Indonesian Dental Association

Journal of Indonesian Dental Association

http://jurnal.pdgi.or.id/index.php/jida
ISSN: 2621-6183 (Print); ISSN: 2621-6175 (Online)

Research Article

Prediction Model of Pre, Peri-, and Postnatal Factors for Early Childhood Caries in Stunted Children of Juwiring, Central Java, Indonesia (A Life Course Approach)

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KEYWORDS

Dental caries, ECC, Life course, Prediction model, Prenatal, Perinatal, Postnatal.

Received: 31 August 2025
Revised: 25 September 2025
Accepted: 24 October 2025
Published: 26 October 2025

ABSTRACT

Introduction: The life course approach highlights how early life, beginning with fetal growth, influences future disease risk. Oral health studies in Indonesia using this approach are still limited. This study examined the relationship between ECC status and retrospective data on stunted children under three and their mothers' pregnancy history at Juwiring District Community Health Center. **Objective:** This study aims to examine the influence of pre, peri-, and postnatal factors on ECC occurrence in stunted children in Juwiring Regency, Central Java. **Methods:** Secondary data of pre, peri-, and postnatal information from 265 stunted children were obtained from the medical records. Oral examination was assisted by local dentists from the health center. Multiple logistic regression analysis was performed to construct a prediction model and determine the factors with the greatest influence on dental caries in stunted children in Juwiring District. **Results:** The prevalence of dental caries was 69.1% in 246 subjects. The variables in the final prediction model for factors related to ECC were the mother's perception of her child's dental problems, the mother's education level, the mother's knowledge of dental caries, and the child's stunting status. The most influential factor was the mother's perception of her child's dental problem, with the highest odds ratio (OR) of 5.1 (1.83–14.23). **Conclusion:** This study revealed that prenatal factors related mothers' education level and postnatal factors related to mothers' perceived dental problems, poor knowledge of dental caries and children's stunting status were included in the ECC prediction model for the stunted children of Juwiring District.

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DOI: 10.32793/jida.v8i2.1434

INTRODUCTION

Early development influences a person's health as an adult. The environment during an individual's infancy or childhood has a long-term impact on their health as an adult. Barker suggested that chronic diseases that a person develops in adulthood are the result of environmental influences programmed from the time of conception through adulthood.[1] This concept is known as the life course perspective or approach, which has been evident from longitudinal studies for cardiovascular, respiratory, diabetes, cancer, psychosocial, etc.[2]

There are four common models of the life course approach, which are not mutually exclusive, and time is an important factor. The first model is the critical period model, also known as fetal programming or biological programming, known as Barker's hypothesis. Exposure during a specific period of growth or physical development can alter several underlying body structures or systems, resulting in damage or disease that emerges later in life. The second model is the critical period model with modifying effects. An individual's risk of developing a disease due to exposure early in life can be modified by exposures received during development. These modifying effects can increase or decrease the risk of disease. The third model is the risk factor accumulation model. The accumulation of risk factors shapes a person's health trajectory from early life to adulthood. The fourth model is the risk factor chain model. This concept is the dynamic interaction between intrinsic individual factors and extrinsic factors, such as family factors, that results in an increased individual risk of developing a disease.[3,4] Another life course model that has been introduced is the intergenerational life course approach. The intergenerational transmission of health inequalities from parents to offspring through the pre- and postnatal environments contributes to socioeconomic inequalities in adult health. The relative positions of parents and offspring in the social hierarchy are closely related, as observed for educational attainment, income, wealth, and occupational class, within time and place variations.[5]

Oral health research with this type of approach is still scarce, especially in Indonesia. The life course concept aligns with the development of oral and dental disease because of its chronic, cumulative, and socially patterned nature.[2] Oral and dental diseases are linked to social conditions, reflected in disparities, with lower-income groups suffering more.[6] Social status is associated with clinical and subjective outcomes throughout a person's life. Poor oral health reflects low socioeconomic status and is strongly associated with general health.[7] Oral health can also be used to identify at-risk individuals, linking it to their general health and socioeconomic environment from conception. Several types of hard dental tissue abnormalities have been shown to be clinically indicative of systemic diseases, socioeconomic status, nutritional status, pregnancy conditions, genetic and hereditary conditions, and depictions of prehistoric societies, such as enamel defects.[8-13]

Dental caries has also been shown to be associated with social class and can interfere with children's growth and development.[14-16] Several cross-sectional studies have examined the relationships between early-life biomarkers such as birth weight and dental caries.[17] Children with a history of low birth weight had a higher average rate of dental caries. A relationship between average caries experience and height was also observed, with taller children having lower caries scores.[18-19] A cross-sectional study in Beji District, Depok, West Java, revealed that the proportion of children with primary tooth decay among mothers with a history of undernutrition (LiLA <23.5 cm) during pregnancy was significantly greater (85%) than that among mothers with a normal nutritional status (46.1%).[20]

The Juwiring District in Klaten Regency Central Java has a special program, organized by the Juwiring Community Health Center for addressing stunting, called JUWITA 1000 Harta (Juwiring Responds to the First 1000 Days). This program started in 2013 to reduce stunting rates, low birth weight, and the risk of maternal and infant mortality. The program's framework has registered hundreds of children within the 19 villages of Juwiring District.[21] The local health authorities administered medical records of mothers and children during their participation in the program. The availability of retrospective data about children's growth and development medical records made it possible to conduct research that linked pre, peri-, and postnatal information to children's current dental caries status. This study is the first in Indonesia to develop a life course prediction model of early childhood caries in stunted children, integrating pre, peri-, and postnatal factors.

MATERIALS AND METHODS

The Juwiring District Stunting Program

The design of this study was cross-sectional and uses secondary data from the Juwiring Community Health Center from 2022--2024 for 264 stunted children aged under 3 years. A purposive sampling technique was applied for respondent selection with criteria such as residing in Juwiring District, being registered in the JUWITA 1000 Harta program, and completing the mother and child health card (KMS) at Integrated Health Service Posts (Posyandu). The children aged under 3 years were already diagnosed with stunting by the Juwiring Community Health Center medical team based on body length or height-for-age index (PB/U or TB/U), according to the anthropometric standards of the WHO.[22]

Secondary data of pre, peri-, and postnatal information about the history of pregnancy, birth, and growth monitoring records were obtained from the health card. The health conditions during pregnancy variables were weight gain, sickness history, and prenatal check-ups. Pregnancy term, birthweight, birth helper, type of delivery, and crying at birth were recorded as perinatal information. For postnatal information, the program recorded nutritional status; sickness history, such as frequency and diagnosed diseases; and vaccination history. To maintain data validity and minimize bias, several steps were taken. Data completeness was ensured through systematic extraction of child health records at the Community Health Center (Puskesmas) (including the JUWITA 1000 Harta register and KMS). Each entry was cross verified using the child's name, mother's name, and date of birth. Inconsistent data were verified directly with the original Puskesmas records.

Clinical Examination and Interview

Dental caries status was assessed via the dmft index.[23] This study used an intraoral camera for clinical examination. Two operators were calibrated prior to the clinical examination, with substantial kappa agreement ranging from 0.70 to 0.75. From 265 children under 3 years old, 246 children aged 6 to 36 months were included in the study according to the pattern of tooth eruption reported by the Journal of American Dental Association (JADA) in 2005.[24] Before the examination, parents were provided with an informed consent form and an assent form. Ethical approval was obtained from the Dentistry Research Ethics Committee, Faculty of Dentistry, University of Indonesia (Protocol Number: 011281024). The research procedures were developed and reported on the basis of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[25]

Additional information, such as socioeconomic and demographic status, child feeding patterns, mothers' knowledge, preventive practices toward dental caries, and perceptions of their children's oral health, was collected via structured questionnaires. The parental education category was based on a national educational system that sets nine years of study throughout elementary and junior high school as low education.[26] Economic status was assessed on the basis of parental income, categorized relative to the regional minimum wage (UMR) of Klaten Regency in 2024, which was IDR 2,244,000. The parents' income was categorized as low if it was under IDR 2,244,000 and high if it was greater than or equal to IDR 2,244,000.[27] The Central Statistics Agency (BPS) defines employment status into formal and informal employment.[28]

Child feeding patterns were categorized as follows: (1) poor= not consuming some complete nutrition from birth until the time the study was conducted, including exclusive breastfeeding for up to 2 years; (2) sufficient= consuming complete nutrition from birth until the time the research was conducted, including exclusive breastfeeding for less than 2 years; and (3) good= consuming complete nutrition from birth until the time the research was conducted, including exclusive breastfeeding for 2 years.[29-30] Mothers' perceptions of their children's oral health are categorized as yes if they think their children have dental problems and no if the mothers feel that their children have no dental health problems. Mothers' knowledge of dental caries and preventive practices for dental caries were also measured. Recall bias was controlled by using a structured questionnaire. Parents' responses were verified whenever possible with community health center (Puskesmas) or integrated health post (Posyandu) records. Enumerators were trained to conduct standardized interviews and avoid suggestive questions.

Data Analysis

Statistical analysis was conducted via SPSS version 29. Multivariate analysis aimed to assess the strength of the relationship between ECC and its influencing pre, peri-, and postnatal factors via multiple logistic regression. For a parsimonious predictive model, the modeling process followed the following steps: (1) determine the independent variables included in the model with $p< 0.250$ and substantially related to the dental caries variable in the bivariate analysis; (2) use the Enter method, all variables are entered into the model to control simultaneously the influence of potentially confounding variables; (3) variables with the highest nonsignificant p values are removed one by one until all final variables reach partial significance of $p< 0.1$; (4) interaction testing is intended to identify potential effect modifier variables; (5) the model quality is tested via the Hosmer–Lemeshow test, classification accuracy, and ROC test; and (6) the most independent variable with the greatest influence on ECC in the final model, along with other predictors that formed the last model, is identified.

RESULTS

Prevalence and Variable Selection

The prevalence of ECC in 246 subjects was 69.1%, with an overall mean number of dmfts of 2.33 (2.4) teeth per person (Table 1). Prenatal factors included parents' education, income, age, height, child order, family size (number of children), mothers' weight gain during pregnancy, sickness history, and prenatal control during pregnancy (Table 2). The prenatal factors that were significantly related to ECC were parents' education and fathers' income. The perinatal factors included in the study were term pregnancy, type of delivery, birth help, birth weight, and whether the child cried at birth. None of the perinatal factors were significantly related to ECC, as shown in Table 3. The postnatal factors included sex, child's age at the time of ECC examination, wasting status, stunting status, sickness history (frequency and diagnosed diseases), and vaccination. A set of questionnaires to interview mothers about perceived dental problems, knowledge levels of dental caries, and preventive practices for the children were also carried out. Postnatal factors that were significantly related to ECC were the child's age at examination time, stunting status, perceived dental problems, number of problematic teeth, mother's knowledge of dental caries, and preventive practices for the children, as shown in Table 4.

Tabel 1. ECC distribution in 246 stunted children in Juwiring District

Early Childhood Caries	Frequency (%)	Mean (SD)
Prevalence		
Yes	170 (69.1)	
No	76 (30.9)	
Dmft index		2.33 (2.4)

Prediction Modeling

The variables included in the multiple logistic regression (LR) model are the variables from the pre, peri-, and postnatal periods that showed a significant relationship and had p values less than 0.250 in the bivariate analysis. The variables in the final prediction model for factors related to ECC for children under 3 years of age in Juwiring District were mothers' perceptions of their child's dental problems, mothers' education level, mothers' knowledge about dental caries, and the child's stunting status. The prenatal factor that was included in the prediction model was only the mother's education level. Mothers' perceived dental problems, poor knowledge about dental caries and the child's stunting status in the prediction model were postnatal factors (Table 5).

The most influential factor was the mother's perception of her child's dental health problem, with the highest odds ratio (OR) of 5.104 (1.83–14.23). Mothers with perceptions of their child having dental problems were 5 times more likely to have dental caries than mothers with no perceptions of oral health problems. Mothers with a low level of education were 3.2 times more likely to have ECC than mothers with a higher level of education. Mothers with poor knowledge about dental caries are 1.975 times more likely to have ECC than mothers with good knowledge. Severely stunted children were 2.4 times more likely to have ECC than were milder stunted children.

The model fit the data ($p<0.005$) because it was significant according to the chi-square test ($x2=58.236$; df=4). The equation quality was assessed via the Hosmer–Lemeshow test, classification accuracy, and receiver operating characteristic (ROC) test. The Hosmer–Lemeshow test revealed that the LR model was well calibrated because $p>0.05$ ($p=0.989$). However, the quality of the prediction model is lacking from some other measures. The predictive accuracy value of this research model was only 69.1%, which is considered fair. The AUC of the ROC curve analysis was 0.775 or 77.5%, indicating that the regression equation has a moderate ability to distinguish healthy and sick subjects. The Nagelkerke R square of 0.297 means that the factors in the final model can explain the ECC by only 29.7%, and the model needs other variables to reach at least 50%.

DISCUSSION

A Global Burden of Oral Diseases study revealed that of the 530 million people with primary dental caries worldwide in 2017, approximately 267 million, or 7.9%, were from lower-middle-income countries such as Indonesia. The global incidence of primary dental caries is 6,776 per 100,000 people (6.78%).[31-32] IHME data on the burden of oral disease in Indonesia in 2018 revealed that the rate of primary dental caries in Indonesia was even higher. A total of 7,251 people per 100,000 people suffer from primary dental caries, or 7.25%.[33]

The prevalence of ECC in ≤3-year-old stunted children in Juwiring District was 69.1%, which was lower than the national prevalence of RISKESDAS 2018 (81.5%).[34] The overall mean dmft of the ≤3-year-old stunted children in Juwiring District was 2.3 (2.4) teeth per person, which was lower than the national dmft mean at 3--4 years of age from RISKESDAS 2018 (6.2) and SKI 2023 (4.9).[34--3]

Table 2. Prenatal factors and ECC in stunted children in Juwiring District

Prenatal variables	Total (N=246)	ECC	OR	*p*
Father's education			2.067	**0.001**‡
Junior High or less	132(53.7)	104(78.8)	(1.359-3.144)	
High School	93(37.8)	55(59.1)		
Bachelor or above	21(8.5)	11(52.4)		
Mother's education			3.064	**0.001**‡
Junior High or less	141(57.3)	114(80.9)	(1.966-4.777)	
High School	85(34.6)	50(58.8)		
Bachelor or above	20(8.1)	6(30.0)		
Father's occupation			1.232	NS‡
Unemployed	4(1.6)	4(100)	(0.244-6.207)	
Nonformal jobs	239(97.2)	163(68.2)		
Formal jobs	3(1.2)	3(100)		
Mother's occupation			0.823	NS$^{\#}$
Unemployed	157(63.8)	105(66.9)	(0.548-1.237)	
Employed	88(35.8)	64(72.7)		
Father's income			2.614	**0.009**‡
No income	6(2.4)	6(100)	(1.275-5.358)	
<Regional min wage	209(85.0)	148(70.8)		
≥Regional mi wage	31(12.6)	16(51.6)		
Mother's income			0.880	NS$^{\#}$
No income	158(64.2)	107(67.7)	(0.589-1.315)	
Have income	88(35.8)	63(71.6)		
Child's order			1.088	NS‡
≥5th born or more	5(2.0)	5(100.0)	(0.644-1.839)	
3rd-4th born	78(31.7)	52(66.7)		
1st-2nd born	163(66.3)	113(69.3)		
Number of children			1.084	NS‡
>5	4(1.6)	4(100)	(0.639-1.839)	
3-5	83(33.7)	56(67.5)		
1-2	159(64.6)	110(69.2)		
Father's age			1.865	NS$^{\#}$
≥45 yo	23(9.3)	19(82.6)	(0.750-4.636)	
<45 yo	222(90.2)	150(67.6)		
Mother's age			1.321	NS$^{\#}$
<20 or >35 yo	90(36.6)	67(74.4)	(0.871-2.003)	
20 to 35 yo	154(62.6)	102(66.2)		
Mother's height			1.084	NS$^{\#}$
<145 cm	7(2.8)	5(71.4)	(0.213-5.912)	
≥145 cm	239(97.2)	165(69.0)		
Mother's weight gain			1.101	NS‡
>16 kg	12(4.9)	9(75.0)	(0.680-1.783)	
<11.5 kg	143(58.1)	99(69.2)		
11.5-16 kg	91(37.0)	62(68.1)		
Prenatal check-ups			1.208	NS‡
Never	4(1.6)	4(100)	(0.723-2.018)	
Midwife	124(50.4)	86(69.4)		
GP/Gynecologist	118(48.0)	80(67.8)		
Sickness history			0.938	NS$^{\#}$
Yes	43(17.5)	29(67.4)	(0.582-1.512)	
No	203(82.5)	141(69.5)		

$^{\#}$Chi square
‡Simple logistic regression

Table 3. Perinatal factors and ECC in stunted children in Juwiring District

Perinatal variables	Total N=246	ECC	OR	*p*
Pregnancy term			1.053 (0.644-1.722)	NS[ǂ]
Preterm	19(7.7)	13(68.4)		
Late term	10(4.1)	8(80.0)		
Full term	217(88.2)	149(68.7)		
Types of delivery			0.844 (0.581-1.225)	NS[#]
Cesarean section	103(41.9)	68(66.0)		
Normal	143(58.1)	102(71.3)		
Birth helper			1.025 (0.773-1.360)	NS[ǂ]
Midwife	103(41.9)	71(68.9)		
GP	18(7.3)	14(77.8)		
Gynecologist	127(50.8)	85(68.0)		
Birth weight			0.563 (0.315-1.009)	0.054[ǂ]
<2.5 kg	54(22.0)	31(57.4)		
2.5-3.8 kg	185(75.2)	134(72.4)		
>3.8 kg	7(2.8)	5(71.4)		
Crying at birth			1.875 (0.310-11.332)	NS[#]
No	6(2.4)	5(83.3)		
Yes	240(97.6)	165(68.8)		

[#]Chi square
[ǂ]Simple logistic regression

Although this study was cross-sectionally conducted for ECC clinical examination and several postnatal risk factors, many other factors that occurred during the pre, peri- and postnatal periods were recorded in the stunting program of the Juwiring District Community Health Center. Therefore, we have the opportunity to establish a temporal relationship for the ECC risk factor prediction model. The final prediction models of ECC risk factors for 3-year-old stunted children in Juwiring District were the mother's education level, the mother's perception of her child's dental problems, the mother’s poor knowledge about dental caries, and the mother’s stunting status.

Socioeconomic status is very important so that children who grow up in an unfavorable socioeconomic environment are more likely to have poor health status as well. Research using a life course approach has proven a consistent relationship.[6] Parents’ education, occupation, income, number of children, and child order have been shown to be associated with ECC in several review studies.[36-39] In this Juwiring District study, although parents’ education and income were significant in the bivariate analysis, only mothers’ education was significantly related to ECC in the final model, with a greater risk of OR= 17.8 times for those with low education levels and OR= 4.3 times for those with moderate education levels to experience ECC in their children. This result was consistent with those of other studies.[40-43]

Socioeconomic inequalities in the fetal environment contribute to inequalities in fetal development and birth outcomes, with lifelong socioeconomic and health consequences.[5] Cohort studies in New Zealand and Brazil demonstrate the importance of socioeconomic status, which can even influence intergenerational health status. This also applies to parental knowledge and attitudes toward oral health.[44-45] Parental oral health knowledge and attitudes appear to underlie the continuity of oral health between generations.[46] The variable of mothers’ knowledge about dental caries was one of the variables in the final model of multivariate analysis in this Juwiring District study. The OR was significant at 10.3, indicating that mothers with poor knowledge levels are 10.3 times more likely for their children to have ECC than are mothers with good knowledge levels. This result is in accordance with studies in Jordan,[47] southern Brazil,[48] Taiwan,[43] and Indonesia[49-50].

Socioeconomic status can determine health beliefs and the perceived need for the use of family dental health care, which can then affect children's oral health, including increased susceptibility to caries. There is a strong relationship between socioeconomic status and dental health behavior.[5] In this study, mothers’ perceptions of their child’s dental health problems were the most influential factor, with the highest OR of 36.539 (12.904--103.464). Mothers with poor perceptions of their child's dental health were 36.5 times more likely for their children to experience dental caries than mothers with good perceptions were. This result is in accordance with studies in Jordan and

Indonesia. A total of 650 pairs of mothers and children in Jordan reported that 25.7% of mothers had perceptions that their children had poor dental health and that more than half (53.3%) were not aware that their children had dental caries.[47] Mothers' perceptions of their children's perceived susceptibility to dental health and the severity risk of dental caries to their children's dental health are related to their attitudes toward their child's oral health.[50]

Table 4. Postnatal factors and ECC in stunted children in Juwiring District

Postnatal variables	Total (N=246)	ECC	OR	*p*
Sex			1.196	NS[#]
Female	121(49.2)	87(71.9)	(0.820-1.743)	
Male	125(50.8)	83(66.4)		
Age at examination time			6.194	**0.001**[‡]
25-36 months			(3.579-10.721)	
13-24 months	163(66.3)	135(82.8)		
≤12 months	71(28.9)	35(49.3)		
	12(4.9)	0(0)		
Wasting status			0.932	NS[‡]
Overweight	98(39.8)	66(67.3)	(0.704-1.234)	
Thinness	13(5.3)	9(69.2)		
Normal	135(54.9)	95(70.4)		
Stunting status			1.846	**0.002**
Severely stunted	172(69.5)	129(75.4)	(1.286-2.650)	[#]
Stunted	75(30.5)	41(54.7)		
Sickness history			0.938	NS[#]
Yes	43(17.5)	29(67.4)	(0.582-1.512)	
No	203(82.5)	141(69.5)		
Sickness frequency per year			0.946	NS[‡]
>4 times	34(13.8)	21(61.8)	(0.652-1.275)	
3-4 times	76(30.9)	56(73.7)		
1-2 times	136(55.3)	93(68.4)		
Diagnosed disease			0.792	NS[#]
Yes	13(5.3)	8(61.5)	(0.388-1.619)	
No	233(94.7)	162(68.5)		
Vaccination history			1.257	NS[#]
Not complete	20(8.1)	15(75.0)	(0.574-2.750)	
Complete	226(91.9)	155(68.6)		
Mothers' perceived dental problem			4.381	**0.001**
No	188(76.4)	117(62.2)	(1.858-10.329)	[#]
Yes	58(23.6)	53(91.4)		
Number of problematic teeth			3.432	**0.001**[‡]
>3	27(11.0)	26(96.3)	(1.709-6.892)	
1-2	30(12.2)	25(83.3)		
None	189(76.8)	119(63.0)		
Eating habit pattern			1.392	NS[‡]
Poor	15(6.1)	14(93.3)	(0.788-2.457)	
Moderate	20(8.1)	11(55.0)		
Good	211(85.8)	145(68.7)		
Mother's knowledge about dental caries			2.086	**0.021**[‡]
Poor	18(7.3)	17(94.4)	(1.118-3.892)	
Moderate	26(10.6)	19(73.1)		
Good	202(82.1)	134(66.3)		
Mother's preventive habit toward caries			1.766	**0.007**[‡]
Poor	39(15.9)	34(87.2)	(1.164-2.679)	
Moderate	121(49.2)	83(68.6)		
Good	86(35.0)	53(61.6)		

[#]Chi square
[‡]Simple logistic regression

Table 5. Prediction model of factors related to ECC in stunted children in Juwiring District

Variabel[c]	β	OR	95% CI	*p*
Mother's perceived of dental problem	1.630	5.104	(1.830-14.234)	0.002
Mother's education level	1.174	3.234	(1.995-5.243)	0.001
Stunting status	0.991	2.693	(1.415-5.123)	0.003
Mother's knowledge of dental caries	0.681	1.975	(1.000-3.901)	0.050

[c]Multiple logistic regression; Constant -6.391

Based on data from UNICEF and the WHO, Indonesia ranks 27th out of 154 countries with a relatively high prevalence of stunting. Although the country has made progress in reducing stunting, with the prevalence decreasing from 24.4% in 2021 to 21.6% in 2022, its rate is still considered notably high, placing it fifth among Asian countries.[51] The WHO stated that 1 in 5 Indonesian children under the age of 5 are stunted or too short for their age.[52] In 2024, the prevalence of stunting in Central Java Province reached 20.8%, whereas in Klaten Regency, it was 11%.3.[53] In this Juwiring District study, severely stunted children were 2.4 times more likely to have ECC than mildly stunted children were in the final prediction model. This result was in accordance with studies in Nigheria and China.[54-56] A study using RISKESDAS 2018 data that linked 5-year-old stunted children with their ECC status revealed that 92.3% of stunted children had ECC.[57] Poor nutritional status, including stunting, is known to affect various aspects of health, including dental and oral health. Several studies have shown that stunting can cause a decrease in the salivary flow rate due to salivary gland atrophy associated with protein and vitamin A deficiency. This decrease in saliva production can weaken the oral cavity's ability to defend against infection, reduce the acid-neutralizing capacity of dental plaque, and therefore increase the risk of dental caries. Chronic malnutrition impedes tooth development, causing a weaker tooth structure due to disturbances in amelogenesis,[58-61] thus increasing the likelihood of ECC.

Despite the use of a cross-sectional design, this study utilized prospectively collected pre, peri-, and postnatal data from the JUWITA 1000 Harta program to approximate temporal patterns across life stages. Therefore, the results are interpreted as predictive associations, not causal effects. However, this study has several limitations. Since it involves purposive sampling and a specific population of children who are diagnosed as stunted, the prediction is also limited in application. For the purpose of building a prediction model, a larger sample size is needed to avoid random error since there are variables with association values that are risk factors that are not statistically significant. Other limitations were still related to bias. Given that prenatal and perinatal information was collected by community health center staff as secondary data, there might be systematic bias for the research instrument. The use of secondary data and parent questionnaires has the potential to introduce information bias; despite bounded recall, matching with community health center records and training of enumerators, recall bias and residual misclassification are still possible. Another limitation concerns the model itself. The model quality assessment met the criteria as an adequate predictor model at some of the assessments, but with such a low coefficient of determination, the study should include more direct variables of dental caries determinants, especially those related to the biological aspects of stunting, which include salivary gland atrophy and nutritional deficiencies.

Regarding the type of life course model, this study more fits to the second model, which is critical period with effect modification. The critical period model with effect modification is a more nuanced version of the critical period concept. It recognizes that early exposures can be critical, but their long-term consequences are not fixed; they can be amplified or mitigated by other exposures or characteristics that act as effect modifiers. Stunting linked to mother's pregnancy condition and can be corrected within 1000 days after birth. There is biological link from stunting to dental caries such as decrease of saliva flow rate, saliva content that could act as dental caries prevention, and tooth structure development.[62] Thus, if stunting status can be corrected during the critical window for intervention, the risk of dental caries occurrence can also be decreased. The growing new model of life course, intergeneration model, was can also be seen in this study. The variables mother's perceived of dental health problems and knowledge about dental caries linked to their children oral health status. Parental behavior appears to underlie oral health continuity between generation, this includes habits such as oral hygiene practice, smoking, going to the dentist, etc.[45-46] Socioeconomic status that usually an important factor in life course approach, unfortunately could not be proven in this study.

ECC and stunting are still public health concerns, especially in Indonesia. Therefore, it is important to plan a multisectoral approach of health promotion and intervention program, especially for critical period of stunting (1000 days. Oral health improvement strategies need to focus on ecomanagement of the underlying social determinants of chronic conditions (NCDs), including oral diseases.

CONCLUSION

As the first study in Indonesia to develop a prediction model for early childhood caries (ECC) in stunted children via a life course approach encompassing pre, peri-, and postnatal factors by utilizing longitudinal data from the JUWITA 1000 Harta program, the model identified a combination of social factors, education, and nutritional status as predictors of ECC. The variables in the final prediction model for factors related to ECC for children under 3 years of age in Juwiring District were mothers' education level as prenatal factors, mothers' perception of their child's dental problems, mothers' poor knowledge of dental caries, and the child's stunting status as post-natal factors. Mothers' education levels indicate that early-life exposure can shape mothers' attitudes and ultimately affect their health. Stunting, which closely results from socioeconomic factors such as poverty, could also be a factor in a child's health deterioration. Understanding these psychosocial determinants is critical for improving long-term oral health, especially ECC prevention. This provides new evidence that goes beyond previous studies, which generally assessed only single risk factors cross-sectionally without producing an integrated prediction model.

ACKNOWLEDGMENT

The authors would like to thank the Juwiring Community Health Center and the Klaten Regency Government, Central Java, for their support of this research.

CONFLICT OF INTEREST

There are no conflicts of interest related to the published article.

REFERENCES

1. Barker DJP. Developmental origins of chronic disease. Public Health. 2012; 126(3): 185–189. DOI: 10.1016/j.puhe.2011.11.014
2. Burton-Jeangros C, Cullati S, Sacker A, Blane D. A Life Course Perspective on Health Trajectories and Transitions. Life Course Research and Social Policies, Vol 4. Springer. 2015. DOI: 10.1007/978-3-319-20484-0_1
3. Ben-Shlomo Y, Kuh D. A life course approach to chronic disease epidemiology: conceptual models, empirical challenges, and interdisciplinary perspectives. Int J Epidemiol. 2002; 31(2): 285-93. DOI: 10.1093/ije/31.2.285
4. Nicolau B, Thomson WM, Steele JG, Allison PJ. Life-course epidemiology: concepts and theoretical models and its relevance to chronic oral conditions. Community Dent Oral Epidemiol. 2007; 35(4): 241–249. DOI: 10.1111/j.1600-0528.2007.00332.x
5. Houweling TAJ, Grünberger I. Intergenerational transmission of health inequalities: toward a life course approach to socioeconomic inequalities in health - a review. J Epidemiol Community Health. 2024; 78(10): 641–649. DOI: 10.1136/jech-2022-220162.
6. Hobdell MH, Oliveira ER, Bautista R, Myburgh NG, Narendran S, Johnson NW. Oral diseases and socioeconomic status (SES). Br Dent J. 2003; 194(2): 91–96. DOI: 10.1038/sj.bdj.4809882
7. Sheiham A, Alexander D, Cohen L, Marinho V, Moysés S, Petersen PE, et al. Global oral health inequalities: Task group – Implementation and delivery of oral health strategies. Adv Dent Res. 2011; 23(2): 259–267. DOI: 10.1177/0022034511402084
8. Lin X, Wu W, Zhang C, Lo ECM, Chu CH, Dissanayaka WL. Prevalence and distribution of developmental enamel defects in children with cerebral palsy in Beijing, China. Int J Pediatr Dent. 2010; 21(1): 23–28. DOI: 10.1111/j.1365-263X.2010.01075.x
9. Salanitri S, Seow W. Developmental enamel defects in the primary dentition: etiology and clinical management. Aust Dent J. 2013; 58(2): 133–140. DOI: 10.1111/adj.12039\
10. Seow WK. Developmental defects of enamel and dentine: Challenges for basic science research and clinical management. Aust Dent J. 2014; *59 Suppl 1*, 143–154. DOI: 10.1111/adj.12104
11. Oliveira RE, Neves WA. Oral health in prehistoric San Pedro de Atacama oases, Northern Chile. J Comp Hum Biol. 2015; 66(6): 492–507. DOI: 10.1016/j.jchb.2015.05.001
12. Heilmann A, Tsakos G, Watt RG. Oral Health Over the Life Course. In Life Course Research and Social Policies, A Life Course Perspective on Health Trajectories and Transition, C. Burton-Jeangros, S. Cullati, A. Sacker, D. Blane, D. Springer, New York. 2015, Vol.4, pp. 53-54. DOI: 10.1007/978-3-319-20484-0_3
13. Modrić VE, Verzak Ž, Karlović Z. Developmental Deffects of Enamel in Children with Intellectual Disability. Acta Stomatol Croat. 2016; 50(1): 65–71. DOI: 10.15644/asc50/1/9
14. Sheiham A. Dental caries affects body weight, growth and quality of life in preschool children. Br Dent J. 2006; 201(10): 625–626. DOI: 10.1038/sj.bdj.4814259
15. Sheiham A, Alexander D, Cohen L, Marinho V, Moysés S, Petersen PE, et al. Global oral health inequalities: Task group – Implementation and delivery of oral health strategies. Adv Dent Res. 2011; 23(2): 259–267. DOI: 10.1177/0022034511402084
16. Duijster D, Sheiham A, Hobdell MH, Itchon G,

Monse B. Associations between oral health-related impacts and rate of weight gain after extraction of pulpally involved teeth in underweight preschool Filipino children. BMC Public Health. 2013; 13: 533. DOI: 10.1186/1471-2458-13-533

17. Nicolau B, Marcenes W, Bartley M, Sheiham A. A life course approach to assessing causes of dental caries experience: the relationship between biological, behavioral, socioeconomic, and psychological conditions and caries in adolescents. Caries Res. 2003; 37: 319-26. DOI: 10.1159/000072162
18. Nicolau B, Marcenes W, Allison P, Sheiham A. The life course approach to explain the association between height and dental caries in Brazilian adolescents. Community Dent Oral Epidemiol. 2005; 33: 93-8. DOI: 10.1111/j.1600-0528.2005.00213.x
19. Peres MA, Macpherson LMD, Weyant RJ, Daly B, Venturelli R, Mathur MR, et al. Oral diseases: a global public health challenge. Lancet (London, England). 2019; 394(10194): 249–260. DOI: 10.1016/S0140-6736(19)31146-8
20. Badrudddin IA, Khansa M, Darwita RR, Rahardjo A. The Relation of Mothers's Nutritional Status to Primary Teeth Dental Caries. Int J App Phar. 2017; Vol.9, Special Issue 2. DOI: 10.22159/ijap.2017.v9s2.38
21. Portal Informasi Warga Jateng. Mengenal JUWITA, di Balik Turunnya Angka Stunting di Klaten [Internet]. 2022. Available from: https://jatengprov.go.id/publik/mengenal-juwita-di-balik-turunnya-angka-stunting-di-klaten/
22. Regulation of the Minister of Health of the Republic of Indonesia (PMK) No. 2 of 2020 concerning Child Anthropometric Standards. https://peraturan.bpk.go.id/Details/152505/permenkes-no-2-tahun-2020.
23. WHO. Oral Health Surveys: Basic Methods. 5th ed. France. 2013. https://www.who.int/publications/i/item/9789241548649
24. ADA Division of Communications, Journal of the American Dental Association, & ADA Council on Scientific Affairs (2005). For the dental patient. Tooth eruption: The primary teeth. J Am Dent Assoc (1939), 136(11), 1619. https://doi.org/10.14219/jada.archive.2005.0095
25. Von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol. 2008; 61(4): 344-349.
26. Ministry of Education Affair. Law Number 20 of 2003 concerning the National Education System. https://pusmendik.kemdikbud.go.id/pdf/file-154
27. Decree of the Governor of Central Java No. 561/45 of 2024 concerning Minimum Wages in 35 Regencies/Cities and Sectoral Minimum Wages in Central Java Province in 2024. https://jdih.jatengprov.go.id/inventarisasi-hukum/detail/kepgub_561-45_th_2024
28. Central Bureau of Statistics. Statistik Indonesia. BPS. 2021. Status pekerjaan utama.
29. Rusmil VK, Ikhsani R, Dhamayanti M, Hafsah T. Relationship between caregiver behavior in young child feeding practice among children aged 12-23 months with stunting at suburban area. Sari Pediatr. 2019; 20(6): 1–5. https://saripediatri.org/index.php/sari-pediatri/article/view/1473
30. Amin A made, Sudargo T, Gunawan IMA. Hubungan Pola Asuh Dan Asupan Gizi Terhadap Status Gizi Anak Umur 6-24 Bulan Di Kelurahan Mangempang, Kecamatan Barru, Kabupaten Barru [Tesis]. Universitas Gajah Mada; 2003. Akses: 11 Juli 2024. https://etd.repository.ugm.ac.id/penelitian/detail/
31. Bernabe E, et al. Global, Regional, and National Levels and Trends in Burden of Oral Conditions from 1990 to 2017: A Systematic Analysis for the Global Burden of Disease 2017 Study. J Dent Res. 2020; 99(4): 362-373. DOI: 10.1177/0022034520908533
32. James SL, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. The Lancet. 2018; 392(10159): 1789–1858. DOI: 10.1016/S0140-6736(18)32279-7
33. IHME. GBD 2019. Institute for Health Metrics and Evaluation [Internet]. 2021. Available from: https://vizhub.healthdata.org/gbd-compare/
34. Kemenkes RI. Laporan Nasional Riskesdas 2018. Lembaga Penerbit Balitbangkes, Jakarta. 2019.
35. Kemenkes RI. Survei Kesehatan Indonesia 2023. Lembaga Penerbit Balitbangkes, Jakarta. 2023).
36. Elamin A, Garemo M, Mulder A. Determinants of dental caries in children in the middle east and north africa region: A systematic review based on literature published from 2000 to 2019. BMC Oral Health. 2021; 21: 1-30. DOI: 10.1186/s12903-021-01482-7
37. Khan SY, Javed F, Ebadi MH, Schroth RJ. Prevalence and Risk Factors for ECC Among Preschool Children from India along with the Need of its Own CRA Tool- A Systematic Review. J Int Soc Prev Community Dent. 2022; 12(3): 295–308. DOI: 10.4103/jispcd.JISPCD_56_22
38. Folayan MO, Coelho EMRB, Ayouni I, Nguweneza A, Al-Batayneh OB, Daryanavard H, et al. Association between early childhood caries and parental education and the link to the sustainable development goal 4: a scoping review. BMC oral health. 2024; 24(1): 517. DOI: 10.1186/s12903-024-04291-w

39. Jabbarian R, Ranjbaran M, Mokhlesi A. et al. Iranian early childhood dental caries: a comprehensive systematic review and meta-analysis of prevalence and associated risk factors. Evid Based Dent. 2025; 26: 66. DOI: 10.1038/s41432-024-01078-4
40. Sahu P, Agrawal A, Jain D, et al. Association of Early Childhood Caries and Multiple Variable Factors in 3-6-year-old Children. Int J Clin Pediatr Dent. 2023;16(1):42-47. DOI: 10.5005/jp-journals-10005-2515
41. Yao S, Zhu J, Zhang H, Wang H, Da D, Yu J, . . . Zhang Y. Prevalence and risk factors for dental caries among 3-year-old children in Shanghai, China: A cross-sectional study. BMC Oral Health. 2025; 25: 1-13. DOI: 10.1186/s12903-025-06454-9
42. Orhan AI, Alkan A, Orhan K, Tezel A, Karaoglanoglu S, Oztas D. Dental caries and associated factors among Turkish children and adults: Findings from the 3rd National Oral Health Survey. Commmunity Dent Oral Epidemiol. 2024; 52(4): 499–508.
43. Chou YC, Cheng FS, Weng SH, Tseng CH, Hu HY, Liu CH. Impact of Parental Health Beliefs on Early Childhood Caries: A Two-Year Longitudinal Study. Int Dent J. 2025; *75*(5): 1-10. DOI: 10.1016/j.identj.2025.100902
44. Peres MA, de Oliverira Lattorre Mdo R, Sheiham A, Peres KG, Barros FC, Hernandez PG et al. Social and biological early life influences on severity of dental caries in children aged 6 years. Community Dent Oral Epidemiol. 2005; 33: 53-63. DOI: 10.1111/j.1600-0528.2004.00197.x
45. Shearer DM, Thomson WM. Intergenerational continuity in oral health: a review. Community Dent Oral Epidemiol. 2010; 38(6): 479-486. DOI: 10.1111/j.1600-0528.2010.00560.x
46. Shearer DM, Thomson WM, Caspi A, Moffitt TE, Broadbent JM, Poulton R. Family history and oral health: findings from the Dunedin Study. Community Dent Oral Epidemiol. 2012; 40(2): 105-115. DOI: 10.1111/j.1600-0528.2011.00641.x
47. Bani Hani A, Tahmassebi J, Zawaideh F. Maternal knowledge on early childhood caries and barriers to seek dental treatment in Jordan. Eur Arch Paediatr Dent. 2021; 22: 433–439. DOI: 10.1007/s40368-020-00576-0
48. Luz PB, Pereira JT, Knorst JK, Bonfadini I, Piva F, Scapinello M, Hugo FN, Araújo FB. The role of mother's knowledge, attitudes, practices in dental caries on vulnerably preschool children. Pesqui Bras Odontopediatria Clín Integr. 2020; 20:e4687. DOI: 10.1590/pboci.2020.007
49. Abdat M, Ramayana I. Relationship between mother's knowledge and behavior with oral health status of early childhood. Padjadjaran J Dent. 2020; 32(3): 166-173. https://jurnal.unpad.ac.id/pjd/article/view/24734
50. Taufan Bramantoro, Yayi Suryo P, Udijanto Tedjosasongko, Djauhar Ismail. Mother's belief regarding their children's dental health as a potential predictor of mother's dental health attitude for early childhood. J Int Dent Med Res. 2018; 11(3): 955-959.
51. UNICEF. Child Malnutrition Estimates; Key findings of the 2020 Joint Child Malnutrition Estimates UNICEF regions. 2020; 1 – 20.
52. WHO. Nutrition: Tackling the 'triple burden' of malnutrion in Indonesia. 2022. https://www.unicef.org/indonesia/nutrition#:~:text=Undernutrition-,Stunting,an%20intergenerational%20cycle%20of%20malnutrition.
53. Pemda Klaten. Bagian protokol dan komunikasi pimpinan Kabupaten Klaten. Membuka rakor evaluasi stunting, Bupati Klaten targetkan angka penurunan stunting 11 persen di 2024. https://prokopim.klaten.go.id/membuka-rakor-evaluasi-stunting-bupati-klaten-targetkan-angka-penurunan-stunting-11-persen-di-2024
54. Folayan MO, Arije O, El Tantawi M, Kolawole KA, Obiyan M, Arowolo O, et al. Association between early childhood caries and malnutrition in a suburban population in Nigeria. BMC Pediatrics. 2019; 19(1); 433. DOI: 10.1186/s12887-019-1810-2
55. Shen A, Bernabé E, Sabbah W. The bidirectional relationship between weight, height and dental caries among preschool children in China. PloS one. 2019; 14(4): e0216227. DOI: 10.1371/journal.pone.0216227
56. Wang D, Wang X, Zhao C, Ma S, Zhang Y, Shi H. Study on the association between malnutrition, early childhood caries and caries activity among children aged 3-5 years. BMC Oral Health. 2024; 24(1): 1035. DOI: 10.1186/s12903-024-04802-9
57. Badruddin IA, Muthia K, Darwita RR, Setiawati F, Adiatman M. Relationship between oral health status and stunting in 5-year-old children in Indonesia. JIDMR. 2021; 14(3): 1039-431. ISSN 1309-100X. https://www.jidmr.com/journal/wp-content/uploads/2021/10/28-D21_1600_Diah_Ayu_Maharani_Indonesia.pdf
58. Hijrawati, Usman AN, Syarif S, Hadju V, As'ad S, Baso YS. Use of technology for monitoring the development of nutritional status 1000 hpk in stunting prevention in Indonesia. Gac Sanit. 2021; 1(35): S231–4. DOI: 10.1016/j.gaceta.2021.10.028.
59. Nursal D, Kasuma N, Wulandari R, Ali H, Roza D, Setiawan I, et al. Stunting and its effects on salivary biomarkers and oral health: a cross-sectional analysis of flow rate, pH, and buffering capacity. Open Dent J. 2025; 19: e18742106366969. DOI: 10.2174/0118742106366969250221045942

60. Setijanto D, Hemadi AS, Dewanto I, Adiatman M, Wulan KA, Ningrum V, et al. The updated trend of association between dental caries and stunting in all age groups: a systematic review. Iran J Public Health. 2025; 54(2): 265–272. PMCID: PMC11992922
61. Setiawan AS, Indriyanti R, Suryanti N, Rahayuwati L, Juniarti N. Neonatal stunting and early childhood caries: A mini review. Front in Pediatr. 2022; 10: 871862. DOI: 10.3389/fped.2022.871862
62. Sadida ZJ, Indriyanti R, Setiawan AS. Does growth stunting correlate with oral health in children? a systematic review. Eur J Dent.x 2022; *16*(1): 32–40. DOI: 10.1055/s-0041-1731887