Perinatal and maternal mortalities in Java became of concern in the 1980s. Since some 90% of births took place at home, the Tanjungsari (TS) district of West Java was identified as a locality where community-based risk management strategy might reduce this health burden. In 1987, traditional birth attendants (TBA) were trained to identify risk factors for unfavourable birth outcomes. From January 1st 1988 to December 1989, some 4,000 pregnant women in TS were followed and assigned either a trained or untrained TBA. In the first year, early neonatal, and maternal mortality rates (MMR) (32.9 per 1000 and 170 per 100,000 deliveries respectively) were reduced, but not sustained in the second year. Nationally, MMR was 446 in 2009 and 126 in 2015. Although possible to improve health worker performance, and community engagement, the most likely explanation for benefit attrition is that people and material resources ‘downstream’ of the TBA services were inadequate. Three decades later, Indonesian neonatal and maternal mortality rates of 14 per 1000 and 126 per 100,000 live births in 2015 (globally 16.2 in 2009 and 216 in 2015) according to UNICEF, still demanded improvement, despite more hospital-based births. The original 1988 cohort of women, their children and grandchildren, can now be interrogated for medium to long term health outcomes of nutritional, such as birth weight and growth, and other risk factors. The evolving TS cohort health and nutrition intermediates and endpoints are instructive. Maternal and early life factors predict adult energy metabolism and cognitive function.

**Key Words:** Sundanese, intergenerational, fetal origins of disease, IUGR (intrauterine growth retardation), stature, energy metabolism, cognition

**MATERIL AND CHILD CONTRIBUTORS TO HEALTH IN INDONESIA**

The advancement of health, nutrition and well-being among Indonesians, while impressive over the period 1960-2017 for life expectancy and infant mortality (Figure 1), remains variable across the nation and problematic overall. By way of example and relevance to the Tanjungsari Cohort (TSC) study, West Java, is reviewed here. West Java is populated principally by those of Sundanese ethnicity, and relatively advantaged according to its vital statistical indices. The factors responsible merit scrutiny (Table 1). A key question is whether and how economic development can be accompanied by accessible, equitable and sustainable health advancement. UNDP (United Nations Development Program) criteria would indicate that multi-system integration is required, with dependence on community consensus about governance of the commons as proposed by Ostrom.5,6

To achieve ‘Health for All for Indonesians’, an appreciation of its ancient and recent history, its cultural diversity and societal structures is required. Indonesian independence was achieved after some 350 years of Dutch colonisation in 1945, but following a Japanese occupation (1942-1945) and in the face of the Indonesian revolution (1945-1949). In 1950, five years after independence, Indonesia’s health systems were in ruins. A public health initiative was set in train after 10 years of independence.

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with health regarded as key to nation building. There was a focus on infectious disease control and improvement of nutritional status along with major public health emergency programs.

The health programs paid attention to social factors as framed by Seno Sastroamidjojo, a leading social medicine exponent during the Soekarno era in Indonesia. For nation building, the socio-economic development and public health approach emphasized an equitable distribution and adequate intake of foods. This embraced all phases of an individual’s life including the prenatal, postnatal, childhood, adolescent, adulthood and older age groups. Conceptually, it had prescience for the Developmental Origins of Health and Disease (DOHaD) enunciated by David Barker in 1986. Sastroamidjojo was concerned about malnutrition. The high prevalence of oedema among Indonesian infants in the 1950s, according to Sastroamidjojo, was due to a shortage of food; a malnourished child mirrored the poor health of the economy. Sastroamidjojo referred to this as pembangunan or developmentalism.

Notwithstanding these early post-Independence policy directions, major public health problems continue to face Indonesians, despite increasing annual national health budgets and enduring efforts to promote health and prevent disease. Communicable disease like tuberculosis is still rampant, and Indonesia is now listed as the country with the third-largest burden of tuberculosis after India and China, and, at the same time, malnutrition, in any of its forms – underweight, wasting and shortness or stunting (pathological shortness), and in any of the recognised at-risk populations – pregnant women, the newborn and underfive children. These infectious disease and dys-nutritional problems are now compounded by an escalation of so-called non-communicable diseases (NCDs).
Table 1. Life expectancy (years) and infant mortality rates (per 1,000 live births) at West Java Province\(^3,4\)

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<tr>
<td>Life expectancy, male (years)</td>
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<td></td>
<td></td>
<td></td>
<td>69.4</td>
<td>69.68</td>
<td>69.95</td>
<td>70.22</td>
<td>70.35</td>
<td>70.54</td>
<td>70.57</td>
<td>70.58</td>
</tr>
<tr>
<td>Life expectancy, female (years)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>73.27</td>
<td>73.53</td>
<td>73.79</td>
<td>74.05</td>
<td>74.18</td>
<td>74.36</td>
<td>74.39</td>
<td>74.42</td>
</tr>
<tr>
<td>Infant mortality rates (per 1,000 live births)</td>
<td>167</td>
<td>134</td>
<td>90</td>
<td>89</td>
<td>61</td>
<td>57</td>
<td>44</td>
<td>39</td>
<td>26</td>
<td>30</td>
<td>27</td>
<td>27</td>
<td>26</td>
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<tr>
<td>Human Development Index</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>66.15</td>
<td>66.67</td>
<td>67.32</td>
<td>68.25</td>
<td>68.8</td>
<td>69.5</td>
<td>70.05</td>
<td>70.69</td>
</tr>
</tbody>
</table>

Source: Indonesian Central Bureau of Statistics Data.
Table 2. Gross Domestic Product (GDP), Life expectancy at birth, Infant Mortality Rate (IMR), low birth weight (LBW), and nutritional status of underfive children in 1995, 2007, 2013, and 2018 in Indonesia.10-14

<table>
<thead>
<tr>
<th></th>
<th>1995</th>
<th>2007</th>
<th>2013</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy at birth (years)</td>
<td>65.03</td>
<td>67.58</td>
<td>68.68</td>
<td>69.19 (2016)</td>
</tr>
<tr>
<td>IMR per 1000 live births</td>
<td>50.4</td>
<td>30.9</td>
<td>24.5</td>
<td>21.4 (2017)</td>
</tr>
<tr>
<td>LBW (%)</td>
<td>10.3 (1997)</td>
<td>11.5</td>
<td>10.2</td>
<td>6.2</td>
</tr>
<tr>
<td>Underweight (%)</td>
<td>30.3</td>
<td>18.4</td>
<td>19.6</td>
<td>17.7</td>
</tr>
<tr>
<td>Wasting (%)</td>
<td>14.9 (1995)</td>
<td>13.6</td>
<td>12.1</td>
<td>10.2</td>
</tr>
<tr>
<td>Stunting (%)</td>
<td>48.1 (1995)</td>
<td>36.8</td>
<td>37.2</td>
<td>30.8</td>
</tr>
</tbody>
</table>

This prospective study commenced in 1978 in view of the high infant mortality rates (IMR) and low birth weights (LBW) in Indonesia at the time. The objectives were to study the natural history of pregnancy and its outcome in one or more rural and in one or more urban areas of the province of West Java; and to study in-depth the problems of perinatal mortality and morbidity and of LBW in one or more teaching hospital precincts, connected with a medical school.20 The Medical School of Universitas Padjadjaran was the institution engaged.

Health, wellbeing and their nutritional dependence are usefully targeted as a package across various life stages,16 with an ecological perspective,17,18 and community participation at the village level or its urban counterpart.3 On this basis, the Tanjungsari cohort study19 was devised, in its first iteration in 1988, with a focus on the improvement of maternal and child health, especially in pregnancy, childbirth and infancy. The Tanjungsari cohort study now merits revisitation for at least 3 reasons: observations of 3 generations since 1988 have been made, re-analysis for potential links between ecological factors and nutritionally-related health (NRD) outcomes has been possible, and valuable insights into public health and nutritional policy across the lifespan may be provided, not only for West Javanese, but for Indonesians in general.

Figure 2. Indonesian Human Development Index (HDI) ranked 116 out of 189 countries.15 Source: Human Development Reports, UNDP.

TANJUNGSARI COHORT STUDY: HISTORICAL PERSPECTIVE

The Tanjungsari Cohort Study described by Alisjahbana et al19 was preceded by a prospective study designed by Dr Hellen Wallace (a WHO Consultant) and supported by the WHO Regional Office for Southeast Asia (WHO-SEARO),...
Table 3. Maternal mortality rate, its pregnancy outcomes, and direct causes in rural study areas of Ujung Berung subdistrict.20 29

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Statistics (per 1,000 deliveries)</th>
<th>Direct causes (practically preventable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Mortality Rate (MMR)</td>
<td>1.7</td>
<td>Toxaemia or eclampsia, haemorrhage, infection</td>
</tr>
<tr>
<td>Stillbirth Rate (SR)</td>
<td>13.7</td>
<td>anoxia/ asphyxia, congenital abnormalities, other</td>
</tr>
<tr>
<td>Perinatal Mortality Rate (PMR)</td>
<td>45.0</td>
<td>Prematurity/LBW, anoxia/ asphyxia, infections, congenital abnormalities, other respiratory problems</td>
</tr>
<tr>
<td>Early Neonatal Mortality Rate (ENMR)</td>
<td>32.9</td>
<td>Prematurity/LBW, anoxia/ asphyxia, infections, congenital abnormalities, other respiratory problems, others</td>
</tr>
</tbody>
</table>

A total of 2,342 and 2,888 pregnant women were observed in the three remote villages of Ujung Berung subdistrict and at Hasan Sadikin Hospital, respectively. The natural history of pregnancy, birth outcomes, and major risks factors in rural and urban settings were recorded. Inter alia, socio-economic factors were considered as putative determinants of pregnancy outcomes. Thus the first comprehensive possible indicators of pregnancy outcomes, especially for rural areas in Indonesia, were obtained (Table 3)20 and early evaluation of the strategy for training semiliterate TBAs was possible.

An earlier study (December 1984 – February 1985) at Sumedang Selatan subdistrict (located 60 km outside Bandung city) served as a feasibility test for the Risk Approach Strategy (RAS) that later would be applied in the TSC study. This used simplified aids like coloured spiral weighing scales, pictorial mother-child cards, and a Problem-Action-Guidelines (PAG) booklet.21-22 The training strategy constructed for the Ujung Berung study was tested for its effectiveness in helping the illiterate TBAs perform their duties.

A conceptual diagram is provided to illustrate how the TSC study was envisaged to address principle questions about the progressive optimisation of maternal health, pregnancy, birth, infancy, childhood, adolescence and ultimately adulthood and subsequent intergenerational well-being in West Java, Indonesia (Figure 3).

The findings from these early studies which established the TCS framework have been published20,24-27 and represent the Tanjungsari subdistrict activities of 1988-1990 to assess whether the RAS of MCH care had utility for often aging and semiliterate TBAs (Figure 4a, 4b) through adaptive training (Figure 5a, 5b). As indicated above, simple technology (eg. coloured spiral weighing scale - Figure 6) and tools (e.g. PAC – Figure 7a-7c., MCC – Figure 7d, referral card) were their premise.

The Tanjungsari sub-district is located about 15-20 km from Bandung and consisted of 27 villages when the study began. It had a total population of about 87,000 (based on the 1990 census) and a mountainous terrain. Only one health centre operated in the area, with one GP and one midwife. At the village level, the informal health services were delivered through an integrated health service post, a so-called Posyandu, which was run by volunteer women health workers, known as cadres.

During the two-year observation period, almost 90% of the women delivered at home and were attended by TBAs. There were 4,108 singletons recorded and 38 (pairs) twin births. Study extension until March 1990, allowed further recruitment and increased cohort size to 4,698 singletons.

Figure 8 shows the sample sizes for the different cohorts reported by Alisjahbana et al.,28 Sofiatin et al.,29 Sasonko et al.,30 and Nugraha et al.31

The TSC study has been conducted in accordance with the WMA Declaration of Helsinki – ‘Ethical Principles for Medical Research Involving Human Subjects’ from 1983 onwards.

TANJUNGSARI: THEN AND NOW

Compared to the situation in 1988 when the study began, there have been major administrative, demographic, socio-economic and geographic changes in the Tanjungsari subdistrict. With increased population density, the administrative area of Tanjungsari subdistrict has been further divided from 27 into 32 villages in 2001 (Figure 9a, 9b). The wide and extensive terraced rice fields documented in 1988 are now much narrower and often replaced with rows of houses (Figure 10a, 10b). The previous rural setting has been transformed into a peri-urban landscape with better road access (Figure 11a–11d). Food-oriented agriculture has partly given way to more lucrative tobacco crops, with their own socioeconomic and health implications.

After some three decades, the TSC now comprises inter-generational groups of cohorts (Figure 12) and cadres (Figure 13) allowing various studies in a changing Tanjungsari. Among previously recruited staff and study personnel, field supervisors and TBA are no longer actively involved with the TSC study. On account of government regulation and a changing health system, TBA are slowly disappearing in the community and being replaced by village midwives. In Tanjungsari, only one TBA remains, with no successor (Figure 14).

PREDICTORS OF AND BY INTRA-UTERINE GROWTH RETARDATION: THE SURROGACY FOR HEALTH AND NUTRITION STATUS OF LOW BIRTH WEIGHT AND SHORTNESS IN TANJUNGSARI

Low birth weight (LBW), which is found among preterm infants, is increasingly recognised as a reflection and predictor of the developmental origins of health and disease.32,33 Although most preterm infants are LBW, term infants may also be LBW as a result of maternal malnutrition and other intrapartum health challenges, which affect intrauterine fetal growth.34,35

Likewise, shortness may be an indicator of compromised growth velocity, with reference to childhood malnutrition or recurrent infection and referred to as stunting.36,37 However, shortness may be physiological or, if pathological, attributable to intragenerational nutritional
Figure 3. Conceptual Framework for the intra-and inter-generational Tanjungsari Cohort study of maternal and child health with example indicators.

**BMI**: Body Mass Index; **FM**: Fat Mass; **FFM**: Fat Free Mass; **IUGR**: Intrauterine Growth Retardation
Maternal contributors to intergenerational well-being

and non-nutritional socio-environmental factors commencing at conception, act during intrauterine life, and continue through growth and development into adulthood.\textsuperscript{38-40} In turn, there may be an association between LBW and shortness, which would most likely be of pathological significance although potentially amenable to recovery or ‘catch-up’.\textsuperscript{41}

The TSC Study has provided an opportunity to review these considerations in a relatively socio-economically disadvantaged population, and with the passage of time and generation, in West Java, Indonesia. Associations operative when the study began around 1988 may not be as evident some 3 decades later, but the investigators have examined whether such associations are predictive into later life and relevant for progeny, notwithstanding societal change. Table 4 summarises the associations between IUGR and indices of growth and development at 5 years, 12 years and in adulthood where the detail is available elsewhere.\textsuperscript{28-31} An intergenerational study has also been published to do with the maternal and offspring associa-
a. Training of TBAs

b. Risk assessment in a meeting with TBAs and pregnant mothers using the Mother Child Card

Figure 5. Activities of Traditional Birth Attendant (TBA) in Tanjungsari subdistrict.

Figure 6. Coloured infant weighing scale, developed for the Tanjungsari study.

SUMMARY
The TSC study began as a community-oriented effort to train and better equip traditional birth attendants (TBA) to decrease the burden of neonatal mortality, maternal mortality and low birth weight in the late 1980s in Tanjungsari, West Java. It was a time when these health outcomes in Tanjungsari were better by comparison with the national and international experience. The early success of the training intervention was not sustained over the reference non-intervention community, for complex reasons, which include ‘leakage’ from the trained to the untrained personnel. Birthing centres known as ‘Polindes (Pondok Bersalin Desa) facilities’ for pregnant women have now been incorporated into the wider health system. The Tanjungsari study participants’ children and grand-
a. Problem Action Card or PAC for ANC, breastfeeding, and family planning

b. Problem Action Card or PAC for complications during pregnancy and action to go for referral center

c. Problem Action Card or PAC for complications during delivery and action at the referral center

Figure 7. Problem action and mother-child cards.
d. Mother-Child Card or MCC

Figure 7. Problem action card and mother child card (cont.).

Figure 8. Sample size of Tanjungsari cohorts (G1 and G2) from 1988 to 2018.
Maternal contributors to intergenerational well-being

A number of examples of these initiatives are provided in the accompanying chart (Figure 3) and in referenced papers.28–31

AUTHOR DISCLOSURES
Dr Widjaja Lukito is Director and Ms Lindawati Wibowo a Consultant of the Indonesian Danone Institute Foundation.


Figure 9. Map of Tanjungsari subdistrict.
a. Terraced rice fields in 1988

![Terraced rice fields in 1988](image1)

b. Rows of houses in 2018 and the piped water system

![Rows of houses in 2018 and the piped water system](image2)

Figure 10. Eco-agricultural conditions.

Professor ML. Wahlqvist has no conflict of interest.

REFERENCES
a. Road conditions in 1988

![Road conditions in 1988](image1)

b. An alternative way to mobilize ill persons in 1988

![Alternative way to mobilize ill persons in 1988](image2)

c. Road conditions in 2018

![Road conditions in 2018](image3)

d. Road conditions in 2018

![Road conditions in 2018](image4)

Figure 11. Transportation system at TS: then and now.


13. World Bank. World Bank Open Data: Life expectancy at birth, total (years). Estimated developed by the UN Inter-agency Group for Child Mortality Estimation (UNICEF, WHO,
Table 4. Adverse effects of low birth weight and their reversibility from infancy to adulthood with later catch-up growth in the Tanjungsari Cohort (TSC) Study.25-31

<table>
<thead>
<tr>
<th>Study</th>
<th>Publication#125</th>
<th>Publication#223</th>
<th>Publication#324</th>
<th>Publication#425</th>
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</thead>
<tbody>
<tr>
<td>Cohort</td>
<td>At birth to infancy (0-1 years old)</td>
<td>Childhood (0-5 years old)</td>
<td>Adolescence (12 years old)</td>
<td>Adulthood (27-29 years old)</td>
</tr>
<tr>
<td>Purposes</td>
<td>Birth weight in combination with birth length used to generate a practical classification of IUGR and explore its predictability of growth, morbidity and survival in the TSC during infancy.</td>
<td>Birth weight, genetic polymorphism, maternal and environmental factors used to predict the risk of growth faltering in the TSC during the first 5 years of life.</td>
<td>Birth weight and shortness at age 2, together with maternal- and environmental factors used to assess any catch-up linear growth in the TSC at the age 12.</td>
<td>Birth weight, catch-up growth in early life, and by adulthood as indicated by anthropometric status, used as predictors of RMR and cognitive function in the TSC in adulthood.</td>
</tr>
<tr>
<td>Design</td>
<td>Prospective cohort</td>
<td>Retrospective cohort</td>
<td>Retrospective cohort</td>
<td>Retrospective cohort</td>
</tr>
<tr>
<td>Methodology</td>
<td>Comparison of by growth, morbidity and survival between non-IUGR, IUGR, and ‘probably preterm’ children.</td>
<td>Comparison of the growth of LBW and NBW children as indicated by their WHZ, HAZ, and WAZ. An evaluation of the predictors of child shortness at the age 5.</td>
<td>A determination of the predictors of normal (HAZ ≥-2 SD) and short stature (HAZ &lt; -2 SD) adolescents at the age 12.</td>
<td>Comparison of RMR and cognitive function in ALBW and ANBW.</td>
</tr>
<tr>
<td>Findings</td>
<td>The combination of weight and length at birth is a better indicator than birth weight itself to recognise IUGR in field conditions without technological support. This approach sensitively identifies the survival and health risks and survival prospects during infancy.</td>
<td>Birth weight is a determinant of postnatal growth in the first years of life, along with maternal education and the sanitary environment represented by drinking water. Stunting is presumed to be socio-environmentally and nutritionally-related shortness. It is partly an adaptive phenomenon, and may not in itself be invariably pathogenic for shortness-associated health outcomes.</td>
<td>Birth weight (dependent on intrauterine exposures), maternal education, sanitary environment (source of drinking water, type of latrine), and height-for-age at age 2 years are predictors of adolescent stunting. Infectious disease and atopic dispositions are more likely to be found in stunted adolescents.</td>
<td>Birth weight and body weight at 2 years of age are positively associated with RMR, but inversely associated with adult attention scores. BMI and FFM in adult life are positively associated with RMR and memory score. Weight catch-up, at least by 2 years, may be a modulating factor for low birth weight and allow better cognitive function in adulthood.</td>
</tr>
</tbody>
</table>

IUGR: Intrauterine Growth Retardation; WHZ: weight for Height Z-score; HAZ: Height for Age Z-score; WAZ: Weight for Age Z-score; RMR: Resting Metabolic Rate; BMI: Body Mass Index; FFM: Fat Free Mass; ALBW: adult with history of Low Birth Weight; ANBW: Adult with history of Normal Birth Weight.


26. Padjajaran University, Faculty of Medicine. The identification of at-risk mothers and infants by community health workers. Proceedings of a seminar, Department of Child Health, Padjajaran University, Bandung, Indonesia; 1985.