70%
North Sulawesi	126	5	4.00%
Central Sulawesi	290	4	1.40%
South Sulawesi	393	2	0.50%
South-east Sulawesi	405	5	1.20%
Gorontalo	150	3	2.00%
West Sulawesi	414	5	1.20%
Maluku Island	544	4	0.70%
North Maluku	281	6	2.10%
West Papua	165	7	4.20%
Papua	195	2	1.00%

Table 4. Bivariate models of comparative study between groups of neonatal death and live birth

Determinant		Neonatal deaths	Neonatal live births	Neonatal deaths (weighted)	OR (95% CI)	p-Value	AOR (95% CI)	p-Value
Socioeconomic determinants								
Maternal education status	Uneducated	51	3016	1.7	1.72 (1.03 – 2.86)	**0.036****	1.46 (0.87 – 2.44)	0.153
	Undergraduate	80	6642	1.2	1.09 (0.78 – 1.51)	0.618		
	Graduate	17	2159	0.8	0.65 (0.46 – 0.91)	**0.016***		
Sufficient antenatal care visits during pregnancy	Yes	98	10,469	0.9	0.25 (0.17 – 0.35)	**0.001****		
	No	50	1344	3.6	3.98 (2.81 – 5.61)		2.81 (1.96 – 4.02)	**0.001****
Earners in family	Mothers and/or fathers employed	144	11,522	1.2	1.09 (0.49 – 2.95)	0.789		
	Mothers and fathers unemployed	4	295	1.3	0.92 (0.34 – 2.50)			
Childbirth status	Planned	110	9819	1.3	0.94 (0.59 – 1.51)	0.897		
	Unplanned	7	1072	0.6	1.77 (0.82 – 3.79)	0.167		
	Unwanted	14	912	1.5	0.70 (0.40 – 1.22)	0.191		
Attending postnatal care	Yes	16	7889	0.4	0.06 (0.04 – 0.11)	**0.001****		
	No	112	3785	2.9	6.60 (4.52 – 9.63)		5.72 (3.90 – 8.38)	**0.001****
Household's wealth index	Poorest	52	3165	1.6	0.67 (0.48 – 0.94)	0.223		
	Poor	25	2364	1	1.23 (0.79 – 1.89)	0.406		
	Middle	22	2202	1	1.31	0.288		

					(0.83 – 2.06)			
	Rich	30	2097	1.4	0.84 (0.56 – 1.27)	0.452		
	Richest	19	1989	0.9	1.37 (0.84 – 2.23)	0.226		
Cluster type	Rural area	77	5999	1.3	1.05 (0.76 – 1.45)	0.804		
	Urban area	71	5818	1.2	0.95 (0.68 – 1.31)			
Region	Java	36	3539	1.3	0.75 (0.51 – 1.09)	0.163		
	Non-Java	112	8278	1	1.33 (0.91 – 1.94)			
Prenatal care assisted by healthcare professionals	Yes	122	11,456	1.2	0.53 (0.25 – 1.09)	0.062		
	No	8	349	2.2	1.87 (0.91 – 3.86)			
Delivery assistance	Physicians	30	2197	1.3	0.22 (0.12 – 0.39)	**0.001***		
	Midwives	77	8540	1	0.50 (0.30 – 0.83)	**0.001***		
	Self-assisted	13	248	5.0	0.82 (0.54 – 1.23	0.381		
	TBA	18	832	2.1	2.06 (1.47 – 2.89)	**0.006****	1.51 (1.07 – 2.12)	**0.017****
Postnatal care assisted by healthcare professionals	Yes	13	7330	1.3	0.42 (0.13 – 1.33)	0.166		
	No	3	551	0.5	2.36 (0.75 – 7.44)			
Delivery place	Home	44	2798	1.5	0.62 (0.43 – 0.89)	0.012		
	Government public hospitals	52	3990	1.3	1.89	**0.001****	1.01	0.933

					(1.28 – 2.79)		(0.71 – 1.45)	
	UKBM (community facilities)	1	221	6.6	2.50 (0.34 – 17.97)	0.523		
	Private healthcare facility	35	4787	0.7	0.78 (0.55 – 1.11)	0.195		
Proximate determinants								
Delivery method	Caesarean section	24	2075	1.1	1.10 (0.70 – 1.70)	0.737		
	Vaginal delivery	107	9726	1.3	0.90 (0.58 – 1.41)			
Delivery complications	No complication	29	3552	0.9	1.48 (0.98 – 2.25)	0.069		
	Prolonged labour	10	865	2.6	0.95 (0.49 – 1.82)	0.865		
	Other complications	91	7388	1.2	0.72 (0.49 – 1.05)	0.102		
Infants' gender	Male	89	6053	1.4	1.43 (1.03 – 2.00)	**0.032***	1.46 (1.04 – 2.05)	0.027*
	Female	59	5764	1	0.69 (0.50 – 0.97)			
Infants' birth weight	2.5–4 kg	49	10,277	1	0.22 (0.15 – 0.32)	**0.001***		
	<2.5 kg	35	758	4.4	4.15 (3.07 – 6.65)		4.37 (2.92 – 6.53)	0.001*

* and bolded = $p < 0.05$ and considered significant

Table 5. Utilisation of perinatal care services by province in Indonesia

Region	n mothers who underwent antenatal care visits <4 x (%)	n mothers who were absent at postnatal care (%)	n mothers facilitated by TBAs	n mothers delivered babies in public hospitals
North Sumatera	137 (21.7)	213 (33.8)	30 (3.5)	104 (16.5)
West Sumatera	18 (7.1)	37 (14.6)	5 (0.6)	93 (36.6)
Riau	54 (18.8)	142 (49.5)	20 (2.4)	32 (11.1)
Jambi	19 (11.4)	34 (20.5)	17 (2.0)	32 (19.3)
Aceh	109 (17.3)	370 (58.7)	27 (3.2)	254 (40.3)
South Sumatera	37 (12.8)	121(42.0)	11 (1.3)	86 (29.9)
Bengkulu	18 (9.3)	60 (30.9)	13 (1.5)	71 (36.6)
Lampung	18 (6.0)	45 (14.9)	20 (2.4)	64 (21.2)
Bangka Belitung	17 (9.6)	57 (32.2)	3 (0.4)	51 (28.8)
Riau	34 (13.9)	97 (39.6)	0 (0.0)	47 (19.2)
DKI Jakarta	9 (2.4)	132 (35.0)	1 (0.1)	127 (33.7)
West Java	73 (6.1)	403 (34.0)	96 (11.3)	245 (20.6)
Central Java	21 (2.8)	192 (25.4)	6 (0.7)	287 (38.0)
DKI Yogyakarta	3 (2.5)	9 (7.4)	0 (0.0)	34 (28.1)
East Java	49 (6.6)	119 (16.0)	21 (2.5)	201 (27.0)
Banten	43 (11.1)	120 (30.8)	60 (7.1)	77 (19.8)
Bali	4 (2.6)	20 (12.9)	1 (0.1)	52 (33.5)
West Nusa Tenggara	11 (3.2)	78 (22.6)	17 (2.0)	153 (44.3)
East Nusa Tenggara	82 (12.2)	303 (45.0)	100 (11.8)	435 (64.5)
West Kalimantan	30 (11.5)	143 (54.8)	28 (3.3)	80 (30.7)
Central Kalimantan	19 (13.8)	36 (26.1)	10 (1.2)	28 (20.3)
South Kalimantan	11 (5.7)	42 (21.9)	15 (1.8)	51 (26.6)
East Kalimantan	30 (9.6)	104 (33.3)	6 (0.7)	101 (32.4)
North Kalimantan	22 (12.4)	15 (8.5)	11 (1.3)	111 (62.7)
North Sulawesi	18 (14.3)	55 (43.7)	8 (0.9)	45 (35.7)
Central Sulawesi	43 (14.8)	85 (29.3)	30 (3.5)	123 (42.4)
South Sulawesi	43 (10.9)	128 (32.6)	23 (2.7)	208 (52.9)
South-east	54 (13.3)	81 (20.0)	34 (4.0)	158 (39.0)

Sulawesi				
Gorontalo	21 (14.0)	26 (17.3)	8 (0.9)	90 (60.0)
West Sulawesi	48 (11.6)	116 (28.0)	43 (5.1)	228 (55.1)
Maluku Island	143 (26.3)	238 (43.8)	115 (13.5)	138 (25.4)
North Maluku	55 (19.6)	96 (34.2)	47 (5.5)	80 (28.5)
West Papua	42 (25.5)	101 (61.2)	16 (1.9)	73 (44.2)
Papua	59	79 (40.5)	8 (0.9)	83 (42.6)