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Determinants of Stunting and Multi-Component Intervention Model for Children Under Five in Riverbank Communities of South Kalimantan, Indonesia

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ABSTRACT

OBJECTIVE: This study aimed to identify the determinants of stunting among children under five years of age in a riverbank settlement and contextualize an evidence-based multi-component intervention model.

METHODOLOGY: A cross-sectional analytical study was conducted on 178 mother-child pairs in South Kalimantan riverbank communities. Data were collected through structured interviews, anthropometric measurements, and health record reviews. Significant determinants were identified using chi-square tests, bivariate and multivariate binary logistic regression.

RESULTS: Prevalence of stunting was 50.6% (90/178). Five factors were independently associated with the risk of SAM (multivariate logistic regression): high food expenditure proportion ≥60% (aOR=6.234; p=0.001), poor maternal diet during pregnancy (aOR=5.512; p=0.003), non-exclusive breastfeeding (aOR=3.245; p=0.003), unsafe drinking water source (aOR=2.814; p=0.010), and inadequate child dietary intake (aOR=2.648; p=0.020). Notably, chronic energy deficiency during pregnancy showed a borderline association (aOR=11.782; p=0.051) that did not reach statistical significance. Using these findings, we developed a multi-component intervention model with three pillars: (i) nutrition-sensitive interventions on maternal nutrition; (ii) combined explicit motherhood caregiver and nutrition-specific interventions to promote exclusive breastfeeding and adequate dietary intake; and (iii) environmental-economic interventions in relation to water treatment and food security at riverbank-based platforms, including mobile river-based health services. This finding warrants cautious interpretation and requires confirmation through future studies with larger sample sizes.

CONCLUSION: Multilevel factors, often intersectoral in nature, found among marginalized populations growing up along the banks of the river, contributed to stunting. Simultaneous, integrated, and context-specific interventions targeting all determinant levels are required for effective stunting reduction in these populations.

KEYWORDS: Stunting, Determinants, Riverbank Community, Intervention Model, Children Under Five

INTRODUCTION

Stunting is an indicator of chronic undernutrition and is associated with higher morbidity and mortality, impaired cognitive development, and lower economic productivity in adulthood[1]. Indonesia continues to face a significant burden of stunting[2]. Rural and riverbank communities are disproportionately affected, with significantly higher prevalence than urban settings because of compounding vulnerabilities such as poor sanitation, limited access to clean water, low educational attainment, and precarious economic circumstances[3].

Direct causes involve insufficient food intake and infectious diseases, while indirect causes include food insecurity, inadequate childcare practices, poor sanitation and hygiene, and low access to health services[4]. Pregnancy variables in mothers, such as nutritional status, chronic energy deficiency (CED), and dietary patterns during the first 1000 days, are important factors[5].

Water- and sanitation-related practices, especially access to safe drinking water, are vital to the etiology of stunting. Inadequate sanitation and substandard water quality contribute to infectious problems such as diarrhea and environmental enteropathy, which block nutrient uptake and direct metabolic energy towards immune activation[6]. It has long been established that children living in environments with inequitable sanitation services are at a greater risk of stunting, and studies have shown that the risk can be up to three times greater[7]. In addition, untreated water has been linked to a higher incidence of waterborne infections in riverbank communities where surface water is the main source[8].

Exclusively breastfeeding for the first 6 months of life has long been recognized as a protective factor against stunting because it provides optimal nutrition and immunological protection[9]. However, exclusive breastfeeding remains low among various communities in Indonesia[10]. In addition to maternal health, complementary feeding practices, immunization, and vitamin A supplementation influence the nutritional status of children[11].

Household food expenditure trajectories indicate food security status and the financial ability to obtain a healthy dietary intake. Those whose total food expenditure accounted for ≥60% of total expenditure have a less diverse and lower-quality diet[12]. This economic dimension matters because it interacts with educational attainment, as parental knowledge of nutrition and feeding practices is shaped by education[13,14].

Although several national stunting reduction programs exist, successful intervention models specifically adapted for riverbank communities remain scarce. Despite the well-documented burden of stunting in rural Indonesia, empirical evidence on the integrated determinants specific to riverbank communities remains limited, and no tailored intervention model has been proposed for these settings. The objectives of this study were to determine the main risk factors for stunting and to develop an evidence-based multicomponent intervention model for stunting in riverbank areas.

METHODOLOGY

Study Design and Setting

This cross-sectional analytical study examined the determinants of stunting in children under 5 years living in riverbank communities in South Kalimantan, Indonesia. The province has extensive river systems, and riverside populations are vulnerable to environmental, sanitation, and socioeconomic factors that likely contribute to childhood malnutrition compared with urban areas, including access to clean water, healthcare, and sufficient nutrition.

Population and Sample

The study included mother-child pairs with children aged 0–59 months living in riverside communities in South Kalimantan. We enrolled 178 mother-child pairs. We calculated the sample size based on proportions from previous literature, using a formula appropriate for hypothesis testing of two population proportions ($\alpha = 0.05$; $Z\alpha = 1.96$; power = 80%; $Z\beta = 0.84$). Using sequential sampling, participants were included if they were women aged 18 years or older, had children aged 0–59 months, lived in the riverside community for at least six months, and provided informed consent. Children with congenital abnormalities or chronic diseases that independently affected linear growth and couples with incomplete health records were excluded.

Variables and Operational Definitions

Stunting status, the dependent variable (Y), was defined using the WHO Child Growth Standards as a height-for-age or length-for-age z-score <-2 SD from the median. Length (for children <24 months) was measured using an infantometer, while standing height (for children ≥24 months) was measured using a stadiometer (microtoise), both with a precision of 0.1 cm. Age was determined on a copy of the birth certificate or maternal and child health records.

The independent variables covered three domains: nutrition and infectious disease factors included the adequacy of the child's nutritional intake (24-hour dietary recall compared to the Indonesian Recommended Dietary Allowances), history of diarrhea, acute respiratory infection, or other infections in the 3 months before the baseline assessment (mother's report and health records), exclusive breastfeeding for the first six months (breastfeeding only for six months), completeness of immunizations (according to the national schedule), regularity of vitamin A supplementation, and frequency of integrated health post visits.

Second, prenatal care and sanitation factors included maternal diet quality (assessed retrospectively using a semi-quantitative food frequency questionnaire), chronic energy deficiency (CHD) during pregnancy (upper arm circumference <23.5 cm as recorded in the maternal health handbook), and drinking water treatment practices (treated vs. untreated).

Third, economic factors were defined as the ratio of food costs to total expenditure, with a cutoff point of ≥60% indicating economic vulnerability. This aligns with the Central Statistics Agency of Indonesia's classification, which states that a high ratio indicates low levels of well-being.

Data Collection

Data were collected using a structured questionnaire administered by trained enumerators through pretested interviews. Standardized Anthropometric Measurements: Three trained health workers obtained anthropometric measurements according to the standard WHO protocols. Immunization status, previous vitamin A supplementation history, and CED status were confirmed using secondary data from maternal and child health handbooks and integrated health post records. All enumerators underwent two days of training to standardize the procedures and reduce inter-observer variability.

Data Analysis

Data were analyzed using SPSS. Bivariate analysis using the chi-square test or Fisher's exact test was performed to examine the association of each independent variable with stunting, with results expressed as odds ratios (OR) and 95% confidence intervals (CI). Independent determinants were identified using multivariate binary logistic regression with backward stepwise selection, including all variables with $p < 0.05$, indicating an adequate fit. Statistical significance was set at $p < 0.05$.

Ethical Considerations

This study was approved by Poltekkes Kemenkes Banjarmasin (ethics approval number: No. 295/KEPK-PKB/2025).

RESULTS

A total of 178 mother-child pairs were enrolled in the study. Of the fathers, 52.8% were >35 years, and 47.2% were 20–35 years old. Of the mothers, 69.7% were aged 20–35 years, 29.2% were >35 years old, and a minority (1.1%) were < 20 years. Most fathers and mothers had a low level of education: 40.4% and 42.7%, respectively, attended only primary school. Fathers were fishermen (28.1%) and private sector workers (21.9%), while 81.4% of mothers were housewives.

Bivariate analysis of nutritional, infectious, and parenting factors associated with stunting is shown in **Table I**. Four variables were significantly associated ($p<0.05$): insufficient nutritional intake (OR = 2.6), infectious diseases (OR = 2.5), non-exclusive breastfeeding (OR = 3.1), and incomplete immunization (OR=2.4). However, vitamin A supplementation (p=0.712) and active involvement in posyandu (p=0.887) were not significantly associated. The association with exclusive breastfeeding, the most pronounced relationship, was a threefold increase in the odds of stunting.

Table I: Bivariate Analysis of Nutritional, Infectious, and Caregiving Factors Associated with Stunting (n=178)

Variable	Stunting (n=90)	Non-Stunting (n=88)	OR (95% CI)	p-value*
	n (%)	n (%)		
Nutritional Intake				
Inadequate	68 (75.6)	48 (54.5)	2.6 (1.3-5.0)	0.008
Adequate	22 (24.4)	40 (45.5)		
Infectious Disease				
Yes	70 (77.8)	52 (59.1)	2.5 (1.3-4.8)	0.012
No	20 (22.2)	36 (40.9)		
Exclusive Breastfeeding				
No	58 (64.4)	33 (37.5)	3.1 (1.6-5.7)	0.001
Yes	32 (35.6)	55 (62.5)		
Immunization				
Incomplete	68 (75.6)	49 (55.7)	2.4 (1.3-4.7)	0.010
Complete	22 (24.4)	39 (44.3)		
Vitamin A Supplementation				
Irregular	15 (16.7)	12 (13.6)	1.3 (0.6-3.0)	0.712
Regular	75 (83.3)	76 (86.4)		
Integrated Health Post Attendance				
Inactive	30 (33.3)	31 (35.2)	0.9 (0.5-1.7)	0.887
Active	60 (66.7)	57 (64.8)		

*Chi-square test; significance level $p<0.05$

Table II presents the bivariate analysis of prenatal, sanitation, and economic factors. All variables were significantly associated with stunting: poor maternal diet during pregnancy (OR=3.9), chronic energy deficiency (CED) during pregnancy (OR=8.8), untreated water

(OR=3.2), and food expenditures exceeding 60% (OR=0.3; reference categories were reversed in the multivariate analysis). CED during pregnancy showed the strongest association with an 8.8-fold increased risk of stunting, although the confidence interval was very wide because of the small number of cases.

Table II: Bivariate Analysis of Prenatal Care, Sanitation, and Economic Factors Associated with Stunting (n=178)

Variable	Stunting (n=90)	Non-Stunting (n=88)	OR (95% CI)	p-value*
	n (%)	n (%)		
Maternal Diet During Pregnancy				
Poor	83 (92.2)	66 (75.0)	3.9 (1.5-9.8)	0.005
Good	7 (7.8)	22 (25.0)		
CED During Pregnancy				
Yes	10 (11.1)	1 (1.1)	8.8 (1.1-69.8)	0.018
No	80 (88.9)	87 (98.9)		
Untreated Drinking Water				
Untreated	66 (73.3)	42 (47.7)	3.2 (1.7-6.0)	0.001
Treated	24 (26.7)	46 (52.3)		
Food Expenditure ≥60%				
≥60%	80 (88.9)	63 (71.6)	0.3 (0.1-0.7)*	0.007
<60%	10 (11.1)	25 (28.4)		

Chi-square test / Fisher's exact test; *Reference category reversed in multivariate analysis.

Results from multivariate logistic regression: the six determinants of stunting are shown in **Table III.** High food expenditure (≥60%) was the most significant predictor (aOR=6.234; p=0.001), followed by poor maternal diet (aOR=5.512), non-exclusive breastfeeding (aOR=3.245), untreated water supply use at home or in larger areas (aOR=2.814), and inadequate nutritional intake (aOR=2.648). CED during pregnancy had the maximum aOR (11.782), which was not statistically significant (p=0.051). The model passed the Hosmer-Lemeshow test.

Table III. Multivariate Logistic Regression of Determinants of Stunting (n=178)

Variable	B	SE	p-value	aOR (95% CI)
High food expenditure (≥60%)	1.830	0.538	0.001	6.234 (2.172–17.893)
Poor maternal diet during pregnancy	1.707	0.576	0.003	5.512 (1.783–17.036)
No exclusive breastfeeding	1.177	0.394	0.003	3.245 (1.499–7.024)
Untreated water	1.034	0.399	0.010	2.814 (1.287–6.153)
Inadequate child nutritional intake	0.974	0.418	0.020	2.648 (1.167–6.008)
CED during pregnancy	2.466	1.258	0.051	11.782 (1.003–138.390)

Backward stepwise binary logistic regression; Hosmer-Lemeshow test p>0.05

This multi-component intervention model to reduce stunting among children under five in riverbank communities in South Kalimantan, Indonesia, is based on six key determinants from multivariate logistic regression, as shown in **Figure 1**. The model comprises three pillars: the first pillar is Nutrition-Sensitive Interventions, which include maternal nutrition and are associated with dietary counseling (aOR=5.512; p=0.003) and chronic energy deficiency

management (aOR=11.782; p=0.051). Second, the caregiving and nutrition-specific interventions promoted Exclusive Breastfeeding (aOR=3.245; p=0.003) and better dietary intake (aOR=2.648; p=0.020). Third, Environmental and Economic Interventions included drinking water treatment (aOR=2.814; p=0.010) and food security programs (aOR=6.234; p=0.001). Components are mediated via platforms adapted to riverbank settings: integrated health posts, community health workers, and, in some recent applications, mobile river-based health services. The model is context-specific and aims of improve maternal nutrition, child feeding practices, environmental health, and economic resilience to reduce the prevalence of stunting.

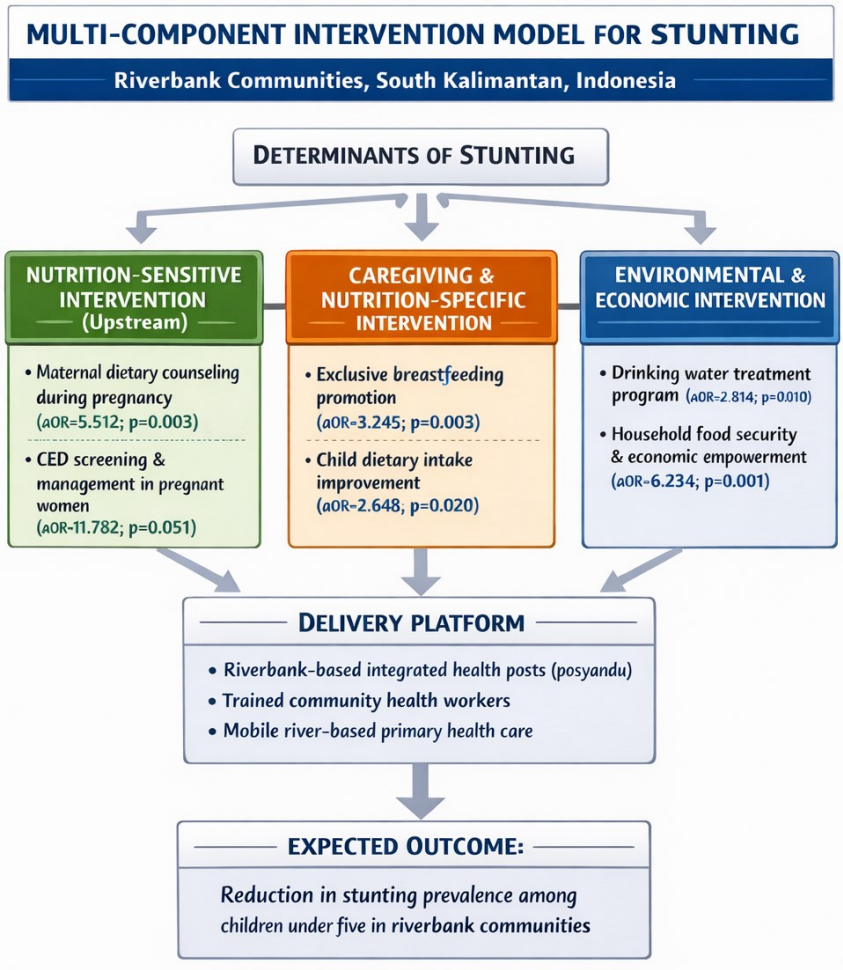


Figure 1: Multi-Component Intervention Model for Stunting Prevention among Children Under Five in Riverbank Communities of South Kalimantan, Indonesia.

DISCUSSION

This study provides a comprehensive overview of factors associated with stunting in children aged 0–59 months living along riverbanks in South Kalimantan, Indonesia. Using a cross-sectional study design, this research contributes to the limited evidence base on stunting determinants in riverbank-dwelling populations, a unique ecological and socioeconomic context that remains underexplored in the existing literature. The findings offer an evidence base for developing a context-specific multi-component intervention to address stunting. This deliberation covers every notable contributor and the intervention structure discussed in this article within the greater literature.

High Food Expenditure as an Indicator of Economic Vulnerability

Multivariate analysis showed that a high food expenditure proportion (≥60% of total household expenditure) was the strongest independent predictor of stunting (aOR=6.234; p=0.001). This result is consistent with the definition given by the Indonesian Central Bureau of Statistics, which states that households spending a significant proportion of their expenditures on food indicate poorer welfare and greater economic vulnerability [15]. Families in this category usually lack the financial power to purchase a range of nutrient-rich foods and instead consume energy-dense, micronutrient-poor staples[16]. Economic constraints in rural Indonesian communities limit dietary diversity, likely affecting linear growth in children. This vulnerability is compounded by challenges associated with the riverbank context, where fishing and farming livelihoods are seasonal and precarious in terms of income stability, limiting regular access to adequate nutrition[17]. These results reinforce the need for stunting reduction strategies to address food security and economic empowerment, rather than relying solely on health sector interventions.

Poor Maternal Diet During Pregnancy

Maternal dietary quality during pregnancy was the second strongest determinant (aOR=5.512; p=0.003), which is consistent with considerable evidence linking maternal nutritional status in the first 1,000 days and fetal growth, as well as child linear growth[18]. Maternal deficiencies in many essential micronutrients (iron, zinc, folic acid, and calcium) threaten placental integrity and fetal skeletal development, creating a predisposition for postnatal growth faltering[19]. Dietary monotony, such as rice with fish but little vegetable or fruit consumption in riverbank communities, may also cause micronutrient deficiency[20]. The results of our study support the need for locally accessible food resources to guide healthy weight gain during pregnancy, consistent with the proposed intervention.

Chronic Energy Deficiency During Pregnancy

Chronic Energy Deficiency (CED) during pregnancy, defined as mid-upper arm circumference (MUAC) <23.5 cm, showed the largest adjusted odds ratio (aOR=11.782); however, this association did not reach statistical significance, reflecting limited statistical power due to the small number of CED cases (n=11) and consequent wide confidence intervals indicating substantial imprecision in the estimate. Despite this imprecision, the magnitude of the effect size warrants clinical attention, consistent with findings in similar populations demonstrating MUAC as an independent predictor of low birth weight and corresponding associations with stunting[21]. The low prevalence of documented CED in this sample may reflect effective antenatal screening or possible misclassification in nutritional status assessment; nonetheless, the substantive effect size supports its inclusion in intervention planning[22]. Early identification of pregnant women with CED through routine MUAC screening should be prioritized, accompanied by targeted nutritional supplementation through health services accessible to riverbank communities.

Non-Exclusive Breastfeeding

Non-exclusive breastfeeding (aOR=3.245; p=0.003) was significantly associated with stunting, corroborating previous evidence that exclusive breastfeeding during the first six months of life is the best nutrition and protection from infections that arrest growth[23]. The fact that 64.4% of stunted children were not exclusively breastfed indicates how similar challenges exist at the national level, with the early intake of complementary food and prelacteal feeding receiving sustained attention as remaining problems[24]. Cultural practices in riverbank communities may replace breast milk through the early introduction of river fish broth and bananas [25]. For use in our intervention model, community-based breastfeeding promotion through trained peer counselors and posyandu cadres was an evidence-based approach with demonstrated success in increasing exclusive breastfeeding in these settings.

Untreated Drinking Water

Untreated drinking water—defined as water consumed directly from the source without boiling, filtration, or chlorination—significantly increased the risk of stunting (aOR = 2.814; p = 0.010). This finding is consistent with studies among riverbank and rural communities relying on surface water as their primary source[26–28]. Untreated river water harbors pathogenic organisms, including *E. coli*, *Giardia*, and *Cryptosporidium*, which cause recurrent diarrheal episodes[29]. Repeated enteric infections, compounded by inadequate sanitation facilities and suboptimal handwashing practices, may promote environmental enteric dysfunction (EED)—a subclinical condition characterized by chronic intestinal inflammation, villous atrophy, and nutrient malabsorption that directly impairs linear growth in young children[30]. Although this study did not adjust for sanitation type or handwashing behavior, these WASH-related factors likely act synergistically with untreated water consumption to perpetuate the infection–malnutrition cycle. These findings suggest that promoting accessible point-of-use water treatment methods, such as boiling, household-level chlorination, or ceramic filtration, may represent a feasible and culturally appropriate intervention to reduce waterborne pathogen exposure and, consequently, stunting risk in riverbank communities.

Inadequate Child Nutritional Intake

Poor dietary intake of children is still an important determinant (aOR=2.648; p=0.020), indicating a direct causal path in the UNICEF conceptual framework. The high prevalence of stunting among children with inadequate dietary intake (75.6%) indicates that complementary feeding practices in riverbank communities do not meet the recommended dietary allowances, likely due to low dietary diversity, low meal frequency, and reliance on carbohydrate-heavy foods. The proposed model combines growth monitoring and targeted counselling with nutrition-specific interventions involving complementary feeding education and cooking demonstrations using locally available nutrient-dense foods.

Multi-Component Intervention Model

The three-pillar structural intervention approach addresses the consensus that multisectoral strategies are essential for stunting reduction[31].

Pillar 1: Nutrition-Specific Interventions: Community health workers (CHWs) deliver monthly growth monitoring, biannual vitamin A supplementation, and weekly iron-folic acid distribution for pregnant women at Posyandu. Targets: children 0–59 months and pregnant/lactating women.

Pillar 2: Nutrition-Sensitive Interventions: Puskesmas staff conduct quarterly WASH education, complementary feeding counseling, and parenting sessions. CHWs perform bi-weekly home visits for at-risk households identified through Posyandu screening.

Pillar 3: Environmental-Economic Interventions: Local government facilitates distribution of water filtration and links caregivers to social protection programs (e.g., PKH conditional cash transfers), coordinated through village-level planning meetings.
Integration Mechanism: Posyandu serves as the primary service delivery platform, with referral pathways to Puskesmas for malnourished children. Monthly coordination meetings between CHWs, Posyandu cadres, and Puskesmas staff ensure data sharing via integrated nutrition surveillance. River-based mobile health units extend coverage to inaccessible settlements.
***Evaluation Plan*:** A stepped-wedge cluster randomized trial across riverbank communities is proposed. Process indicators include service coverage, home visit frequency, and referral completion rates. Outcome indicators comprise stunting prevalence (height-for-age z-score <−2), dietary diversity scores, and exclusive breastfeeding rates, measured at baseline, 12, and 24 months.
Funding Sustainability. Integration within existing Dana Desa (village fund) allocations and Puskesmas operational budgets (BOK) ensures long-term financing, supplemented by provincial health office co-investment.

CONCLUSION

This study aimed to identify factors associated with stunting among children under five years of age living in riverbank communities in South Kalimantan, Indonesia. Statistically, high household food expenditure, poor maternal diet during pregnancy, non-exclusive breastfeeding, unboiled drinking water, and low child dietary diversity were all significant determinants of underweight, and chronic energy deficiency during pregnancy had a clinically important predicted probability at borderline significance. These results verify that stunting among riverbank people results from interrelated economic, nutritional, parental, and environmental influences. This study proposes a multi-component intervention model guided by an evidence-based framework for stunting reduction based on nutrition-sensitive, nutrition-specific, and environmental-economic pillars, and delivered through an adaptive riverbank platform. Consistent with the existing literature, the study highlights the need for integrated, tailored approaches to address gaps in maternal nutrition supply, exclusive breastfeeding promotion, water treatment practices, and household economic resilience packages.

Ethical Permission: Poltekkes Kemenkes Banjarmasin, Banjarmasin, South Kalimantan, Indonesia, ERC approval letter No. 295/KEPK-PKB/2025.
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Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Fathurrahman: Conception, design of the work or the acquisition, analysis, interpretation of data for the work, drafting the work or revising, final approval of the version to be published
Magdalena: Conception, Design of the work or the acquisition, analysis, or interpretation of data for the work, drafting the work or revising, final approval of the version to be published
Mas'odah S: Conception, Design of the work or the acquisition, analysis, or interpretation of data for the work, drafting the work or revising, final approval of the version to be published
Yuliastuti E: Conception, Design of the work or the acquisition, analysis, or interpretation of data for the work, drafting the work or revising, final approval of the version to be published

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