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Research article

Determinants of neonatal deaths in Indonesia: A national survey data analysis of 10,838 newborns

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ABSTRACT

Background: Neonatal mortality is one of the key impediments in achieving global sustainable development goals, especially in lower middle income countries (LMICs). As an LMIC with the highest reported neonatal mortality rate in Southeast Asia, Indonesia faces inequitable distribution of health facilities across the archipelago. Therefore, in this paper, we aim to evaluate the determinants of neonatal mortality rate in Indonesia to search for better strategies to overcome this problem.

Methods: We conducted an analysis of the 2017 Indonesia Demographic Health Survey dataset of 10,838 live-born infants born from singleton pregnancies in 2017. Using a hierarchical approach, multivariate analysis was conducted to identify potential factors (including socioeconomic, household, and proximate determinants) that contributed to neonatal mortality.

Results: The lack of participation in postnatal care [odds ratio (OR) = 20.394, p = 0.01)] and delivery complications other than prolonged labour (OR = 2.072, p = 0.02) were the maternal factors that significantly associated with increased risk of neonatal death. Regarding neonatal factors, low-birth-weight infants appeared to be more vulnerable to neonatal death (OR = 12.489, p = 0.01).

Conclusion: Low participation in postnatal care, development of labour complications, and low birth weight were associated with higher neonatal mortality. It implies that in a limited resource and geographically challenging country such as Indonesia, improving the quality and optimizing services of public hospitals with equitable distribution of quality health care services in all regions should be prioritized in the efforts of reducing neonatal mortality rate.

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1. Background

According to the World Health Organization, an estimated 2.4 million children die within 1 month after birth worldwide in 2019. Around 47% of this number was contributed by 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 such as preterm birth (35%) and intrapartum events (24%) are the leading causes of neonatal death, whereas infections (15%) and congenital defects (11%) play a lesser role [1–3]. Although the rate of neonatal deaths indicates a 2.6 million decrease since 1990, the rate of decline in mortality is still slower than that in the 0–5-year age group. With 28 deaths per 1000 live births, countries in Central Asia and sub-Saharan Africa had the highest neonatal mortality rates in the past decade [1,2,4]. The sustainable developmental goals envisage reduction in the neonatal mortality rate to at least 12 deaths per 1000 live births by 2030. However, in 2016, the rate of neonatal deaths in Southeast Asia was still 14 per 1000 live births [2,4]. In 2019, 60,000 neonatal deaths were reported in Indonesia, which corresponded to a neonatal mortality rate of 12.1 per 1000 live births [1,5]. In a recent study based on the Indonesia Demographic Health Survey (IDHS) dataset, variables such as birth size, delivery at public hospitals and delivery complications were significantly associated with increased odds of neonatal mortality. In addition, utilisation of perinatal care services (antenatal and postnatal care services) was found to significantly reduce neonatal mortality [6].

Implementation and scaling up of interventions against preventable conditions can aid in reducing neonatal mortality. Poor quality of perinatal care services is directly associated with diseases and conditions conducive to neonatal death. Thus, robust health services and availability of skilled personnel to implement cost-effective interventions for the treatment and prevention of such diseases is imperative. The greatest proportion of vulnerable children belong to resource-constrained areas and poor households. Therefore, concerted efforts by the international community to stop preventable neonatal deaths are required to attain consistency in pursuing the sustainable developmental goal targets [2,4].

As mentioned before, lower middle-income countries with their limited resources had more challenges to reduce neonatal mortality. The situation in Indonesia can be a really good representation to show the challenges faced by the LMICs. As a country which just recently became a middle-income country, Indonesia has a large population of vulnerable children and there is also problem of inequality health care service distribution caused by the geographical situation of Indonesia as an archipelago country [7]. Before its transition to a middle-income country, in the early 1970s, Indonesia was included among the poorest countries in the world, with low life expectancy and literacy rates [8]. The health facilities in Indonesia are not well distributed in rural and remote areas, which contain uneducated and poor communities [9]. With regard to health insurance, Indonesia has implemented a national health insurance scheme for all citizens [10]. Well-educated households have better knowledge and awareness, allowing them to utilise antenatal care services and, therefore, secure immunisation for their children [11,12]. A better understanding of the neonatal death determinants could aid Indonesia in reducing the neonatal mortality rate and achieving the neonatal death rate goal of 8 babies out of 1000 birth in 2030.

1.1. Study objectives

In this study, using demographic health survey data, we aimed to identify various determinant factors that can predispose to neonatal mortality in Indonesia. Learning from a previous study that assessed the determinants of neonatal deaths in a representative dataset of Indonesian births from 1997 to 2002, we examined a spectrum of health-related and socioeconomic factors that may predict neonatal mortality [13]. This examination allows for an extended evaluation of inequality among communities in achieving the sustainable developmental goal of reducing the neonatal mortality rate.

2. Methods

2.1. Data sources and ethical approval

This population-based study aimed to examine the individual and community determinants that affect neonatal mortality. We used the 2017 dataset of the IDHS retrieved from 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 each province into either urban or rural areas. The datasets were obtained from the online source of IDHS in 2017 using a standard format designed for Indonesia.

We downloaded data from the DHS after presenting our project proposal and receiving permission from the DHS Program (132989.0.000). The original datasets of the IDHS were collected in accordance with international and national ethical guidelines. The National Institute for Health Research and Development of the Indonesian Ministry of Health has already provided ethical approval for use of the 2017 IDHS datasets for demographic study purposes. The National Institute for Health Research and Development of the

Abbreviations

CI confidence interval

IDHSIndonesia Demographic Health Survey
OR odds ratio

Indonesian Ministry of Health has also approved the waiver of informed consent of study participants for this study. The utilisation of the 2017 IDHS datasets in this demographic study has already been confirmed by ICF International through the website https://dhsprogram.com after reporting and communicating the study purposes and the analysis method.

2.2. Study design and variables

We conducted a secondary data analysis based on the study by Mosley and Chen, which applied a conceptual framework to evaluate child survival in developing countries [3]. Using this framework, we subdivided the information from the IDHS data sets containing the determinants into socioeconomic and proximate determinants. We defined all variables that can have a direct impact on neonatal

Table 1
Characteristics of respondents.

VARIABLE	n	Percentage
Socioeconomic Determinants		
Maternal educational status		
Uneducated/elementary school	2516	23%
Junior/high school	6233	58%
University Graduates	2089	19%
Sufficient antenatal care visits, at least four times during pregnancy		
No	962	9%
Yes	9876	91%
Earners in family		
Mothers and/or fathers unemployed	270	2%
Mothers and fathers employed	10,568	98%
Childbirth status		
Planned childbirth	9044	83%
Unplanned childbirth	958	9%
Unwanted childbirth	836	8%
Attending postnatal care during 2 months after delivery		
No	3420	32%
Yes	7418	68%
Household wealth index		
Poorest	2485	23%
Poor	2196	2%
Middle	2127	2%
Rich	2060	19%
Richest	1970	18%
Cluster type		
Urban	5215	48%
Rural	5623	52%
Region		
Non-Java	7410	68%
Java	3428	32%
Antenatal care assisted by healthcare professionals		
No	171	2%
Yes	10,667	98%
Delivery assistance by healthcare professional		
No	521	5%
Yes	10,317	95%
Delivery place in healthcare facilities		
No	2003	18%
Yes	8835	82%
Proximate Determinants		
Delivery complications		
No complications	3220	3%
Prolonged labour	796	7%
Other complications	6822	63%
Delivery method		
Vaginal delivery	8792	81%
Caesarean section	2046	19%
Infants' gender		
Female baby	5296	49%
Male baby	5542	51%
Infants' birth weight		
2500–4000 g	10,070	93%
<2500 g	768	7%
Neonatal deaths		
No	10,755	99%
Yes	83	1%

death, including maternal- and neonatal-derived factors, as proximate determinants. Socioeconomic determinants consist of maternal educational status, sufficient antenatal care visits, earners in family, childbirth status, attending postnatal care, household wealth index, cluster type, region, antenatal care assistant, delivery assistant, delivery place, while proximate determinants consist of delivery complications, delivery method, infant's gender, and infant's birth weight. The neonatal mortality was the primary outcome of this study. The neonatal mortality rate is defined as the number of neonatal deaths per 1000 live birth.

2.3. Statistical analyses

Statistical analysis was performed using a logistic regression model. The analysis was conducted after considering the unit on 2017 IDHS datasets. The primary sampling unit in this DHS study was the 1970 census block of 2017 DHS, selected using the probability proportional to size method, with the household size based on the listing of the population survey conducted in 2010. The datasets

Table 2
Bivariate models of comparative study between groups of neonatal death and live birth.

Variables	Crude OR	95% CI	p-value	Adjusted OR	95% CI	p-value
Socioeconomic determinant						
Maternal education status						
Uneducated/elementary school	reference					
Junior/high school	0.647	0.353–1.188	0.160	0.686	0.341–1.379	0.290
University	0.698	0.298–1.632	0.407	0.699	0.262–1.866	0.474
Sufficient antenatal care visit during pregnancy						
No	reference					
Yes	0.439	0.225–0.856	0.016*	0.528	0.258–1.078	0.079
Earners in family						
Father and mother unemployed	reference					
Father and/or mother employed	0.913	0.214–3.905	0.902	1.361	0.225–8.212	0.737
Childbirth status						
Planned	reference					
Unplanned	0.225	0.060–0.843	0.027*	0.233	0.059–0.926	0.039*
Unwanted	1.262	0.594–2.681	0.544	1.065	0.463–2.449	0.883
Attending postnatal care						
No	reference					
Yes	0.049	0.022–0.109	0.000*	0.049	0.021–0.112	0.000*
Household's wealth index						
Poorest	reference					
Poor	0.828	0.381–1.799	0.634	1.181	0.533–2.615	0.682
Middle	0.931	0.410–2.115	0.864	1.436	0.599–3.443	0.418
Rich	1.250	0.607–2.572	0.545	2.059	0.844–5.023	0.112
Richest	0.763	0.334–1.742	0.520	1.385	0.474–4.048	0.551
Cluster type						
Rural area	reference					
Urban area	1.355	0.803–2.286	0.255	1.220	0.663–2.247	0.522
Region						
Non-Java	reference					
Java	0.526	0.298–0.931	0.027*	0.569	0.299–1.082	0.085
Prenatal care assisted by healthcare professional						
No	reference					
Yes	1.377	0.187–10.164	0.754	4.047	0.453–36.152	0.211
Delivery assistance by healthcare professional						
No	reference					
Yes	1.678	0.370–7.609	0.502	1.548	0.261–9.195	0.630
Delivery place in healthcare facilities						
No	reference					
Yes	1.181	0.602–2.316	0.629	0.998	0.465–2.142	0.996
Proximate determinant						
Delivery method						
Vaginal delivery	reference					
Caesarean section	1.433	0.800–2.568	0.227	1.373	0.701–2.691	0.355
Delivery complication						
No complication	reference					
Prolonged labour	0.712	0.215–2.360	0.579	0.603	0.168–2.163	0.437
Other complication	1.974	1.048–3.719	0.035*	2.103	1.096–4.037	0.025*
Infants' gender						
Female	reference					
Male	2.947	1.719–5.053	0.000*	3.253	1.836–5.765	0.000*
Infants' birth weight						
2.5–4 kg	reference					
<2.5 kg	12.201	7.233–20.583	0.000*	12.264	6.894–21.816	0.000*

OR: Odds Ratio; *$p < 0.05$.

were stratified according to the provinces and urban/rural classification. In every census block, 25–30 households were recorded. However, unequal probability was applied during sample acquisition to increase the sample size in certain areas. Obtaining a representative sample necessitates a weighing process that consists of household and gender group weighing. However, in our study, the weighing process was conducted using maternal variables. The criteria for including women in our study were age 15–49 years and history of childbirth during the period 2014–2017.

A logistic model was adopted for this study because of the binary nature of the dependent variable (neonatal death). In logistic analysis, odds ratios (Ors) for each independent variable need to be calculated. The measured OR demonstrated the log odds of neonatal death occurrence as an outcome of the changes in independent variables. Crude OR does not take into account the effect of other confounding variables, whereas adjusted OR accounts for the effect of other independent variables. Furthermore, the estimation method used was maximum likelihood. Multivariate analysis was performed using STATA software version 16.1 (StataCorp, College Station, TX, USA) with svy command. The aforementioned command had been integrated with logistic regression to accommodate statistical modelling of complex survey datasets such as DHS. Before executing svy command on the logistic model, the datasets should be adjusted with svyset command. The analyzed correlations between dependent and independent variables were then defined as significant if $p < 0.05$. In the first model, the correlation between the determinants and outcome was presented as Ors and 95% confidence intervals (CI).

3. Results

We recorded 10,838 newborns from singleton pregnancies. With regard to location, 5623 newborns (52%) were from rural areas and 5215 (48%) were from urban areas. Of these, 3428 (32%) newborns were born in Java island and the remaining were born in regions outside Java island. As shown in Table 1, 83 cases (0.7%) of neonatal death were recorded across Indonesia. Most cases of neonatal deaths were among mothers who had completed high school education (58%). In terms of antenatal care coverage, almost all women (91%) had a sufficient number of antenatal visits (at least four routine visits during pregnancy). Two months after delivery, 68% respondents had been participating in postnatal care. Up to 98% of the sampled households were employed (either single-earner or dual earner status). With regard to childbirth status, 10,002 parents (83%) reported that the pregnancy was planned/accepted, whereas the other 836 reported that it was unwanted. Furthermore, in terms of the categorisation of the wealth index of families, the number of families that were categorised as poor and poorest were much higher than those categorised as rich families. Table 2 presents the community-level factors, including perinatal care. Approximately 98% of the study population had undergone prenatal care assisted by healthcare professionals, including midwives or physicians. During labour, most women were assisted by healthcare professionals. However, approximately 5% of women did not receive appropriate medical assistance and thus sought help from other attendants. Childbirth events occurred mostly at public healthcare facilities (82%).

Multivariate analyses to identify potential correlates of neonatal death revealed some remarkable findings (Table 2). Several socioeconomic determinants, including maternal education status, number of earning members in the family, childbirth status, household wealth index, cluster type, delivery assistance and place of delivery were not significantly associated with neonatal death. However, lack of active participation in antenatal care visits (OR = 2.276, 95% CI = 1.168–4.435) and postnatal care 2 months after delivery (OR = 20.575, 95% CI = 9.159–46.219) were significant risk factors for neonatal death. Compared with that in Java island, the population of infants born outside Java island was at a significantly higher risk of neonatal death (OR = 1.90, 95% CI = 1.074–3.360). Male sex (OR = 2.947, 95% CI = 1.719–5.053) and birth weight <2500 g (OR = 12.201, 95% CI = 7.233–20.583) were associated with an increased risk of adverse neonatal outcomes. In term of maternal factors, complications other than prolonged labour (OR = 1.974, 95% CI = 1.048–3.719) were the only determinants that promoted neonatal death.

Furthermore, these socioeconomic determinants were still significantly associated with the outcome even after adjusting for potential confounding variables. After adjusting for confounding variables, lack of active participation in antenatal care was not significantly associated with the outcome; however, lack of participation in postnatal care was still associated with a higher risk of neonatal death (OR = 20.394, 95% CI = 8.936–46.542). Mothers with deliveries outside Java island showed a higher OR for neonatal death (OR = 1.701, 95% CI = 0.897–3.224), although the association was not significant after adjusting for other variables. Low-birthweight infants (OR = 12.264, 95% CI = 7.015–22.234) still showed the same association with the outcome after adjusting for other variables. In terms of maternal factors, various delivery complications also showed a significant association with adverse neonatal outcome (OR = 2.103, 95% CI = 1.082–3.970). Compared with all determinants, lack of participation in postnatal care and low birth weight showed the strongest association with neonatal death.

4. Discussion

In this study we reveal several factors that contribute to the risk of neonatal mortality. By assessing the risk of neonatal mortality using IDHS 2014–2017, we also provide the latest evidence of maternal health conditions in Indonesia. Our result showed that patients with sufficient antenatal care visits during pregnancy have a lower odds of neonatal mortality. These findings were consistent with a meta-analysis of studies conducted in African countries [14,15]. They showed the benefits of antenatal care provided by skilled providers in reducing neonatal mortality. A study of Nepal NHS data (2001–2016) regarding neonatal death in their country revealed the lack of antenatal care, especially regarding the antenatal tetanus vaccination program, as the most prominent contributor; other contributing factors were maternal illiteracy and young maternal age (<20 year old) at the time of delivery (13). DHS datasets study done in Ethiopia (2016) also found that lack of participation in antenatal care appeared to increase the neonatal mortality rate [16].

However, after adjustment by using the multivariate analysis, we found no significant correlation between adequate antenatal care

service and neonatal mortality. This could be explained by different preference of Indonesian women in choosing antenatal care service. For some women, traditional birth assistant or midwifey was preferred because of low cost and more accessible [17]. They also more convenient if sharing their problem with women [18]. However, for several conditions or high risk pregnancy, the antenatal care with obstetrician is more preferred [17,19,20].

Postnatal care may attenuate the risks of neonatal mortality after delivery and therefore help improve neonatal health [21,22]. Our study showed that adequate postnatal care service had strong correlation with lower neonatal mortality risk. Unfortunately, postnatal care utilisation in Indonesia is still low. Study conducted in Garut, Sukabumi, and Ciamis found that cost was a major barrier for women to engage in postnatal care [23]. The pregnant women also report that they only will go for postnatal care if there are any complications [23]. This is consistent with the study by Titaley et al. [24], that showed lack of participation in postnatal care services was related to low household wealth index, lack of understanding of pregnancy complications and low education levels. A study conducted in India and Cambodia also reported an increased odds of neonatal death among women who did not attend a postnatal check-up [25].

In our study, childbirths which occur in the Java region were associated with a lower risk of neonatal mortality. Since the Java region is the center of economy in Indonesia, the healthcare provider is more accessible, especially for pregnant women. The disparities among communities living in different areas present a challenge to the equitable distribution of health service determinants, including infrastructure, service quality and skilled personnel [26-29]. Underserviced healthcare in rural areas outside Java region also accompanied with low wealth index and low maternal education level. However, this results must interpret with caution, since the study in 2003–2004 still found the high mortality in pregnancy delivery in east java [24].

There is considerable variability in the use of antenatal care services among various regions in Indonesia, with a low coverage (fewer than four visits) observed in the Maluku and Papua regions [30]. The distance from health facility also lower the utilisation of antenatal care services [12]. A study by Suharmiati et al. showed the low utilisation of antenatal care services in the remote and border islands with extreme topography was attributable to the poor availability of healthcare services and facilities [31]. Furthermore, poor facility and quality of antenatal care services in urban areas are still a problem to improve the antenatal care in urban areas of Indonesia [32].

It was already predicted that complication can bring more harm to the mother and babies. Our study is consistent with prior studies which assess the IDHS data in the period 1994–2007 [6]. They showed a strong association between comorbidity and neonatal death. Another study using the 2003–2004 IDHS data also showed similar result [24]. Neonates with delivery complication is at higher risk of death [24].

Studies have explained the association of labor complications, including postpartum hemorrhage, postpartum infection, and prolonged rupture of membranes, with adverse neonatal outcomes. Maternal infections such as chorioamnionitis, which is possibly induced by premature rupture of membranes, may lead to a two-fold higher risk of preterm birth following perinatal or vertical transmission of infectious agents. At 23 weeks of gestation, bacterial colonization is estimated to be as high as 79% [33]. Conditions such as neonatal sepsis and congenital infection may occur due to acquisition of infection during vaginal delivery in parturients with cervical and vaginal infection [34,35]. In southeast Asia, neonatal infection was shown to contribute to more than 50% of all neonatal deaths [36]. Although pre-eclampsia is associated with preterm birth and may be related to fatal outcomes in newborns, the mechanism by which preeclampsia directly induces neonatal death is not completely understood [37,38].

In this study, we found that male neonates tend to have a higher probability to have poor outcomes. This finding is in line with the results of previous demographic studies, which showed a higher risk of neonatal death in male infants and newborns who were small in size [6,39,40]. In contrast to our study, female infants were at a higher risk of neonatal death in India [41]. The increasing number of male infant deaths was earlier attributed to poor perinatal conditions in the decades before improvements in obstetric practices. However, the innate biological differences between both sexes were later found to play a more significant role in conferring a higher risk of death among male infants [42].

As mentioned in several prior studies, low birth weight is one of the factors of neonatal mortality. A study of Brazilian governmental databases linear with our study which showed fetal determinants such as congenital anomalies and low birth weight were the primary factors associated with neonatal mortality as well as inadequate antenatal visits which had strong association with adverse neonatal outcomes [43]. Studies conducted in other countries have revealed various trends. Based on multivariate analyses conducted in Brazil, maternal characteristics showed no significant association with neonatal death. Instead, neonatal characteristics, including low birth weight, fetal congenital anomaly, and low Apgar score at 1 min, were significantly associated with neonatal death [43].

4.1. Study limitations

This study's strength lies on the utilization of a nationwide database which can better represent neonatal patients in Indonesia. We also conducted multivariate analysis to identify independent variables of neonatal mortality. However, several limitations exist in our study. We were unable to include other potentially contributing factors, including maternal complications and neonatal variables, such as genetic and environmental factors individually, since they are not provided in the database. In terms of maternal variables, other complications, including vaginal bleeding, fever and convulsions were incapable to be specified since the data were widely distributed.

4.2. Recommendations

Owing to the disparities in the utilisation of perinatal care services, including antenatal care and postnatal care services, among various regions in Indonesia, healthcare providers and policymakers must refer to the findings of the IDHS to plan interventions in

maximizing the utilisation of such services. Based on our findings, women's education about the importance of antenatal and postnatal care were fundamental to increase better maternal outcomes. Policymakers should also aim to ensure equitable distribution of quality antenatal care services throughout Indonesia. In addition, prioritizing to increase the utilisation of healthcare services must be carried out along subsequent with the improvement of healthcare facilities.

5. Conclusions

With regard to proximate determinants, notable factors associated with neonatal mortality included male sex and low birth weight. Policymakers should aim to reduce the incidence of low-birth-weight infants through prioritizing efficient perinatal and postnatal care. Furthermore, postnatal factors showed the most significant association with neonatal deaths. To reduce the incidences of neonatal death, all pregnant women should be advised to attend postnatal care. A better integrated system with contributions by healthcare providers and policymakers is required to improve the awareness of pregnant women and facilitate their access to routine perinatal care services, including antenatal and postnatal care.

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 datasets of the IDHS were collected in accordance with international and national ethical guidelines. The National Institute for Health Research and Development of the Indonesian Ministry of Health has already provided ethical approval for use of the 2017 IDHS datasets for demographic study purposes.

The National Institute for Health Research and Development of the Indonesian Ministry of Health has also approved the waiver of informed consent of study participants for this study. The utilisation of the 2017 IDHS datasets in this demographic study has already been confirmed by ICF International through the website 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. The dataset was also uploaded in Figshare: https://doi.org/10.6084/m9.figshare.19386998. Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

Competing interests

The authors declare that they have no competing interests.

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Not applicable.

Authors' contributions

Mahendra Tri Arif Sampurna: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Kartika Dharma Handayani, Martono Tri Utomo, Dina Angelika, Risa Etika, Agus Harianto, Risma Kerina Kaban, Rinawati Rohsiswatmo: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Muhammad Pradhika Mapindra, Muhammad Pradhiki Mahindra, Ferry Efendi, Visuddho, Putu Bagus Dharma Permana: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

All authors listed have significantly contributed to the development and the writing of this article.

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