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Asian Neonatal Network Collaboration (AsianNeo): a study protocol for international collaborative comparisons of health services and outcomes to improve quality of care for sick newborn infants in Asia – survey, cohort and quality improvement studies

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ABSTRACT

Introduction Reducing neonatal deaths in premature infants in low- and middle-income countries is key to reducing global neonatal mortality. International neonatal networks, along with patient registries of premature infants, have contributed to improving the quality of neonatal care; however, the involvement of low-to-middle-income countries was limited. This project aims to form an international collaboration among neonatal networks in Asia (AsianNeo), including low-, middle- and high-income countries (or regions). Specifically, it aims to determine outcomes in sick newborn infants, especially very low birth weight (VLBW) infants or very preterm infants, with a view to improving the quality of care for such infants.

Methods and analysis Currently, AsianNeo comprises nine neonatal networks from Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Sri Lanka, Taiwan and Thailand. AsianNeo will undertake the following four studies: (1) institutional questionnaire surveys investigating neonatal intensive care unit resources and the clinical management of sick newborn infants, with a focus on VLBW infants (nine countries/regions); (2) a retrospective cohort study to describe and compare the outcomes of VLBW infants among Asian countries and regions (four countries/regions); (3) a prospective cohort study to develop the AsianNeo registry of VLBW infants (six countries/regions); and (4) implementation and evaluation of educational and quality improvement projects in AsianNeo countries and regions (nine countries/regions).

Ethics and dissemination The study protocol was approved by the Research Ethics Board of the National Center for Child Health and Development, Tokyo, Japan (reference number 2020–244, 2022–156). The study findings will be disseminated through educational programmes, quality improvement activities, conference presentations and medical journal publications.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ One of the strengths of this study will be the participation of leading neonatologists or paediatricians from each country/region in this project as steering committee members, which will encourage the engagement of stakeholders from each country/region.

⇒ Another strength of this study will be the wide variations in neonatal intensive care unit (NICU) systems, resource availabilities, ethnicities and cultural backgrounds among participating countries/regions that will provide unique opportunities to assess how variations identified can affect clinical practices in NICUs and infant outcomes.

⇒ One of the limitations will be that not all NICUs in each country/region will participate in this project, and the proportion of participation varies among countries/regions.

⇒ All planned studies in this project will be observational studies and a potential risk of bias and confounding may limit the study findings.

INTRODUCTION

Reducing neonatal deaths is an urgent global health issue. The Sustainable Development Goals, adopted by the United Nations Sustainable Development Summit in 2015, aim to reduce neonatal mortality to as low as 12 per 1000 live births by 2030 and reduce the under-5 mortality rate to 25 per 1000 live births.[1] Neonatal mortality rates have decreased in the last few decades; however, the pace of reduction has been slower for under-5 mortality. Of all deaths under the age of 5 years in 2018, 47% were neonatal deaths.[2] Most neonatal deaths occur in low- and middle-income countries in Africa (neonatal mortality, 27 per 1000 live births), Eastern Mediterranean areas (26 per 1000 live births) and Southeast Asia (20 per 1000 live births).[2] The leading cause of neonatal death is premature birth, followed by asphyxia.[3] Therefore, the prevention of neonatal deaths in premature infants and birth asphyxia in low- and middle-income countries is key to reducing global neonatal mortality.

Over the last 30 years, various regional, national and international neonatal networks (collaborative groups of people and facilities dedicated to the care of newborn infants) accompanied with patient registries for very low birth weight (VLBW) or very preterm infants have been established, primarily in high-income countries.[4–6] Quality improvement with benchmarking within and between institutions and clinical research in these neonatal networks has contributed to a reduction in neonatal mortality and severe complications in fragile premature infants.[7 8] Furthermore, some neonatal networks in high-income countries have initiated international collaboration among neonatal networks, such as the International Network for Evaluation of Outcomes in Neonates (iNeo).[9–11] This international collaboration is useful in benchmarking infants' outcomes against other countries, understanding differences in clinical practice between countries and improving the quality of care for sick newborn infants through learning exchanges.[9 12] However, many low- and middle-income countries have not been successful in developing their own neonatal networks and patient registries, and international collaboration among them has been limited.[13] In Asia, only Japan participates in the iNeo. The potential barriers for many Asian countries (especially low- and middle-income countries) in joining such international collaborations include the lack of population-based patient registries, a lack of research funding and resources and limited incentives to collaborate with other countries.[13] The effectiveness of an international neonatal network collaboration that includes both low- and middle-income countries and high-income countries remains to be evaluated; however, such collaboration may provide a unique opportunity not only for low- and middle-income countries, but also for high-income countries to learn from each other. Newborn care in high-income countries may not always be better than that in low- and middle-income countries; therefore, the former can learn from the latter in some areas (eg, the promotion of breastfeeding and kangaroo mother care).[14–16]

In this context, the Asian Neonatal Network Collaboration (AsianNeo), comprising nine neonatal networks spanning low-, middle- and high-income countries or regions (Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Sri Lanka, Taiwan and Thailand), was established with the aim of providing an international platform for paediatricians or neonatologists, researchers and other healthcare providers.[17] Building on the framework provided by the AsianNeo, the present study aims to evaluate and compare perinatal and neonatal medical systems, clinical practices and outcomes concerning sick newborn infants, especially VLBW or very preterm infants, to improve the quality of care in sick newborn infants in AsianNeo countries/regions. For this purpose, in this study, we will perform four projects including[1] an institutional-level questionnaire survey (nine countries/regions),[2] a retrospective cohort study of VLBW infants (four countries/regions),[3] a prospective registry and cohort study of VLBW infants (six countries/regions) and[4] a quality improvement study (nine countries/regions).

METHODS AND ANALYSES

AsianNeo structure

AsianNeo is an international collaboration that includes national and regional neonatal networks in Asian countries. Nine neonatal networks already participate in AsianNeo from the following countries: Indonesia, Japan, Malaysia, the Philippines, Singapore, South Korea, Sri Lanka, Taiwan and Thailand (figure 1). Moving forward, AsianNeo will be open to additional member countries/regions, welcoming the participation of other countries and regions. New countries that are not currently members of the AsianNeo may apply for membership through the AsianNeo website (https://asian-neo.org/index.html), and on approval by all the steering committee members, may join the AsianNeo.[17] As shown in online supplemental table 1, there are wide variations in income levels, economic equality and baseline perinatal indexes (birth rates, preterm birth rates, neonatal mortalities, etc) among the participating countries/regions. The governance structure of AsianNeo is shown in online supplemental s-Figure 1. The AsianNeo steering committee consists of one or two representatives from each neonatal network (ie, voting members). Steering committee members comprise experienced neonatologists or paediatricians, who are leaders in the field of neonatology in each country/region. The steering committee holds monthly meetings (mostly online) to discuss collaboration activities. AsianNeo invites stakeholders both in and out of member countries/regions to provide advice on its activities. These stakeholders may include academic paediatric organisations, government organisations and funding agencies of member countries, regions and global organisations. The AsianNeo Bureau

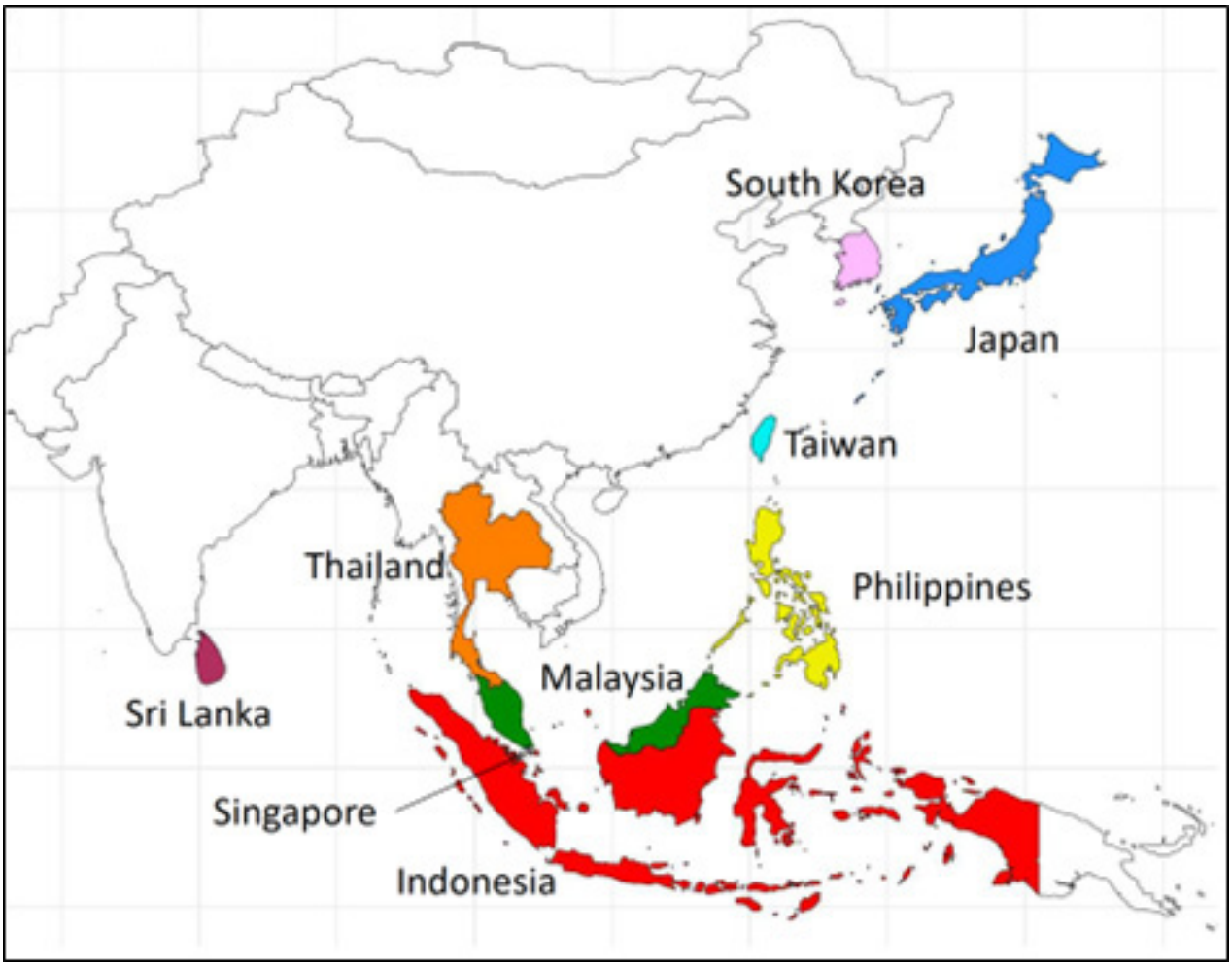

Figure 1 Asian Neonatal Network Collaboration countries or regions.

is housed at the National Center for Child Health and Development (NCCHD), Tokyo, Japan.

Characteristics of AsianNeo member countries or regions

In preparation for the AsianNeo project, we conducted a brief network-level survey to assess the healthcare systems, resources and clinical practices of each country/region. We asked one representative from each network (country/region) in AsianNeo, familiar with the overall picture of the systems and clinical practices of neonatal intensive care units (NICUs) in their country/region, to respond to a country-level or region-level questionnaire. In most networks, births of newborn infants occur at hospitals or clinics, except in Indonesia and the Philippines, where there are still a substantial number of home births (online supplemental table 2). All networks, including those in low- and middle-income countries, report resuscitating extremely preterm infants at <26 weeks of gestational age, although there are slight differences in the lowest gestational age (range, 22–26 weeks) and birth weight (range, <300–600 g) of very preterm infants who receive active resuscitation (limit of viability). Among the nine networks, five (Japan, Korea, Malaysia, Taiwan and Thailand) have nationwide patient registry databases of VLBW infants, where data and outcomes are prospectively collected. Population coverage of the databases ranges from 50% to close to 90%. The availability of medications and medical devices for monitoring or treatment varies among the networks (figure 2, online supplemental table 3). Despite some medical devices (eg, incubators, continuous positive airway pressure, pulse oximeters) being generally available in all nine networks, the availability of many other medications and devices is limited in some low- and middle-income countries.

Project 1: an institutional-level questionnaire survey

To understand differences in perinatal and neonatal healthcare systems, resources and clinical management of sick newborns in Asian countries/regions, we plan to conduct an international questionnaire survey at the institutional level concerning the human and physical resources of NICUs (eg, types of NICUs, care levels, patient volume, workforce, availability of devices and facilities) and clinical management of very preterm infants (eg, resuscitation, respiration, circulation, nutrition/feeding, neurology and follow-up systems). This questionnaire is written in English and is coded using an online SurveyMonkey tool.[18] Responses to the questionnaire will be written in English whenever possible. In non-English-speaking countries, where responding

		Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Sri Lanka	Taiwan	Thailand
Availability of treatments	Incubators	Mostly	Mostly	Mostly	Mostly	Often	Mostly	Mostly	Mostly	Mostly
	Surfactant	Sometimes	Mostly	Mostly	Mostly	Sometimes	Mostly	Mostly	Mostly	Often
	Mechanical ventilation	Sometimes	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly
	HFO	Rarely	Mostly	Mostly	Mostly	Rarely	Often	Often	Mostly	Sometimes
	CPAP	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly
	Peripherally inserted central catheter	Often [about 50%]	Mostly	Mostly	Mostly	Sometimes*	Mostly	Sometimes*	Mostly	Sometimes
	Total parenteral nutrition	Sometimes	Mostly	Mostly	Mostly	Often	Mostly	Never	Mostly	Often
	Probiotics	Sometimes	Mostly	Mostly	Rarely	Rarely	Sometimes	Rarely	Often	Rarely
	Donor milk	Rarely	Mostly	Rarely	Rarely	Sometimes	Mostly	Rarely	Mostly	Rarely
	Indomethacin	Never	Mostly	Never	Mostly	Sometimes	Mostly	Rarely	Often	Often
	Ibuprofen	Rarely	Mostly	Mostly	Mostly	Sometimes	Mostly	Rarely	Mostly	Sometimes
	Corticosteroids	Sometimes	Mostly	Mostly	Mostly	Often	Mostly	Mostly	Often	Often
	Caffeine	Sometimes	Mostly	Mostly	Often	Rarely	Mostly	Never	Rarely	Never
	Inhaled nitric oxide (iNO)	Rarely	Mostly	Mostly	Sometimes	Never	Often	Often	Mostly	Rarely
	Therapeutic hypothermia	Often [about 50%]	Mostly	Mostly	Mostly	Mostly*	Mostly	Often	Mostly	Sometimes
Availability of tests	Pulse oximeter (SpO2 monitor)	Often	Mostly [80-101%]	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly
	Electrocardiogram monitor	Often	Mostly	Mostly	Mostly	Sometimes	Mostly	Mostly	Mostly	Rarely
	Transcutaneous CO_2 monitor	Rarely	Mostly	Often	Rarely	Rarely	Mostly	Never	Sometimes	Rarely
	Brain ultrasound	Sometimes	Mostly	Mostly	Mostly	Mostly	Mostly	Sometimes	Mostly	Sometimes
	Echocardiography	Sometimes	Mostly	Mostly	Often	Often	Mostly	Sometimes	Mostly	Sometimes
	aEEG	Rarely	Often	Often	Sometimes	Rarely	Often	Often	Sometimes	Rarely

Figure 2 Availability of treatment and diagnostic tests. The information in the table is based on the personal understanding of the steering committee members regarding NICU care in their respective countries. The words of 'Mostly', 'Often', 'Sometimes', 'Rarely' and 'Never' indicate the proportions of 80–100%, 50–79%, 20–49%, 1–19%, and <1 %, respectively. *Available only in level-III NICUs. aEEG, amplitude-integrated electroencephalogram; CO_2, carbon dioxide; CPAP, continuous positive airway pressure; HFO, high-frequency oscillation; SpO2, oxygen saturation.

to the survey in English is challenging, respondents will complete the questionnaire in their native language and their responses will be translated into English. An invitation to complete the survey will be sent by the representative of each neonatal network to all NICUs participating in nine AsianNeo countries/regions. When the survey results are published, individual facility names will be anonymised and unidentifiable, excluding acknowledgements concerning participation in the survey. NICU resources and clinical management of preterm infants will be compared between countries/regions. Information obtained from responses to this survey will be essential to understanding the current situation of neonatal healthcare systems and resources and the clinical management of sick newborn infants in AsianNeo countries/regions.

Project 2: a retrospective cohort study of VLBW infants

To describe and compare outcomes in sick newborns in Asian countries/regions, a retrospective cohort study of VLBW infants will be conducted in four networks, namely, Japan, Malaysia, Taiwan and Thailand, using existing nationwide databases of VLBW infants. After these networks have approved the study protocol, the data of VLBW infants born in these five networks will be sent to the AsianNeo Bureau in NCCHD in a secure manner with password protection. Four other countries (Indonesia, the Philippines, Singapore and Sri Lanka) do not currently have a nationwide patient database; however, some of the NICUs in these networks may consider participating either through submitting their existing individual NICU database to a similar password-protected platform or retrospectively collecting data concerning VLBW infants in their NICUs.

Eligibility criteria of the database

All VLBW or very preterm infants (birth weight <1500 g or birth at <32 weeks of gestation) born in or admitted to hospitals participating in each neonatal network within 48 hours of birth from 2015 to 2023 (or for a part of this period) will be eligible for this study. Some networks have even more limited inclusion criteria; therefore, those networks are not required to provide data on infants not included in their registry. For example, the registry of the Taiwan Neonatal Network (TNN) includes infants born at ≤29 weeks gestational age or those with birth weights ranging from 401 g to 1500 g. Therefore, the TNN will not provide data on infants born at 30–31 weeks gestational age with a birth weight of ≥1500 g who are eligible for this study.

Database variables

The variables included in this cohort study are summarised in online supplemental s-Table 1. A common variable list was developed through evaluating the types and definitions of the variables used in the participating networks and harmonising the variable definitions among the networks.

Perinatal and neonatal baseline characteristics

Baseline characteristic data concerning the study infants will include perinatal variables (maternal age, hypertension during pregnancy, maternal antenatal steroid and

delivery mode (caesarean section or vaginal delivery)) and neonatal variables (gestational age at birth, birth weight, sex, Apgar score at 1 min and 5 min and outborn infants transferred from lower-level perinatal centres within 2 days after birth).

Primary and secondary outcomes

The primary outcome for the comparison between countries and regions will be all-cause mortality prior to NICU discharge. The main secondary outcomes will include the following five major neonatal morbidities: (1) severe intraventricular haemorrhage (IVH), defined as grade III or IV IVH according to Papile's classification[19]; (2) necrotising enterocolitis, defined as stage ≥2 according to Bell's criteria or requiring surgical intervention; (3) retinopathy of prematurity requiring treatment, including laser treatment and intraocular injections of anti-vascular endothelial growth factor agents; (4) chronic lung disease, defined as supplemental oxygen use or any respiratory support at 36 weeks post-menstrual age; and (5) late-onset sepsis, defined as culture-positive sepsis after 72 hours of birth.[20] Respiratory distress syndrome, air leak or pneumothorax, early onset sepsis with positive culture within 72 hours of birth, patent ductus arteriosus requiring pharmacological or surgical treatment, cystic periventricular leukomalacia, the number of days on mechanical ventilation and the number of days on continuous positive airway pressure will also be assessed.

Analyses

Descriptive analyses of baseline factors

The perinatal and neonatal baseline characteristics of the study infants will be summarised as counts and percentages for categorical variables, and as means and SDs or medians and IQRs for continuous variables. A χ^2 test for categorical variables and analysis of variance or Mood's median test for continuous variables will be used to compare the baseline characteristics among all networks.

Comparisons of outcomes between networks

Pairwise comparisons of the primary and secondary outcomes between specific networks will be performed using multivariable regression models adjusted for potential confounders (eg, gestational age at birth, small for gestational age or birth weight z-score, outborn status, sex and Apgar score at 1 min of birth). Generalised linear mixed models will be used to account for the clustering of infants within networks and units. Calculated adjusted ORs and 95% CIs for each network compared with a reference network (Japan) will be graphically displayed as forest plots. In addition, standardised outcome ratios for the primary and secondary outcomes will be calculated for each network using indirect standardisation. The standardised outcome ratios will be calculated from the observed outcome rates in each network divided by the expected rates estimated using multivariate regression models derived from the samples from all other networks. The standardised outcome ratios will be displayed graphically using funnel plots with 95% prediction intervals to compare between the networks. Complete case analysis will be used.

Analyses of the associations between institutional-level NICU resources or clinical practice and clinical outcomes for VLBW infants

Institutional-level information regarding NICU resources and clinical management of VLBW infants surveyed in Project 1 will be combined with patient-level data in this retrospective cohort study. The association between institutional-level NICU characteristics and the clinical outcomes of VLBW infants will then be assessed using generalised mixed-effect models with individual-level analyses, including institutions as a random effect.

Data security (data transfer/data centre)

De-identified patient data with unique AsianNeo facility codes assigned by each network will be stored in an Excel file in each network and locked with a password. The data file will be securely sent from each network to the AsianNeo Bureau at the NCCHD, Tokyo, Japan, via an online file transfer using Dropbox (Dropbox, California, USA). The password for the Excel data file will be sent from each network to the AsianNeo Bureau. The transferred data will be stored with password protection. Access to the data will be restricted, and persons who handle the data must obtain permission from the AsianNeo steering committee. A table linking the unique AsianNeo facility codes with facility names will be stored and managed by representatives from each country/region.

Sample size and others

The sample size of this study will be determined based on convenience sampling (data availability in each country/region). All statistical analyses were performed using R Statistical Software (V.4.3.1; R Core Team 2021) with a two-sided significance level of 0.05.[21]

Project 3: a prospective registry and cohort study of VLBW infants

To establish a prospective patient registry of sick newborn infants (eg, VLBW infants) among AsianNeo countries/regions through harmonising database variable definitions, we will develop an AsianNeo registry of VLBW infants using the same variable set and common variable definitions to perform a cohort study in six countries/regions (Indonesia, Japan, Malaysia, Philippines, Taiwan and Thailand). For this purpose, the definitions of the data variables among the participating networks have been harmonised in as far as possible. For networks that do not have their own VLBW infant registry (Indonesia, Philippines), we will develop the AsianNeo registry database using Research Electronic Data Capture (REDCap) tools hosted at the NCCHD that enable caregivers or research assistants to enter the information on VLBW infants online on their mobile phones or personal computers.[22 23] Automated data checkers will be in place in the REDCap tool. The training of data collectors in

each country/regions will be provided online by the AsianNeo bureau.

Eligibility criteria and database variables

All VLBW or very preterm infants (birth weight <1500 g or birth at <32 weeks of gestation) born in or admitted to hospitals participating in each neonatal network within 48 hours of birth from 2024 to 2026 will be eligible for this study. The sample size of this study will be determined based on convenience sampling (data availability in each country/region). The same database variables as the Project 2 (the same perinatal and neonatal baseline characteristics and the same primary and secondary outcomes) will be assessed (online supplemental s-Table 1).

Cause of death algorithm

Cause of death data comprise important information, with definitions or categorisations often varying among countries; therefore, we have developed a common algorithm to describe the cause of death of VLBW infants in the registry, with reference to previous studies (figure 3).[24–26] This algorithm has been approved by the AsianNeo steering committee. Each participating network will attempt to collect cause of death data using this common algorithm.

Analyses

The same analysis used in Project 2 will be used in Project 3. In addition, cause-specific mortality will be compared between the networks using generalised mixed-effect models. Furthermore, changes in clinical outcomes among VLBW infants between 2015 and 2020 and after 2020 will be evaluated for the four neonatal networks participating in Project 2.

Project 4: education programmes and quality improvement of care

Based on the information obtained in Projects 1–3, we will develop and implement educational programmes and quality improvement activities among all nine AsianNeo country/regions and evaluate the effectiveness of their implementations. We will hold online conferences to share the results of Projects 1–3 with participating NICUs. Based on information obtained from Projects 1–3, we will identify areas (NICU systems, clinical practices and outcomes) that need to be improved in each country, region or NICU and develop quality improvement projects to address challenges identified in these areas. Quality improvement projects will comprise the identification of such challenges, plan for practice changes, evaluation and monitoring of outcomes and practices and follow Plan-Do-Study-Act cycles.[27] Furthermore, this international quality improvement project will include regular meetings for mutual learning from other countries/regions and the dispatch of experts from high-performing NICUs to those requiring improvement. The effectiveness of the quality improvement projects will be assessed through comparing outcomes before and after the implementation of the quality improvement projects using data from the prospective VLBW infant registry developed in Project 3 (six participating countries/regions).

Patient and public involvement statement

There is no plan to involve patient/participants and public in designing or any phase of the study.

ETHICS AND DISSEMINATION

All methods were carried out in accordance with relevant guidelines and regulations. This study protocol was approved by the Research Ethics Board of the NCCHD, Tokyo, Japan (reference number 2020–244, 2022–156). In addition, the research ethics approvals were obtained in Japan, Taiwan, Thailand and Philippines for this study. In Indonesia and Malaysia, the research ethics approval for this study will be applied before using individual patent data. Because South Korea, Singapore and Sri Lanka participate only in the unit-level questionnaire survey, these countries do not require the research ethics approval other than the one that has been obtained in the NCCHD, Tokyo, Japan. Each network will obtain regulatory or research ethics approval or the equivalent from its local committee to send de-identified data from the network to the AsianNeo Bureau at the NCCHD. All networks signed data transfer agreements with the NCCHD before data transfer. No data identifiable at the patient level will be collected or transmitted to the AsianNeo bureau, and only aggregate data will be reported to the public. Written informed consent was obtained from each participant in Project 1 (questionnaire survey). For Projects 2–3 (retrospective and prospective cohort studies), an opt-out approach for informed consent was approved by the research ethics board of the NCCHD. This is because these studies will collect only de-identified data without any study interventions on patients. However, according to local or regional regulatory requirements or research ethics board requirements, some units or countries may still require written informed consent from each patient registered in the database.

To disseminate the study findings, we will develop educational programmes and quality improvement activities using Plan-Do-Study-Act cycles among AsianNeo countries/regions as in Project 4. In addition, the study findings will be presented in national or international medical conferences and published in peer-reviewed medical journals.

Data ownership and intellectual properties

The survey and patient data collected in AsianNeo will be used for various projects (eg, clinical research, quality improvement of care and policymaking) proposed by any individual or group (paediatricians, epidemiologists, researchers or policymakers) after approval from all AsianNeo steering committee members of the countries/regions that provide the data to the project. All neonatal

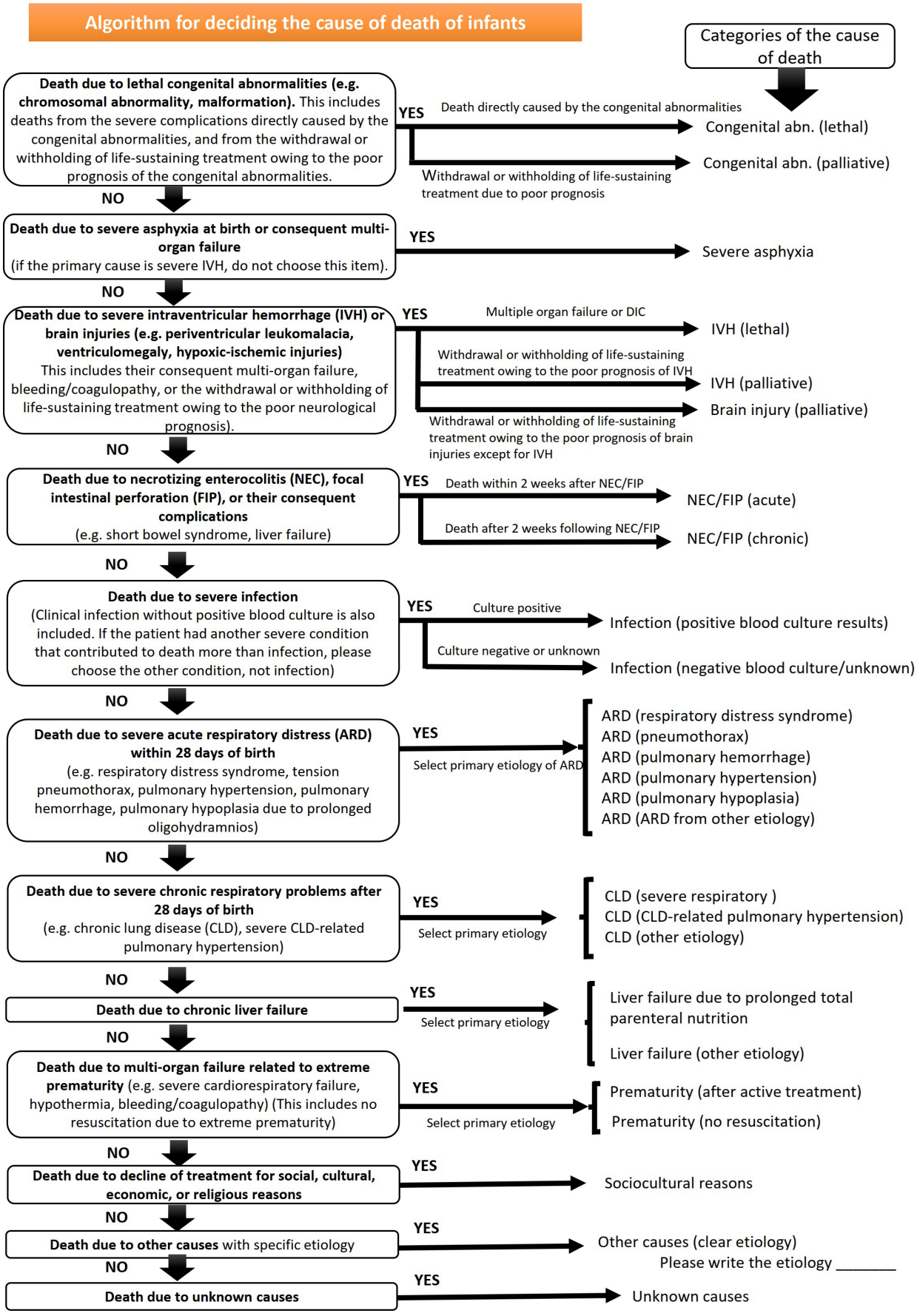

Figure 3 Cause of death algorithm. abn, abnormality; ARD, acute respiratory distress; CLD, chronic lung disease; FIP, focal intestinal perforation; IVH, intraventricular haemorrhage; NEC, necrotising enterocolitis.

networks have the right to decline participation in certain projects or decline the use of data collected in their countries/regions for such projects. A network could cease to participate in the study at any time.

The research programme will be administered by the AsianNeo Bureau, housed at the NCCHD, Tokyo, Japan. The policies and procedures for data transfer, application for data use, data analysis and publication of the results will be finalised in discussion with steering committee members, and agreements will be signed between each network and the AsianNeo Bureau at the NCCHD.

Strength and limitations

The strengths of this study will be as follows. First, leading neonatologists or paediatricians in the area of neonatology in each country/region will participate in this project as steering committee members. Involving such a nationwide network of healthcare providers in NICUs will encourage the engagement of stakeholders from each country/region. Second, compared with other international collaborations, such as the iNEO, which involves countries across the globe, this project fosters geographically close collaboration in Asia. This will facilitate having regular online meetings with minimal time differences and may help promote mutual visits to learn from each other's countries/regions. Third, wide variations in NICU systems, resource availabilities, ethnicities and cultural backgrounds among participating countries/regions will provide unique opportunities to assess how variations identified can affect clinical practices in NICUs and infant outcomes. Finally, the openness of this collaboration, which welcomes additional future participation from other countries/regions, will be helpful in expanding collaboration across Asia.

This study has some limitations. One major limitation is that not all NICUs in each country/region will participate in this project, and the proportion of participation varies among countries/regions. Across most networks, large tertiary or quaternary NICUs are more likely to participate in this project rather than small or secondary NICUs, which may limit the generalisability of our results. However, the potential success of the AsianNeo project may prompt non-participating NICUs to join in the future. Five networks already have nationwide patient registries for VLBW or very preterm infants; however, the population coverage in some registries is suboptimal (<80%), which may limit the generalisability of results derived from registry data. In addition, the lack of patient registries in the other four networks is likely to limit our retrospective evaluation at a patient level. We hope that Project 3 to address Aim 3 (a prospective registry of VLBW infants) will resolve this issue through developing prospective patient registries in these four networks. Finally, all planned studies in this project will be observational studies; therefore, a potential risk of bias and confounding may limit the findings. However, we hope that this international collaboration will evolve into a platform for promoting international multicentre clinical research in Asia.

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Correction notice This article has been corrected since it was published Online First. The collborator name (Eleanor DR Cuarte) was misspelled.

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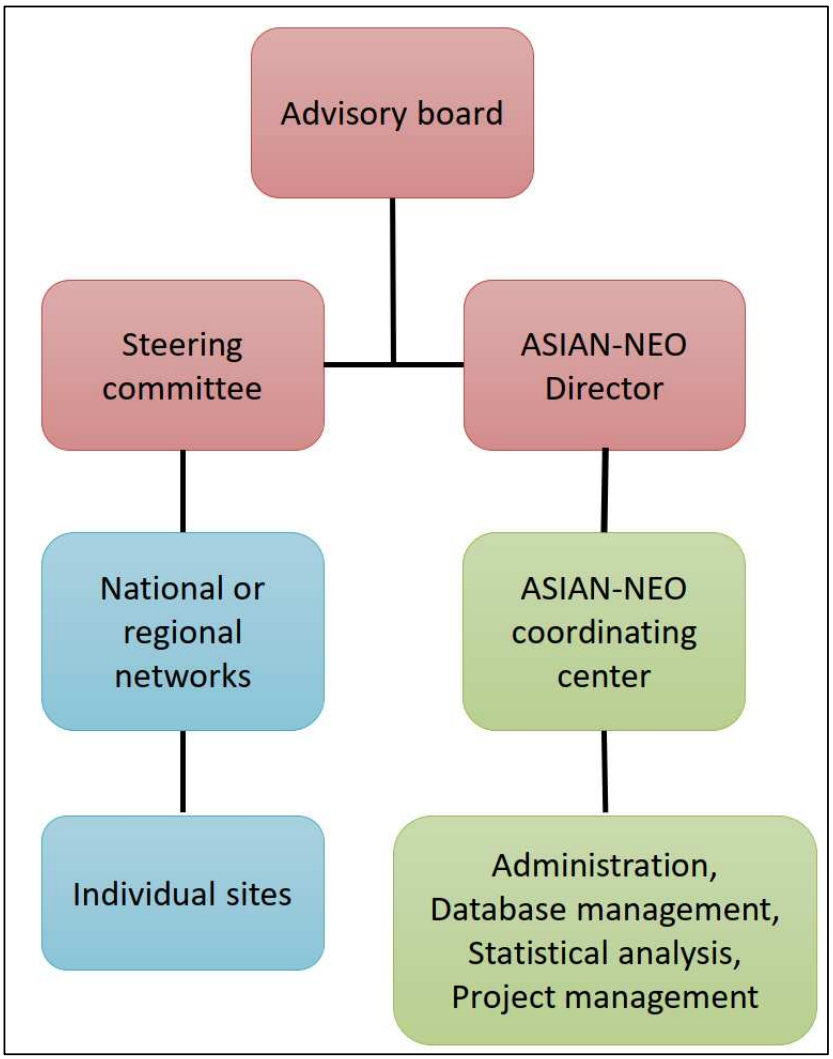
Supplemental material

Contents

s-Figure 1: AsianNeo governance structure



s-Table 1: Variable list of the AsianNeo registry

	Variable	Unit/answer choices	Definitions/ notes
Mother	maternal age	age	Maternal age at delivery
	gravida	number of times	Not including current pregnancy*
	parity	number of times	Not including current pregnancy*
Pregnancy	multiple fetus	number	Number of fetuses at birth
	plurality	monochorionic /dichorionic/unknown	If multiple pregnancy, specify mono- or multi-chorionic
	Pregnancy DM	Y/N/U (Yes/No/Unknown)	Including GDM Maternal diabetes mellitus or gestational diabetes mellitus
	chronic hypertension	Y/N/U	Maternal hypertension diagnosed before this pregnancy
	pregnancy induced hypertension	Y/N/U	Including pregnancy induced renal disease and hypertension, superimposed pregnancy induced hypertension, and eclampsia
	CAM clinical	Y/N/U	Diagnosed based on the clinical findings such as maternal fever, leukocytosis, and local pain
	CAM pathological	Y/N/U	Diagnosed with pathological examination
	maternal eclampsia	Y/N/U	Maternal eclampsia
	maternal abraptio placenta	Y/N/U	Maternal abraptio placenta
	Cord prolapse	Y/N/U	Cord prolapse
Delivery	PROM	Y/N/U	Defined as rupture of membranes before an onset of labor
	maternal antibiotics	Y/N/U	Maternal medication within the period mother is in labor, with the intent of preventing infection of the fetus. This includes the prophylactic use of parenteral penicillin or ampicillin.
	MgSO4	Y/N/U	Maternal medication (prior to delivery)
	maternal steroid (partial vs complete	Y/N/U	Defined as administration of any corticosteroids to accelerate fetal lung maturity

	course, if possible)		
	NRFS	Y/N/U	Defined as non-reassuring fetal status
	delivery mode	vaginal birth/ vaginal (vacuum extraction, forceps)/caesarean section	Mode of delivery
	cord-blood transfusion (delayed cord clamping/ cord milking)	Y/N/U	Defined as any method of cord blood transfusion at birth
Neonate	age of admission	day after birth (must be less than 28 days after birth)	Must be less than 28 days after birth
	admission temperature	℃	Within the first hour after admission
	sex	M/F/U	Male/Female/Ambiguous
	outborn	Y/N	If an infant was born outside a participating hospital, yes
	gestational age	week, day	Gestational age
	confirmation of gestational age with US	Y/N	If gestational age was determined by the obstetric examination with ultrasonography
	Apgar at 1 min	number	Apgar score
	Apgar at 5 min	number	Apgar score
	Apgar at 10 min	number	Apgar score
	oxygen use at birth	Y/N	Resuscitation with oxygen
	face mask ventilation at birth	Y/N	Face mask ventilation at birth
	epinephrine at birth	Y/N	Resuscitation with epinephrine at birth
	chest compresssion during initial resuscitation	Y/N	Resuscitation with cardiac compression at birth
	NCPAP at birth	Y/N	NCPAP use at birth

	endotracheal intubation at birth	Y/N	Resuscitation with an endotracheal tube
	birthweight	g	Body weight at birth
	body length at birth	cm	Body length at birth
	HC at birth	cm	Head circumference at birth. If not available, enter the value at the first examination
	NICU admission	Y/N	If an infant was cared in NICU, yes
	cord blood gas pH	number	Measured pH
	cord blood gas PCO2	number	PCO2 in Torr
	cord blood gas BE	number	mmol/L of base excess in negative value
Respiratory system	RDS	Y/N	Diagnosed by clinical and radiographic findings ARDS not included
	airleak	Y/N	Any type of air leak included
	pulmonary hemorrhage	Y/N	only massive hemorrhage included
	PPHN	Y/N	Defined as right-to-left shunt at foramen oval and/or ductus arteriosus without any anatomical malformation detected by cardiac echocardiography
	duration of O2 supply	days	Days of age when oxygen supplementation stopped If still on: 999
	duration of CPAP	days	CPAP and DPAP not included
	duration of MV	days	Days of CPAP and DPAP not included MV
	HFO	Y/N	Use of HFO for mechanical ventilation
	Surfactant administration	number of times	Pulmonary surfactant (Surfacten®) given during the acute phase of respiratory problems
	iNO use	days	Days of iNO
	CLD 28d of birth	Y/N	Supplemental oxygen with chest X-ray changes on 28th day after birth
	CLD systemic steroid	Y/N	Steroid given during the hospital stay for prevention or treatment of CLD
	CLD 36wk demand of O2	Y/N	Supplemental oxygen use at 36th week postmenstrual age
	CLD 36wk demand of	Y/N	Supplemental CPAP use at 36th week postmenstrual age

	respiratory support		
Circulatory system	PDA	Y/N	Diagnosed by both echocardiographic findings and clinical evidence of volume overload due to left-to-right shunt
	drug use for PDA	Y/N	Regardless of purpose of use (prophylactic use and therapeutic use), if use drug for PDA, choose yes
	PDA surgery	Y/N	Operation for PDA
Central nervous system	IVH	Y/N	Diagnosed with cranial echography Subependymal and intra choroid plexus hemorrhage included
	IVH grade	I/II/III/IV	According to the classification of Papile
	IVH hydrocephalus	Y/N	Only hydrocephalus treated shunt operation
	cPVL	Y/N	Only cystic PVL diagnosed by using either head ultrasound or cranial MRI scans, performed after two weeks of age or later
	Shunt or reservoir for hydrocephalus	Y/N	Use of shunt or reservoir for hydrocephalus
Infection	sepsis (late onset sepsis (after 72hours of birth)	Y/N (after 72hours of birth)	Culture proven septicemia or bacteremia
	early onset sepsis within 72hours after birth	Y/N (within 72hours after birth)	Culture proven septicemia or bacteremia
	fungal infection after day3	Y/N	Culture proven at any time during the stay in NICU
	meningitis	Y/N	Diagnosed based on CSF examination or clinical symptoms
Digestive system	NEC	Y/N	Defined according to Bell's classification stage II or greater
	perforation	Y/N	Diagnosed if free air was detected in the abdominal cavity by X-ray examination due to other than NEC
	surgery for NEC, suspected NEC, or bowel perforation	Y/N	Including laparotomy and drainage
	probiotics	Y/N	Use of probiotics

Retinopathy	ROP stage	Stage 1, Stage 2, Stage 3, Stage 4, Stage 5	Worst stage according to the International classification
	Tx (laser, cryotherapy)	Y/N	If infants were treated with either laser- or cryo-coagulation therapy, or both.
	anti VEGF	Y/N	Use of anti-VEGF antibody
Other complications	congenital anomaly	Y/N	Only major and fatal anomaly
	diagnosis of congenital anomaly	code (NRN operation manual)	Enter a code for major congenital anomaly Refer Table 2 in operational manual
Feeding	feeding at 120 ml/kg/day	days after birth	days to reach feeding at 120 ml/kg/day
	enteral feeding >100ml/kg/day	days after birth	days to reach feeding over 100 ml/kg/day
	discharge feeding status	Breast milk 100%/ Formula 100%/Mix/ No data (death)	Feeding status at discharge
Discharge	age of discharge	days after birth	Day of age at discharge
	death at discharge	Alive/Death	Death at discharge
	cause of death	ICD11	Refer to algorism of cause of death
	disposition to home	home/others	Home: discharge to home/ Others: discharge to the place excepting home
	place to transfer	hospital at birth/NICU in other hospital/pediatric department in the hospital/pediatric department in other hospital/facilities for the disabled/infant home	Place to hospital transfer
	HOT (discharge-oxygen)	Y/N	Use of home oxygen after discharge
	bodyweight at discharge	g	Body weight at discharge

	body length at discharge	cm	Body length at discharge
	HC at discharge	cm	Head circumference at discharge
	growth status at 36week PMA	SGA/AGA	According to Fenton reference, defined as Small-for-Gestational-Age (SGA) or Appropriate-for-Gestational-Age (AGA)

Supplementary Table 1: Baseline information of participating networks and countries

	Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Sri Lanka	Taiwan	Thailand
Gross domestic product (per capita, $USD; 2020) [a]	3870	39990	31947	10402	3299	58114	3729	25026[l] (2018)	7189
Gini index [b]	37.9 (2021)	32.9 (2013)	31.4 (2016)	41.1 (2015)	42.3 (2018)	NA	39.3 (2016)	34[m] (2020)	35.0 (2020)
Health expenditure (% of gross domestic product; 2019) [b]	2.9	10.75	8.14	3.84	4.17	4.42	3.66	6.1[n] (2018)	3.86
Mother's mean age at first birth [c]	22.4 (2017)	30.7 (2018)	32.2 (2019)	NA	23.5 (2017)	30.5 (2015)	25.6[f] (2016)	32[o] (2018)	23.3 (2009)
Maternal mortality ratio (per 100 000 live births; 2017) [d]	177	5	11	29	121	8	29[g] (2020)	13[m] (2020)	37
Birth rate, crude (per 1000 people; 2020) [b]	17.4	6.8	5.3	16.4	19.9	8.5	13.8[h] (2020)	7.7[p] (2018)	10.0
Preterm birth rate (per 100 live births; 2010) [a]	16.0	6.0	9.0	12.0	15.0	12.0	7.9[i] (2014)	9.3[q] (2010)	12.0
Low birth weight rate (%, 2015) [d]	10	9.5	5.8	11.3	20.1	9.6	16.1[j] (2018)	9.04[r] (2010)	10.5
Neonatal mortality rate (per 1000 live births; 2020) [d]	11.7	0.8	1.5	4.6	12.6	0.8	4[k] (2021)	2.4[s] (2019)	4.9
Infant mortality rate (per 1000 live births; 2020) [d]	19.5	1.8	2.6	7.4	20.9	1.8	6[k] (2021)	3.8[s] (2019)	7.4
Cause of death 1st (0-1 year; 2019) [e]	Prematurity	Congenital anomalies	Prematurity	Prematurity	Prematurity	Congenital anomalies	Congenital anomalies	Congenital anomalies [s]	Prematurity
Cause of death 2nd (0-1 year; 2019) [e]	Acute LRI	Prematurity	Congenital anomalies	Congenital anomalies	Acute LRI	Prematurity	Prematurity	Perinatal Respiratory disease[s]	Congenital anomalies
Cause of death 3rd (0-1 year; 2019) [e]	Congenital anomalies	Sudden infant death syndrome	Sudden infant death syndrome	Acute LRI	Congenital anomalies	Acute LRI	Hypoxic ischemic encephalopathy	Prematurity[s]	Acute LRI

Abbreviations: LRI: lower respiratory infection, NCD: non-communicable disease

a: UN Data (https://data.un.org/)

b: World Bank (http://data.worldbank.org/products/wdi)

c: Central Intelligence Agency, World Fact book (https://www.cia.gov/the-world-factbook/field/mothers-mean-age-at-first-birth/)

d: UNICEF Data (https://data.unicef.org/#)

e: World Health Organization (https://www.who.int/data)

f: Sri Lanka Demographic and Health Survey 2016. (http://www.statistics.gov.lk/Resource/en/Health/DemographicAndHealthSurveyReport-2016-Chapter4.pdf)
g: Family Health Bureau. Ministry of Health Sri Lanka
h: Department of Census and Statistics of Sri Lanka
(http://www.statistics.gov.lk/Population/StaticalInformation/VitalStatistics/CrudeBirthRatesCrudeDeathRatesProvinceDistrictSex2019-2022)
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j: Family Health Bureau. Annual Report of the Family Health Bureau, Ministry of Health Sri Lanka, 2019.
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l: CEIC Data (https://www.ceicdata.com/en/indicator/taiwan/gdp-per-capita)
m: Statistica.com (https://www.statista.com/markets/)
n: Taiwan Insight (https://taiwaninsight.org/2020/10/08/sustaining-taiwans-high-performing-national-health-insurance-a-call-to-invest-in-health/)
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p:Trends in birth rate provided by the National Development Council, Taiwan (https://pop-proj.ndc.gov.tw/chart.aspx?c=1&uid=61&pid=60)
q: Live Births and Still Births by Weeks of Pregnancy (https://www.hpa.gov.tw/File/download/themeParkId=542/000804/1.13b.pdf)
r: 2015 Statistics of Birth Reporting System by Health Promotion Administration, Ministry of Health and Welfare, Taiwan (Page 47) (https://www.hpa.gov.tw/Pages/ashx/File.ashx?FilePath=~/File/Attach/1266/File_2470.pdf)
s: Ministry of Health and Welfare, Taiwan (https://www.mohw.gov.tw/np-125-2.html)

Supplementary Table 2: Information of neonatal care and neonatal research networks

		Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Sri Lanka	Taiwan	Thailand
Birth places of newborn infants (term or preterm infants)	**Home**	16%	< 1%	0.5 %	_1_ %	9%	< 1%	< 1%	< 1%	3-5 %
	Birth center	29%	< 1%	1.1%	< 1%	NA	0%	0%	< 1%	0%
	Clinics	18-22%	45%	NA	NA	33%	0%	0%	28%	0%
	Hospitals	33%	54%	98.4%	95%	57%	> 99 %	> 99 %	72%	95-97 %
	Other places	NA	0%	0.03%	2%	< 1%	0%	0%	< 1%	0%
Neonatal resuscitation program (NRP)		Indonesian NRP	Japanese NRP	AAP's NRP	AAP's NRP	NRPhPlus	Singapore NRP	Sri Lanka NRP	AAP's NRP (modified)	AAP's NRP
The lowest GA or BW of infants resuscitated (Viability)	**The lowest GA**	25-26 weeks	22 weeks	22 weeks	24 weeks	24-25 weeks	23 weeks	23weeks	22-23 weeks	23 weeks
	The lowest BW	600 g	250-300 g	>300 g	500 g	400 g	400 g	400-500 g	300-400 g	500 g
Who pay the cost of NICU care of preterm infants?		Some patients use national insurance which do not cover all the needs. Others use their own money	National insurance & Government	Government	Government in public hospital. Individuals in private hospital	National insurance run by private company but supported by Government	Patients and government as co-pay system (Full subsidy for patients with very low income)	Government	Government	Government (Rare cases paid by their own parents)
Neonatal research networks (NRN) with registries of VLBW infants	**Existence of NRN**	NO	YES	YES	YES	NO	NO*	NO	Yes	YES
	Inclusion criteria of the registries	NA	GA < 32 weeks or BW ≤ 1500g	BW < 1500g	GA < 32 weeks or BW 500-1500g	NA	GA < 32 weeks or BW ≤ 1500g *	NA	GA ≤29 weeks or BW 401-1500g	GA <32 weeks or BW < 1500 g
	Population coverage of the registries	NA	50-60 %	87%	70-80 %	NA	>80 %*	NA	70%	No data

The information in the table is based on the personal understanding of the steering committee members regarding NICU care in their respective countries.

* There is no national registry of VLBW infants in Singapore. However, the three NICUs manage more than 80% of VLBW infants born in the country, and each of them have their own unit database of VLBW infants.

Abbreviations: AAP, American Academy of Pediatrics; BW, birth weight; GA, gestational age; NA, not applicable or unavailable; NICU, neonatal intensive care unit; NRN, neonatal research network; NRP, neonatal resuscitation program.

Supplementary Table 3: Availability of treatment and diagnostic tests

		Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Sri Lanka	Taiwan	Thailand
Availability of treatments	**Incubators**	Mostly	Mostly	Mostly	Mostly	Often	Mostly	Mostly	Mostly	Mostly
	Surfactant	Sometimes	Mostly	Mostly	Mostly	Sometimes	Mostly	Mostly	Mostly	Often
	Mechanical ventilation	Sometimes	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly
	HFO	Rarely	Mostly	Mostly	Mostly	Rarely	Often	Often	Mostly	Sometimes
	CPAP	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly
	Peripherally inserted central catheter	Often [about 50%]	Mostly	Mostly	Mostly	Sometimes*	Mostly	Sometimes*	Mostly	Sometimes
	Total parenteral nutrition	Sometimes	Mostly	Mostly	Mostly	Often	Mostly	Never	Mostly	Often
	Probiotics	Sometimes	Mostly	Mostly	Rarely	Rarely	Sometimes	Rarely	Often	Rarely
	Donor milk	Rarely	Mostly	Rarely	Rarely	Sometimes	Mostly	Rarely	Mostly	Rarely
	Indomethacin	Never	Mostly	Never	Mostly	Sometimes	Mostly	Rarely	Often	Often
	Ibuprofen	Rarely	Mostly	Mostly	Mostly	Sometimes	Mostly	Rarely	Mostly	Sometimes
	Corticosteroids	Sometimes	Mostly	Mostly	Mostly	Often	Mostly	Mostly	Often	Often
	Caffeine	Sometimes	Mostly	Mostly	Often	Rarely	Mostly	Never	Rarely	Never
	Inhaled nitric oxide (iNO)	Rarely	Mostly	Mostly	Sometimes	Never	Often	Often	Mostly	Rarely
	Therapeutic hypothermia	Often [about 50%]	Mostly	Mostly	Mostly	Mostly*	Mostly	Often	Mostly	Sometimes
Availability of tests	**Pulse oximeter (SpO2 monitor)**	Often	Mostly [80-101%]	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly	Mostly
	Electrocardiogram monitor	Often	Mostly	Mostly	Mostly	Sometimes	Mostly	Mostly	Mostly	Rarely
	Transcutaneous CO_2 monitor	Rarely	Mostly	Often	Rarely	Rarely	Mostly	Never	Sometimes	Rarely
	Brain ultrasound	Sometimes	Mostly	Mostly	Mostly	Mostly	Mostly	Sometimes	Mostly	Sometimes
	Echocardiography	Sometimes	Mostly	Mostly	Often	Often	Mostly	Sometimes	Mostly	Sometimes
	aEEG	Rarely	Often	Often	Sometimes	Rarely	Often	Often	Sometimes	Rarely

* Available only in level-III NICUs.

The information in the table is based on the personal understanding of the steering committee members regarding NICU care in their respective countries. The words of “Mostly”, “Often”, “Sometimes”, “Rarely”, and “Never” indicate the proportions of 80-100%, 50-79%, 20-49%, 1-19%, and <1 %, respectively.

Abbreviations: aEEG, amplitude-integrated electroencephalogram; CPAP, continuous positive airway pressure; CO_2, carbon dioxide; HFO, high-frequency oscillation; SpO2, oxygen saturation.