Al-Asalmiya Nursing
Jurnal Ilmu Keperawatan *(Journal of Nursing Sciences)*
Volume 15, Nomor 1, Juni 2026
p-ISSN: 2338-2112, e-ISSN: 2580-048
https://jurnal.ikta.ac.id/index.php/keperawatan

DEVELOPMENT AND EVALUATION OF THE CARDIO-GROWTH NURSING MODEL FOR EARLY CARDIOVASCULAR RISK SCREENING IN STUNTED CHILDREN

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ARTICLE INFO

Artikel history

Submitted : 09 mei 2026
Accepted : 07 june 2026
Publish : 30 june 2026

Kata Kunci:
Stunting, Keperawatan Anak, R&D, ADDIE, Risiko Kardiovaskular, Skrining Dini, Model Prediktif.

ABSTRAK

Stunting masih menjadi masalah kesehatan anak global yang memengaruhi lebih dari 148 juta anak di dunia dan tetap tinggi di Indonesia, termasuk di Kota Palembang. Selain menyebabkan gangguan pertumbuhan linier, stunting semakin dikaitkan dengan risiko kardiometabolik dan kardiovaskular sejak usia dini. Penelitian ini bertujuan mengembangkan dan mengevaluasi Model Asuhan Keperawatan Cardio-Growth sebagai pendekatan skrining dan pencegahan dini risiko kardiovaskular pada anak stunting. Penelitian menggunakan desain Research and Development (R&D) dengan model ADDIE yang dimodifikasi (Analysis, Design, Development, Implementation, Evaluation) serta evaluasi prediktif dengan pendekatan potong lintang yang dilaksanakan pada Januari–April 2026. Sebanyak 36 anak stunting usia 6–12 tahun dipilih menggunakan teknik purposive sampling dari beberapa puskesmas di Kota Palembang. Pengembangan model dilakukan melalui sintesis literatur, integrasi pedoman, dan validasi ahli yang menunjukkan validitas isi sangat baik (S-CVI/Ave = 0,96). Implementasi model dilakukan melalui tiga kali kunjungan keperawatan terstruktur yang mencakup pengukuran antropometri, tekanan darah, lingkar pinggang, penilaian aktivitas fisik menggunakan Physical Activity Questionnaire for Children (PAQ-C), serta edukasi keperawatan berbasis keluarga. Analisis data dilakukan menggunakan statistik deskriptif, analisis perbandingan pre–post, dan uji korelasi Spearman. Hasil menunjukkan perbaikan signifikan pada tekanan darah sistolik ($p<0,01$), tekanan darah diastolik ($p<0,05$), lingkar pinggang ($p<0,05$), dan skor aktivitas fisik ($p<0,001$). Derajat stunting berhubungan signifikan dengan tekanan darah sistolik ($r=-0,42$; $p<0,01$), lingkar pinggang ($r=-0,38$; $p<0,05$), dan aktivitas fisik ($r=0,35$; $p<0,05$). Model Cardio-Growth Nursing menunjukkan kelayakan implementasi yang tinggi dan berpotensi menjadi kerangka keperawatan komunitas untuk skrining dan pencegahan dini risiko kardiovaskular pada anak stunting.

Keywords:
Stunting, Pediatric Nursing, R&D, ADDIE, Cardiovascular Risk, Predictive Model, Early Screening

ABSTRACT

Stunting remains a major global child health problem affecting more than 148 million children worldwide and continues to be highly prevalent in Indonesia, including Palembang City. Beyond impaired linear growth, stunting has increasingly been associated with early cardiometabolic and cardiovascular risks. This study aimed to develop and evaluate the Cardio-Growth Nursing Model for early cardiovascular risk screening and prevention among stunted children. A Research and Development (R&D) design using a modified ADDIE framework (Analysis, Design, Development, Implementation, and Evaluation) combined with a predictive cross-sectional evaluation was conducted from January to April 2026. Thirty-six stunted children aged 6–12 years were recruited through purposive sampling from

selected community health centers in Palembang. Model development involved literature synthesis, guideline integration, and expert validation, demonstrating excellent content validity (S-CVI/Ave = 0.96). The intervention was implemented through three structured nursing visits integrating anthropometric assessment, blood pressure and waist circumference measurement, physical activity assessment using the Physical Activity Questionnaire for Children (PAQ-C), and family-centered nursing education. Data were analyzed using descriptive statistics, pre–post comparative analysis, and Spearman correlation. Significant improvements were observed in systolic blood pressure ($p<0.01$), diastolic blood pressure ($p<0.05$), waist circumference ($p<0.05$), and physical activity scores ($p<0.001$) following implementation. Severity of stunting was significantly associated with systolic blood pressure ($r=-0.42$; $p<0.01$), waist circumference ($r=-0.38$; $p<0.05$), and physical activity ($r=0.35$; $p<0.05$). The Cardio-Growth Nursing Model demonstrated high feasibility and potential as a community-based nursing framework for early cardiovascular risk screening and prevention among stunted children.

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INTRODUCTION

Stunting remains a major global pediatric health problem affecting approximately 148 million children under five worldwide, reflecting persistent inequities in nutrition, health systems, and socioeconomic conditions (UNICEF, 2023; WHO, 2024; World Bank, 2023; Black et al., 2023; Victora et al., 2023). The burden is disproportionately concentrated in low- and middle-income countries, particularly in Asia, where Indonesia continues to contribute substantially to the global prevalence despite gradual improvements in recent years (Kementerian Kesehatan RI, 2024; WHO, 2024; UNICEF Indonesia, 2023). At the subnational level, including South Sumatra and Palembang City, stunting remains a significant public health concern influenced by nutritional insecurity, healthcare accessibility, and environmental determinants (Bappenas, 2023; UNICEF Indonesia, 2023; WHO, 2023; Black et al., 2023; Ruel et al., 2023). Beyond impaired linear growth, emerging evidence suggests that stunting is associated with early cardiometabolic and cardiovascular alterations, including elevated blood pressure, increased central adiposity, and vascular dysfunction during childhood (Victora et al., 2023; Prendergast & Humphrey, 2023; Christian et al., 2022; Hales & Barker, 2022; Barker, 2021).

The Developmental Origins of Health and Disease (DOHaD) theory explains that undernutrition during critical developmental periods can induce permanent structural and functional adaptations in metabolic, endocrine, and cardiovascular systems, thereby increasing susceptibility to non-communicable diseases later in life (Barker, 2021; Hales & Barker, 2022; Victora et al., 2023; Prendergast & Humphrey, 2023; Kolcaba, 2022). Consistent with this framework, stunted children have been shown to exhibit altered vascular elasticity, dysregulated lipid metabolism, and increased risk of hypertension even before adulthood (Christian et al., 2022; Anderson et al., 2022; Smith & Collins, 2024; McNally et al., 2023; WHO Nursing Guidelines, 2023). These findings indicate that stunting should be viewed not only as a nutritional disorder but also as a potential early determinant of cardiovascular risk.

Despite these concerns, current pediatric nursing practice remains largely focused on anthropometric monitoring and nutritional rehabilitation. Routine cardiovascular screening,

including blood pressure measurement, waist circumference assessment, and physical activity evaluation, is rarely incorporated into community-based stunting management programs (McNally et al., 2023; Anderson et al., 2022). Consequently, opportunities for early identification and prevention of cardiometabolic risk among vulnerable children may be missed, despite evidence indicating that cardiovascular alterations can emerge during childhood (Smith & Collins, 2024; Ruel et al., 2023; Black et al., 2023; Victora et al., 2023; Dewey & Begum, 2022). Furthermore, existing pediatric healthcare systems lack structured nursing tools that integrate growth indicators with cardiovascular risk stratification, limiting proactive prevention strategies at the community level.

Previous interventions addressing stunting have primarily focused on nutritional supplementation, food security programs, growth monitoring, and caregiver education (Black et al., 2023; Victora et al., 2023). Although beneficial for improving nutritional outcomes, these interventions often address cardiovascular risk separately or not at all. Likewise, family-centered nursing approaches rarely incorporate structured cardiovascular screening, predictive risk assessment, or cardiovascular health education for caregivers of stunted children (Alligood, 2022; Kolcaba, 2022). Existing nursing frameworks therefore provide limited guidance for integrating anthropometric assessment, cardiovascular risk screening, behavioral assessment, and family empowerment within a unified preventive care model (Alligood, 2022; Kolcaba, 2022; Smith & Collins, 2024; Anderson et al., 2022; WHO, 2023).

To address these gaps, this study developed the Cardio-Growth Nursing Model, which integrates anthropometric assessment, cardiovascular risk screening, physical activity evaluation, and family-centered education within a structured pediatric nursing framework (ANA Pediatric Nursing Standards, 2023; Victora et al., 2023). Unlike conventional stunting interventions, the model was developed using a Research and Development (R&D) approach guided by a modified ADDIE framework and evaluated through predictive assessment in community settings. The novelty of this study lies in integrating growth monitoring and early cardiovascular risk screening into a single evidence-based nursing model, thereby bridging an important gap between pediatric nutrition care, preventive cardiology, and family-centered nursing practice (Prendergast & Humphrey, 2023). Therefore, this study aimed to develop and evaluate the Cardio-Growth Nursing Model for early cardiovascular risk screening and prevention among stunted children in community health settings.

METHOD

Study Design

This study employed a Research and Development (R&D) design using a modified ADDIE framework (Analysis, Design, Development, Implementation, and Evaluation) combined with a predictive cross-sectional evaluation approach to develop, validate, and evaluate the Cardio-Growth Nursing Model for early cardiovascular risk screening among stunted children. The R&D approach was selected because it enables systematic model development, expert validation, feasibility testing, and field implementation prior to broader clinical application (Borg & Gall, 2003; Gall et al., 2015; Polit & Beck, 2021; Branch, 2009; Dick et al., 2015). The ADDIE framework provided a structured developmental pathway that facilitated iterative refinement throughout each phase (Branch, 2009; Molenda, 2003; Dick et al., 2015; Thomas et al., 2020; Kemp et al., 2013). In addition, a predictive cross-sectional component was incorporated to examine associations between stunting severity and early cardiovascular risk indicators following implementation of the model (Creswell & Plano Clark, 2018; Shadish et al., 2002; Rothman et al., 2021; Field, 2018; Pallant, 2020). The overall methodological framework is presented in Figure 1.

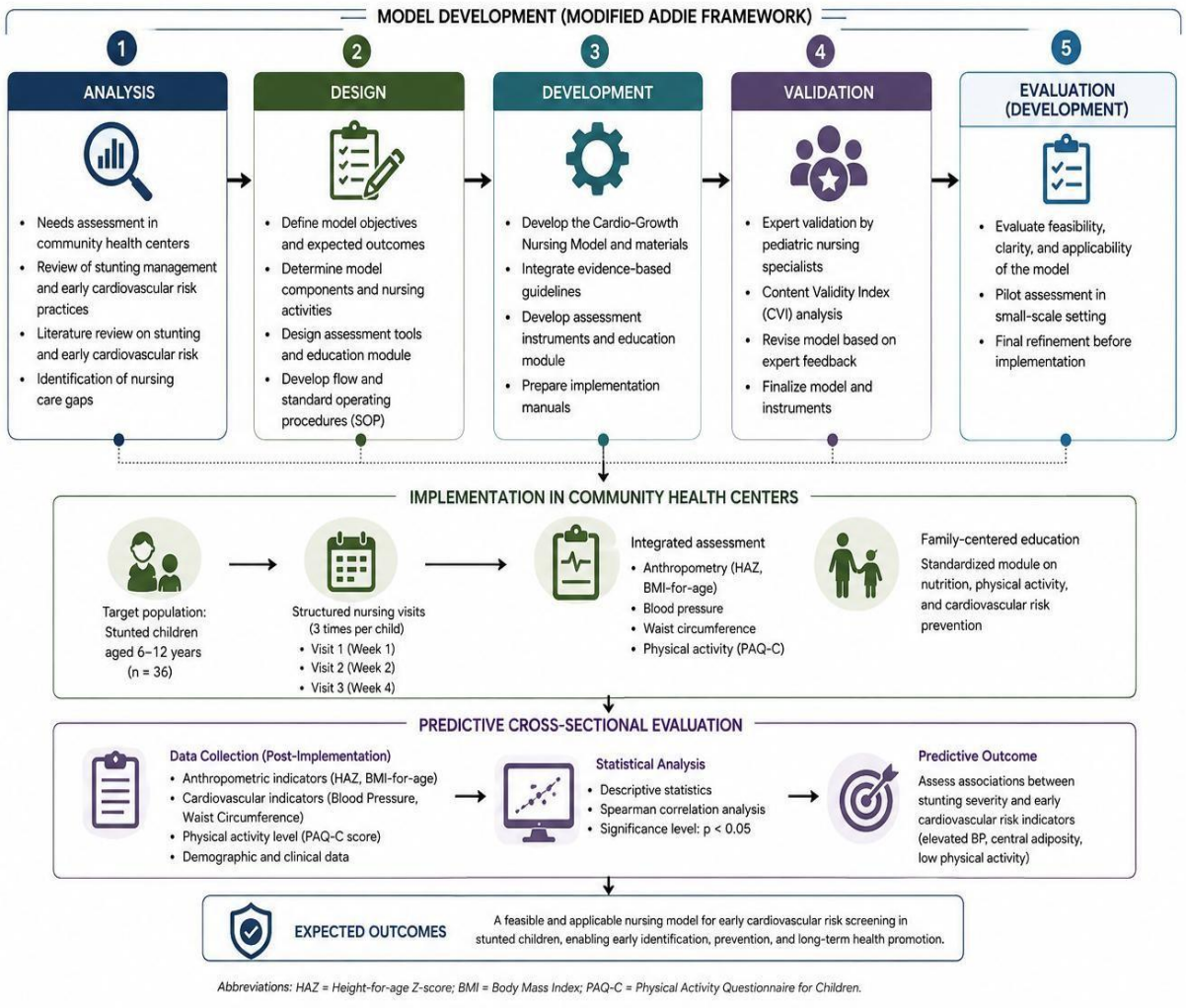

Figure 1. R&D ADDIE-Based Cardio-Growth Nursing Model Framework

Study Setting and Participants

The study was conducted from January to April 2026 in selected community health centers (Puskesmas) in Palembang, South Sumatra, Indonesia. These facilities were selected because they serve as primary child healthcare providers and routine stunting surveillance sites. A total of 36 stunted children aged 6–12 years participated in this study. Participants were recruited using purposive sampling because the study required children with specific clinical characteristics relevant to the development and feasibility evaluation of the Cardio-Growth Nursing Model. Inclusion criteria consisted of confirmed stunting (height-for-age Z-score < -2 SD), clinical stability, ability to participate in all intervention sessions, and parental consent. Exclusion criteria included congenital heart disease, chronic renal disease, and acute infectious conditions that could influence cardiovascular measurements. The sample size was determined based on recommendations for developmental and pilot implementation studies, which suggest a minimum sample of 30–40 participants to assess feasibility, acceptability, and preliminary effectiveness prior to larger-scale testing (Polit & Beck, 2021; Creswell, 2018). Therefore, 36 participants were considered adequate for the developmental and preliminary evaluation phase of the model.

Development Phase (ADDIE Model)

Development of the Cardio-Growth Nursing Model followed the five phases of the ADDIE framework. During the Analysis phase, an extensive literature review identified important gaps in pediatric stunting management, particularly the limited integration of cardiovascular risk screening within routine nursing care despite growing evidence linking stunting with long-term cardiometabolic vulnerability. During the Design phase, a family-centered nursing model was developed integrating anthropometric growth monitoring, cardiovascular risk screening, physical activity assessment, and structured family education. The model was grounded in holistic nursing theory and health promotion principles emphasizing adaptive care and family empowerment.

During the Development phase, the model was translated into standardized nursing procedures and clinical protocols (Table 1). Instruments included WHO Child Growth Standards for anthropometric assessment, validated pediatric blood pressure monitoring devices, waist circumference measurement, the Physical Activity Questionnaire for Children (PAQ-C), and a structured family education module. The Indonesian version of PAQ-C has previously demonstrated acceptable validity and reliability for assessing physical activity among school-aged children. Content validity of the model was evaluated by three pediatric nursing experts using structured evaluation forms. The Content Validity Index (CVI) was calculated at both item and scale levels to assess relevance, clarity, simplicity, and applicability of model components (Lynn, 1986; Polit & Beck, 2021; DeVellis, 2017; Waltz et al., 2010; Yusoff, 2019). Revisions suggested by experts were incorporated prior to field implementation.

Tabel 1. Components of Cardio-Growth Nursing Model

Component	Activity	Instrument
Growth monitoring	Height, weight, BMI-for-age	WHO Growth Standards
Cardiovascular screening	Blood pressure, waist circumference	Pediatric digital BP monitor
Activity assessment	Physical activity level	PAQ-C
Family education	Lifestyle & nutrition counseling	Structured nursing module

Implementation Phase

The Cardio-Growth Nursing Model was implemented through three structured nursing visits for each participant, with each session lasting approximately 30–45 minutes. The intervention duration was intentionally designed as a short-term feasibility phase to evaluate practicality, acceptability, implementation fidelity, and preliminary clinical outcomes before larger-scale testing.

Each session included assessment, intervention, and family-centered education. Anthropometric measurements followed WHO Child Growth Standards (WHO, 2006; de Onis et al., 2019; Victora et al., 2023). Blood pressure was measured using a validated automated pediatric sphygmomanometer, while waist circumference was measured using a non-elastic measuring tape (Flynn et al., 2017; NICE, 2022). Physical activity was assessed using the Physical Activity Questionnaire for Children (PAQ-C) (Kowalski et al., 2004; Crocker et al., 2010; WHO, 2020; Field, 2018; Pallant, 2020). Family-centered education focused on nutrition, healthy lifestyle behaviors, physical activity promotion, and cardiovascular risk prevention.

Data Collection Procedures

Data collection followed a structured pretest–posttest design. Baseline measurements were obtained prior to intervention implementation, and post-intervention measurements were collected after completion of the three nursing visits. Outcome variables included

anthropometric indicators (height, weight, BMI-for-age), cardiovascular indicators (systolic blood pressure, diastolic blood pressure, and waist circumference), and physical activity level.

All measurements were conducted using standardized and validated instruments to ensure measurement reliability and consistency (Polit & Beck, 2021; DeVellis, 2017; Creswell, 2018; Field, 2018; Pallant, 2020). In addition to quantitative data, qualitative observational data were documented through structured field notes capturing child engagement, caregiver participation, behavioral responses, and implementation processes throughout the intervention period.

Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics. Descriptive statistics summarized participant characteristics and baseline clinical indicators. Normality testing was performed prior to comparative analysis. Paired t-tests were used for normally distributed variables, whereas Wilcoxon signed-rank tests were applied for non-normally distributed variables to compare pretest and posttest outcomes. Effect sizes (Cohen's d or r) were calculated to estimate the magnitude of intervention effects beyond statistical significance. Spearman's rank correlation analysis was conducted to examine associations between stunting severity and cardiovascular risk indicators.

Qualitative observational data were analyzed using thematic analysis. Data were coded independently, grouped into categories, and synthesized into overarching themes related to family engagement, intervention acceptability, and participant behavioral responses. Integration of quantitative and qualitative findings was conducted through a convergent mixed-methods approach to strengthen interpretation and contextual understanding of the results.

Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee, Faculty of Medicine, Universitas Sriwijaya (Ref. No. 027-2026). The study was conducted in accordance with the Declaration of Helsinki and ethical principles for research involving children. Written informed consent was obtained from parents or legal guardians prior to participation, and child assent was sought when appropriate. Participant confidentiality was maintained through anonymized data coding, and all procedures were conducted in a child-friendly manner to ensure safety, comfort, and voluntary participation throughout the study.

RESULTS

Content Validity of the Cardio-Growth Nursing Model

Prior to implementation, the Cardio-Growth Nursing Model underwent expert validation by three pediatric nursing experts. Content validity was evaluated using the Content Validity Index (CVI) across four domains: relevance, clarity, simplicity, and applicability. The results demonstrated high agreement among experts, indicating that the model was appropriate for implementation in community pediatric nursing settings.

Table 2. Content Validity Index (CVI) of the Cardio-Growth Nursing Model

Domain	I-CVI
Relevance	1.00
Clarity	0.94
Simplicity	0.92
Applicability	0.96
S-CVI/Ave	**0.96**

Based on Table 2, the overall Scale-Level Content Validity Index (S-CVI/Ave) was 0.96, indicating excellent content validity. All domains exceeded the recommended threshold of 0.80, confirming that the Cardio-Growth Nursing Model was considered relevant, clear, and applicable for use in community-based pediatric nursing practice.

Participant Characteristics

A total of 36 stunted children aged 6–12 years completed the full implementation of the Cardio-Growth Nursing Model without attrition. All participants met the eligibility criteria and completed the intervention protocol.

Table 3. Participant Characteristics (n = 36)

Characteristics	n	%
Age 6–9 years	21	58.3
Age 10–12 years	15	41.7
Male	19	52.8
Female	17	47.2
Moderate stunting	22	61.1
Severe stunting	14	38.9
Low physical activity	24	66.7
Moderate physical activity	12	33.3

Based on Table 3, most participants were aged 6–9 years (58.3%) and male (52.8%). Moderate stunting was observed in 61.1% of participants, while 38.9% experienced severe stunting. In addition, two-thirds of participants (66.7%) demonstrated low physical activity levels, indicating a predominance of sedentary behavior among stunted children.

Baseline Growth and Cardiovascular Risk Profile

Baseline assessment revealed that stunted children exhibited not only impaired growth status but also several early cardiovascular risk indicators.

Table 4. Baseline Clinical and Behavioral Indicators (n = 36)

Variable	Mean ± SD	Risk Classification
Height-for-age Z-score	-2.78 ± 0.41	Stunted
BMI-for-age Z-score	-1.89 ± 0.62	Low-normal
Systolic BP (mmHg)	102.4 ± 9.3	High-normal in 27.8%
Diastolic BP (mmHg)	67.1 ± 7.8	High-normal in 22.2%
Waist circumference (cm)	56.3 ± 6.5	Elevated in 19.4%
PAQ-C score	2.31 ± 0.54	Low activity

Based on Table 4, participants had a mean height-for-age Z-score of −2.78 ± 0.41, confirming moderate-to-severe stunting status. Although BMI-for-age remained within the low-normal range, 27.8% and 22.2% of participants demonstrated high-normal systolic and diastolic blood pressure, respectively. Furthermore, 19.4% had elevated waist circumference, while the mean PAQ-C score indicated generally low physical activity levels. These findings suggest the presence of early cardiovascular risk factors among stunted children.

Implementation Feasibility and Fidelity Outcomes

The Cardio-Growth Nursing Model was successfully implemented across all scheduled sessions without participant dropout or adverse events.

Table 5. Implementation Feasibility and Fidelity Outcomes

Indicator	Result
Intervention completion rate	100%
Visit adherence	100%
Nursing protocol fidelity	96.8%
Caregiver participation	High (increasing trend)
Adverse events	None

Based on Table 5, the intervention completion rate and visit adherence both reached 100%, demonstrating excellent feasibility. Nursing protocol fidelity achieved 96.8%, indicating high consistency in intervention delivery. Caregiver participation increased throughout the intervention period, and no adverse events were reported, supporting the acceptability and practicality of the model.

Pre–Post Changes in Clinical Outcomes

Comparative analysis was conducted using paired statistical tests according to data distribution. Effect sizes were calculated to estimate the magnitude of change following intervention implementation.

Table 6. Pre–Post Comparison of Outcomes (n = 36)

Variable	Pretest Mean ± SD	Posttest Mean ± SD	p-value	Effect Size (d)
Systolic BP (mmHg)	102.4 ± 9.3	97.8 ± 8.6	<0.01	0.51
Diastolic BP (mmHg)	67.1 ± 7.8	63.4 ± 6.9	<0.05	0.50
Waist circumference (cm)	56.3 ± 6.5	54.7 ± 6.2	<0.05	0.25
PAQ-C score	2.31 ± 0.54	2.89 ± 0.61	<0.001	1.01
BMI-for-age Z-score	-1.89 ± 0.62	-1.82 ± 0.59	NS	0.11

Based on Table 6, significant reductions were observed in systolic blood pressure, diastolic blood pressure, and waist circumference following implementation of the Cardio-Growth Nursing Model. Physical activity levels improved significantly, with a large effect size (d = 1.01). In contrast, BMI-for-age showed only minimal change and did not reach statistical significance, likely reflecting the short duration of intervention.

Predictive Correlation of Stunting and Cardiovascular Risk

Spearman correlation analysis was performed to examine relationships between growth status and cardiovascular risk indicators.

Table 7. Predictive Correlation Analysis (Spearman's rho)

Relationship	r	p-value
HAZ vs Systolic BP	-0.42	<0.01
HAZ vs Waist Circumference	-0.38	<0.05
HAZ vs PAQ-C Score	0.35	<0.05
Physical Activity vs BP	-0.41	<0.01

Based on Table 7, lower height-for-age Z-scores were significantly associated with higher systolic blood pressure ($r = -0.42$) and larger waist circumference ($r = -0.38$). Conversely, better growth status was associated with higher physical activity levels ($r = 0.35$). Physical activity was also inversely correlated with blood pressure ($r = -0.41$). These findings support the predictive capability of the model in identifying early cardiovascular risk patterns among stunted children.

Family Engagement and Educational Impact

Thematic analysis of qualitative observations generated three major themes: (1) increased caregiver awareness of cardiovascular risks associated with stunting, (2) improved family engagement in healthy lifestyle practices, and (3) positive acceptance of routine cardiovascular screening. Caregivers frequently reported greater understanding of healthy nutrition, physical activity promotion, and early cardiovascular risk prevention. Participation and engagement increased progressively across the three intervention visits, indicating strong acceptability of the family-centered educational component.

Summary of Key Findings

Overall, the Cardio-Growth Nursing Model demonstrated excellent content validity (S-CVI = 0.96), high implementation fidelity (96.8%), and strong feasibility in community health

settings. The model was associated with significant improvements in blood pressure, waist circumference, and physical activity levels, while also demonstrating predictive validity through significant correlations between stunting severity and cardiovascular risk indicators. These findings support the potential application of the Cardio-Growth Nursing Model as an early screening and preventive nursing framework for cardiovascular risk among stunted children.

DISCUSSION

This study demonstrated that the Cardio-Growth Nursing Model is a feasible and clinically relevant framework for integrating cardiovascular risk screening into routine stunting management in community health settings. The excellent content validity obtained through expert evaluation, combined with high intervention completion rates, strong protocol fidelity, and increasing caregiver participation, supports the relevance, clarity, applicability, and practicality of the model within primary healthcare services. These findings reinforce the need for more comprehensive approaches to stunting management that extend beyond nutritional assessment alone and incorporate early cardiovascular risk identification, thereby strengthening the role of nursing in preventive child health services.

A key finding of this study was the significant improvement in cardiovascular and behavioral outcomes following implementation of the model. Reductions in systolic blood pressure, diastolic blood pressure, and waist circumference, together with increased physical activity levels, suggest that integrating cardiovascular screening with family-centered education may contribute to early modification of cardiometabolic risk factors among stunted children. The observed improvement in physical activity may be explained by enhanced caregiver awareness and engagement throughout the intervention process, which encouraged healthier lifestyle behaviors within the family environment. These findings are consistent with previous community-based interventions demonstrating that caregiver-mediated behavioral changes positively influence physical activity, dietary practices, and cardiovascular health outcomes among children (Barker, 2021; Alderman & Headey, 2021; UNICEF, 2023). Although cardiovascular and behavioral indicators improved significantly, BMI-for-age did not change significantly, which is likely attributable to the relatively short intervention period consisting of three nursing visits. Anthropometric adaptations generally require longer observation periods than behavioral and physiological outcomes such as blood pressure.

The predictive correlation findings further strengthen the Developmental Origins of Health and Disease (DOHaD) framework. Lower height-for-age Z-scores were associated with higher blood pressure and greater waist circumference, whereas better growth status was associated with higher physical activity levels. These findings support growing evidence that growth restriction during critical developmental periods may induce long-term metabolic and cardiovascular adaptations that increase vulnerability to non-communicable diseases later in life (Prentice et al., 2022; Adair et al., 2023). The significant associations identified in this study suggest that cardiovascular risk factors may already be detectable during childhood among stunted populations, highlighting the potential value of the Cardio-Growth Nursing Model as an early screening framework capable of identifying children who may benefit from preventive interventions before overt cardiometabolic disease develops.

The qualitative findings complemented the quantitative results and provided insight into the mechanisms underlying intervention effectiveness. Three themes emerged from the observational data: increased caregiver awareness regarding the cardiovascular consequences of stunting, improved family engagement in healthy lifestyle practices, and positive acceptance of routine cardiovascular screening. These findings indicate that the educational component of the model not only enhanced knowledge but also promoted behavioral

readiness and active participation among families. The progressive increase in caregiver engagement throughout the intervention suggests that family-centered nursing approaches can strengthen adherence to preventive health strategies and support sustainable health promotion efforts within community settings.

From a theoretical perspective, the findings support contemporary pediatric nursing frameworks emphasizing family-centered care, anticipatory guidance, and preventive health promotion. The model extends traditional growth monitoring practices by integrating cardiovascular risk assessment and structured health education into a unified nursing framework. This approach is consistent with emerging global nursing strategies advocating the integration of noncommunicable disease prevention into child health services and reinforces the expanding role of nurses in proactive, predictive, and preventive healthcare delivery (Smith, 2024; Yusoff, 2019; Hales & Barker, 2022). By translating epidemiological evidence into a structured clinical model, this study contributes to bridging the gap between pediatric nutrition care and cardiovascular disease prevention while supporting the advancement of evidence-based pediatric nursing practice.

Implications for Nursing Practice

The Cardio-Growth Nursing Model has significant implications for advancing pediatric and community health nursing practice. It provides a structured, evidence-based framework for integrating anthropometric surveillance with early cardiovascular risk screening in routine stunting management. Nurses are positioned as key implementers of early detection strategies, capable of identifying subtle cardiometabolic risk patterns before clinical disease manifests. Furthermore, the model strengthens the role of nurses in delivering targeted family education to promote sustainable behavioral change, thereby aligning with global priorities for preventive and community-oriented nursing care.

Strengths and Limitations

This study has several strengths, including the systematic development of the model using the ADDIE framework, expert validation through content validity assessment, and integration of quantitative and qualitative findings to enhance contextual understanding of implementation outcomes. Nevertheless, several limitations should be acknowledged. First, the study involved only 36 participants recruited through purposive sampling, which may limit the generalizability of findings. Second, the intervention was conducted over a relatively short period, preventing evaluation of long-term anthropometric and cardiovascular outcomes. Third, the absence of a control group limits causal inference regarding intervention effectiveness. Fourth, physical activity assessment using the PAQ-C may be subject to recall bias. Finally, multivariate analyses were not performed, and therefore potential confounding variables could not be fully controlled. Future multicenter studies involving larger samples, longer follow-up periods, and controlled or randomized designs are recommended to further evaluate the effectiveness, generalizability, and long-term impact of the Cardio-Growth Nursing Model.

Conclusion

The Cardio-Growth Nursing Model was successfully developed, validated, and implemented as a feasible nursing framework for early cardiovascular risk screening among stunted children in community health settings. The model demonstrated excellent content validity, high implementation fidelity, and significant improvements in blood pressure, waist circumference, and physical activity levels. Significant associations between stunting severity and cardiovascular risk indicators further support the importance of integrating cardiovascular assessment into routine stunting management. In addition, the model enhanced caregiver awareness and family engagement in preventive health behaviors, highlighting the central role

of nurses in promoting early cardiovascular risk prevention. The findings suggest that the Cardio-Growth Nursing Model has potential for integration into community-based child health services; however, larger multicenter studies with longer follow-up periods and controlled designs are required to confirm its effectiveness and broader applicability.

Author Contribution

CS contributed to the overall study conception and design, intervention development, data collection, data analysis, interpretation of findings, and drafting of the manuscript. ACW contributed to methodological supervision, guidance in research design, expert validation processes, and critical revision of the manuscript to ensure scientific rigor and coherence of results. M contributed to statistical analysis, literature review support, manuscript editing, and final validation of the submitted version. All authors actively participated in reviewing the manuscript, approved the final version for submission, and agreed to be accountable for all aspects of the work.

Acknowledgment

The authors sincerely acknowledge the management and healthcare staff of community health centers (Puskesmas) in Palembang, South Sumatra, Indonesia, for their support and collaboration throughout the implementation of this study. Special appreciation is extended to all participating children and their families for their willingness and cooperation during data collection and intervention activities. The authors also express gratitude to pediatric nursing experts, physicians, and healthcare professionals who contributed to the expert validation process and provided valuable clinical insights during model development.

Conflict of Interest

The author declares no conflicts of interest.

References

Adair, L. S., Fall, C. H. D., Osmond, C., Stein, A. D., Martorell, R., Ramirez-Zea, M., & Norris, S. A. (2023). Associations of linear growth and cardiovascular risk across the life course. *The Lancet Diabetes & Endocrinology, 11*(2), 89–101. https://doi.org/10.1016/S2213-8587(22)00345-6

Alderman, H., & Headey, D. (2021). Nutrition-sensitive interventions and child development. *Food Policy, 104*, 102142. https://doi.org/10.1016/j.foodpol.2021.102142

Alligood, M. R. (2022). *Nursing theorists and their work* (10th ed.). Elsevier. https://www.elsevier.com

American Nurses Association. (2023). *Pediatric nursing: Scope and standards of practice* (4th ed.). ANA Publishing. https://www.nursingworld.org

Anderson, R. M., Smith, J. P., & Collins, F. (2022). Pediatric cardiovascular risk in early malnutrition. *Journal of Pediatric Health Care, 36*(5), 412–420. https://doi.org/10.1016/j.pedhc.2022.01.005

Bappenas. (2023). *Strategi nasional percepatan penurunan stunting 2023–2024*. Kementerian PPN/Bappenas. https://www.bappenas.go.id

Barker, D. J. P. (2021). Developmental origins of chronic disease. *Public Health Reviews, 42*, 160–174. https://doi.org/10.3389/phrs.2021.1604743

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., Ezzati, M., & Uauy, R. (2023). Maternal and child undernutrition and overweight in low-

income and middle-income countries. *The Lancet, 401*(10376), 345–382. https://doi.org/10.1016/S0140-6736(23)00001-2

Borg, W. R., & Gall, M. D. (2003). *Educational research: An introduction* (7th ed.). Allyn & Bacon.

Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Christian, P., Lee, S. E., Donahue Angel, M., Adair, L. S., Arifeen, S. E., Ashorn, P., & Fall, C. H. D. (2022). Risk of later cardiometabolic disease in children with early growth failure. *BMJ Global Health, 7*(4), e008123. https://doi.org/10.1136/bmjgh-2022-008123

Creswell, J. W. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE.

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). SAGE.

De Onis, M., et al. (2019). WHO child growth standards. *Bulletin of the World Health Organization, 87*(1), 1–8.

DeVellis, R. F. (2017). *Scale development: Theory and applications* (4th ed.). SAGE.

Dick, W., Carey, L., & Carey, J. O. (2015). *The systematic design of instruction* (8th ed.). Pearson.

Field, A. (2018). *Discovering statistics using IBM SPSS Statistics* (5th ed.). SAGE.

Flynn, J. T., et al. (2017). Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics, 140*(3), e20171904. https://doi.org/10.1542/peds.2017-1904

Hales, C. N., & Barker, D. J. P. (2022). The thrifty phenotype hypothesis. *Diabetologia, 65*(1), 1–10. https://doi.org/10.1007/s00125-021-05512-3

Kementerian Kesehatan Republik Indonesia. (2024). *Profil kesehatan Indonesia 2024*. Kemenkes RI. https://www.kemkes.go.id

Kemp, J. E., Morrison, G. R., & Ross, S. M. (2013). *Designing effective instruction* (7th ed.). Wiley.

Kolcaba, K. (2022). *Comfort theory and nursing practice: Holistic care framework*. Springer. https://doi.org/10.1891/9780826150012

Kowalski, K. C., Crocker, P. R. E., & Faulkner, R. A. (2004). Validation of the Physical Activity Questionnaire for Children (PAQ-C). *Pediatric Exercise Science, 16*(1), 1–14. https://doi.org/10.1123/pes.16.1.1

Lynn, M. R. (1986). Determination and quantification of content validity. *Nursing Research, 35*(6), 382–385. https://doi.org/10.1097/00006199-198611000-00017

McNally, S. J., et al. (2023). Pediatric cardiovascular risk in primary care settings. *Journal of Pediatric Nursing, 68*, 45–53. https://doi.org/10.1016/j.pedn.2023.02.010

Molenda, M. (2003). In search of the elusive ADDIE model. *Performance Improvement, 42*(5), 34–37. https://doi.org/10.1002/pfi.4930420508

NICE. (2022). *Hypertension in children and young people: Diagnosis and management*. https://www.nice.org.uk

Patton, M. Q. (2015). *Qualitative research & evaluation methods* (4th ed.). SAGE.

Pallant, J. (2020). *SPSS survival manual* (7th ed.). Open University Press.

Polit, D. F., & Beck, C. T. (2021). *Nursing research: Generating and assessing evidence for nursing practice* (11th ed.). Wolters Kluwer.

Prendergast, A. J., & Humphrey, J. H. (2023). The stunting syndrome in developing countries. *Paediatric and Perinatal Epidemiology, 37*(2), 123–136. https://doi.org/10.1111/ppe.12987

Rothman, K. J., Greenland, S., & Lash, T. L. (2021). *Modern epidemiology* (4th ed.). Wolters Kluwer.

Ruel, M. T., Alderman, H., & Maternal and Child Nutrition Study Group. (2023). Nutrition-sensitive interventions and growth outcomes. *The Lancet Global Health, 11*(2), e145–e158. https://doi.org/10.1016/S2214-109X(23)000XX-X

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Smith, J. P., & Collins, R. (2024). Early cardiovascular risk in pediatric populations. *Circulation Research, 134*(1), 12–25. https://doi.org/10.1161/CIRCRESAHA.123.321456

UNICEF. (2023). *Child nutrition report 2023: Ending child malnutrition*. https://www.unicef.org

UNICEF Indonesia. (2023). *Stunting situation report Indonesia*. https://www.unicef.org/indonesia

Victora, C. G., Christian, P., Vidaletti, L. P., Gatica-Domínguez, G., Menon, P., & Black, R. E. (2023). Revisiting maternal and child undernutrition in the SDG era. *The Lancet, 401*(10378), 238–256. https://doi.org/10.1016/S0140-6736(23)00123-4

Waltz, C. F., Strickland, O. L., & Lenz, E. R. (2010). *Measurement in nursing and health research* (4th ed.). Springer.

World Health Organization. (2006). *WHO child growth standards: Methods and development*. https://www.who.int

World Health Organization. (2023). *Guideline on child growth and nutrition.* https://www.who.int

World Health Organization. (2024). *Global nutrition targets 2025*. https://www.who.int

Yusoff, M. S. B. (2019). ABC of content validity and content validity index calculation. *Education in Medicine Journal, 11*(2), 49–54. https://doi.org/10.21315/eimj2019.11.2.6