



ORIGINAL ARTICLE

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Relationship between overall child development and caries severity in Chilean three-year-old preschool children.

Abstract: To determine the relationship between caries and overall child development in three-year-old children in the cities of Linares and Talca, Chile, 2014-2015. Method: Cross-sectional study conducted in a sample of 170 preschool children attending daycare centers in Linares and Talca. Four dimensions of child development (language, cognition, motor skills and socio-emotional development) were qualitatively assessed using the child learning and development test (TADI, for its acronym in Spanish). Nutritional development was calculated with the weight/height index. Caries history was assessed by the dmft index and compromised tissue quantification. Statistical analysis was performed using Pearson's rho, ANOVA, Student's t-test, Fisher's exact test and Kruskal-Wallis. Results: A negative linear correlation was observed between dmft and total TADI score ($r=-0.20$, $p=0.00$), and the dimensions of language ($r=-0.19$, $p=0.01$), cognition ($r=-0.18$, $p=0.02$) and socio-emotional development ($r=-0.21$, $p=0.01$). Preschoolers with a dmft of >6.5 had a lower average TADI score than those with a dmft of <2.6 ($p=0.009$). There were no statistically significant differences in the level of compromised tissue quantification between preschool children with normal and altered development. No statistically significant association between dmft and nutritional development was found. Conclusion: A relationship between caries severity and overall child development in three-year-old preschool children was observed. Longitudinal studies are required to assess causality.

Keywords: *Dental Caries, Growth and Development, Child Development, Child, Preschool.*

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INTRODUCTION.

A number of fundamental skills are acquired during the overall child development process. Qualitative changes in motor, cognitive, language, emotional and social skills,^{1,2} and quantitative changes involving physical development are observed. In addition, it has been found that childhood experiences play a crucial role in the life course.³

At a global scale, at least 200 million children are not fully developed, having a negative impact on their health and the

society as a whole.⁴ In Chile, about 25% of children suffer from developmental delay, *i.e.*, they do not reach all the development milestones expected for their age.⁵ Research has shown that development is influenced by biological, socio-economic and cultural factors.⁶

Moreover, dental caries is the most prevalent oral disease in preschool children. In Chile, caries prevalence at two and four years of age reaches 17% and 50%, respectively.⁷ Caries and resulting infections cause pain and feeding problems,

and may hinder child development.⁸ It has been reported that advanced caries produce pain, irritability and disturbance in sleep, affecting the quality of life of children and potentially leading to impaired secretion of growth hormone.⁹

Infection and inflammation caused by caries result in increased energy expenditure and metabolic demand, and can lead to a decrease in micronutrients.⁹ Levels of glucocorticoids increase in response to pain caused by tooth infection,¹⁰ producing an alteration in neurogenesis.¹¹ Caries in preschoolers can cause depression, school distraction and increased chances of missing school, which can damage self-esteem resulting in school failure.¹²

There are no studies conducting an integrated assessment of development (cognition, language, motor skills and socio-emotional development)¹³ and its relationship with caries in preschool children. The aim of this study is to determine the relationship between caries severity and overall child development in three-year-old preschool children in the cities of Linares and Talca during the period 2014-2015.

MATERIALS AND METHODS.

A cross-sectional study was conducted in preschool children in the cities of Linares and Talca during the period 2014-2015. The study was approved by the Bioethics Committee of Universidad de Talca (No. 2014-024-CO). The children's parents signed an informed consent. Additionally, an assessment of the children's willingness to participate in the study was performed by researchers at the moment of the examination.

Population and sample size

All three-year-old preschoolers regularly attending the daycare centers selected for convenience in Talca and Linares between August 2014 and January 2015 were asked to participate in the study. Sample size calculation considered a level of significance of 5%, a power of 80%, and a proportion of preschool children who were underweight, with short stature, with dental caries and underweight, and with qualitative developmental delay of 11%.⁵ The estimated sample size was 164 preschoolers.

Data collection

Measurements were carried out at the daycare centers on different days, and registered on separate sheets to avoid bias. Each parent was asked to complete a questionnaire on demographic data. Data were collected by three calibrated observers. Techniques for measuring dmft index, the child learning and development test (TADI, for its acronym in Spanish) and the weight/height index were standardized. The dmft calibration was performed in 10 three-year-old preschoolers. Each observer examined a preschool child twice, having at least a 30-minute gap between both examinations, without access to the initial examination. Intra-observer Kappa coefficient was 0.94 and inter-observer, 0.84.

Variables

The following variables were considered in the study: *Qualitative overall child development*: 4 dimensions (cognition, socio-emotional development, language and motor skills) were included. The total score was obtained from the average scores of each dimension. Qualitative overall child development was determined by means of TADI, which evaluates each dimension with a specific score. Total development and each developmental dimension were classified as: advanced, normal, normal with delay, risk for developmental delay and developmental delay.² This variable was categorized into normal development (total score between 40 and 59) and altered development (normal total score with some altered dimension or a score of ≤ 39).

Quantitative overall child development: measured by the weight/height index, classified as: malnourished, risk of malnutrition, normal, overweight or obese.¹⁴ This variable was categorized into: altered by underweight, normal and altered by overweight.

Presence of caries: caries history, classified into present or absent.

Severity of caries: dmft was measured and classified into the following categories: very low dmft (0-1.2), low (1.2-2.6), moderate (2.7 to 4.4), high (4.5-6.5) or very high (>6.5).¹⁵

Compromised tissue quantification: Degree of involvement of the tooth structure, categorized into: no carious lesion (D0), white spot lesions (D1), enamel lesion (D2), dentine lesion

(D3) and compromised pulp (D4).¹⁶

Sex: male or female.

Place of residence: urban or rural.

Socioeconomic level: including income, educational level and stock of wealth accumulated by each household. It was categorized into: very high and high, mid and low.¹⁷

Statistical analysis

One-way ANOVA test was used to determine the association between dmft and *qualitative* child development as numeric variable. Fisher's exact test was used for its analysis as dichotomous variables. The correlation between dmft and TADI was determined by Pearson's rho. Student's t test or Mann-Whitney U test were used to determine the association between the level of compromised tissue quantification (quantitative variable) and *qualitative* child development, depending on the distribution of the variable. Fisher's exact test was used to determine the relationship between dmft and *quantitative* child development. One-way ANOVA test

was used to determine the relationship between the level of compromised tissue quantification (quantitative variable) and *quantitative* child development. Correspondence analysis was performed to observe the association of TADI and dmft indices; the closer they were to each other, the stronger their association. Data analysis was performed with Infostat (Infostat, Argentina) and SPSS 14.0 (IBM, USA).

RESULTS.

Two hundred and sixty preschool children were originally asked to participate in the study. Eighty-five did not respond, 3 children did not cooperate during the clinical examination and 2 parents refused to participate. The final sample consisted of 170 preschoolers.

Socioeconomic status of participating families was mainly mid-level (88.82%). The 66.47% of preschoolers were caries-free. The 24.00% had normal development with delay and 8.00% were at risk for developmental delay (Table 1).

Table 1. Description of the population by *qualitative* development

Variables		Total n (%)	Qualitative child development n (%)	
		n=170	Normal n=116	Altered n=54
Sex	Male	88 (51.76)	56 (48.27)	32 (59.25)
	Female	82 (48.23)	60 (51.72)	22 (40.74)
Place of residence	Urban	165 (97.05)	113 (97.41)	52 (96.29)
	Rural	5 (2.90)	3 (2.58)	2 (3.70)
Socioeconomic level	Very high and high	1 (0.58)	1 (0.86)	0 (0.00)
	Mid	151 (88.82)	103 (88.79)	48 (88.88)
	Low	18 (10.58)	12 (10.34)	6 (11.11)
dmft	Very low	123 (72.35)	85 (73.27)	38 (70.37)
	Low	9 (5.29)	8 (6.89)	1 (1.85)
	Moderate	16 (9.41)	13 (11.20)	3 (5.55)
	High	15 (8.82)	8 (6.89)	7 (12.96)
	Very high	7 (4.11)	2 (1.72)	5 (9.25)
Caries free		113 (66.47)	80 (68.96)	33 (61.11)
With caries		57 (33.52)	36 (31.03)	21 (38.88)
Compromised tissue quantification*	D2	46 (27.05)	29 (25.00)	17 (31.48)
	D3	30 (17.64)	17 (14.65)	13 (24.07)
	D4	1 (0.58)	0 (0.00)	1 (1.85)

*D2: enamel; *D3: dentin; *D4: compromised pulp.

Table 2. Description of population by quantitative development.

Variables		Total n (%)	Quantitative child development n (%)		
			Normal n=98	Altered by underweight* n=9	Altered by overweight* n=63
Sex	Male	88 (51.76)	50 (51.02)	5 (55.55)	33 (52.38)
	Female	82 (48.23)	48 (48.97)	4 (44.44)	30 (47.61)
Place of residence	Urban	165 (97.05)	95 (96.93)	9 (100.00)	61 (96.82)
	Rural	5 (2.9)	3 (3.06)	0 (0.00)	2 (3.17)
Socioeconomic level	Very high and high	1 (0.58)	0 (0.00)	0 (0.00)	1 (1.58)
	Mid	151 (88.82)	91 (92.85)	8 (88.88)	52 (82.53)
	Low	18 (10.58)	7 (7.14)	1 (11.11)	10 (15.87)
dmft	Very low	123 (72.35)	66 (67.34)	7 (77.77)	50 (79.36)
	Low	9 (5.29)	6 (6.12)	0 (0.00)	3 (4.76)
	Moderate	16 (9.41)	11 (11.22)	1 (11.11)	4 (6.34)
	High	15 (8.82)	9 (9.18)	1 (11.11)	5 (7.93)
	Very high	7 (4.11)	6 (6.12)	0 (0.00)	1 (1.58)
Caries-free		113 (66.47)	59 (60.20)	7 (77.77)	47 (74.60)
With caries		57 (33.52)	39 (39.79)	2 (22.22)	16 (25.39)
Compromised tissue quantification*	D2	46 (27.05)	31 (31.63)	2 (22.22)	13 (20.63)
	D3	30 (17.64)	21 (21.42)	1 (11.11)	8 (12.69)
	D4	1 (0.58)	1 (1.02)	0 (0.00)	0 (0.00)

* **Altered by underweight:** malnourished and risk of malnutrition. * **Altered by overweight:** overweight and obese.
* **D2:** enamel; **D3:** dentin; **D4:** compromised pulp.

The 1.18% (n=2) presented malnutrition and 4.12% (n=7) were at risk of malnutrition (Table 2).

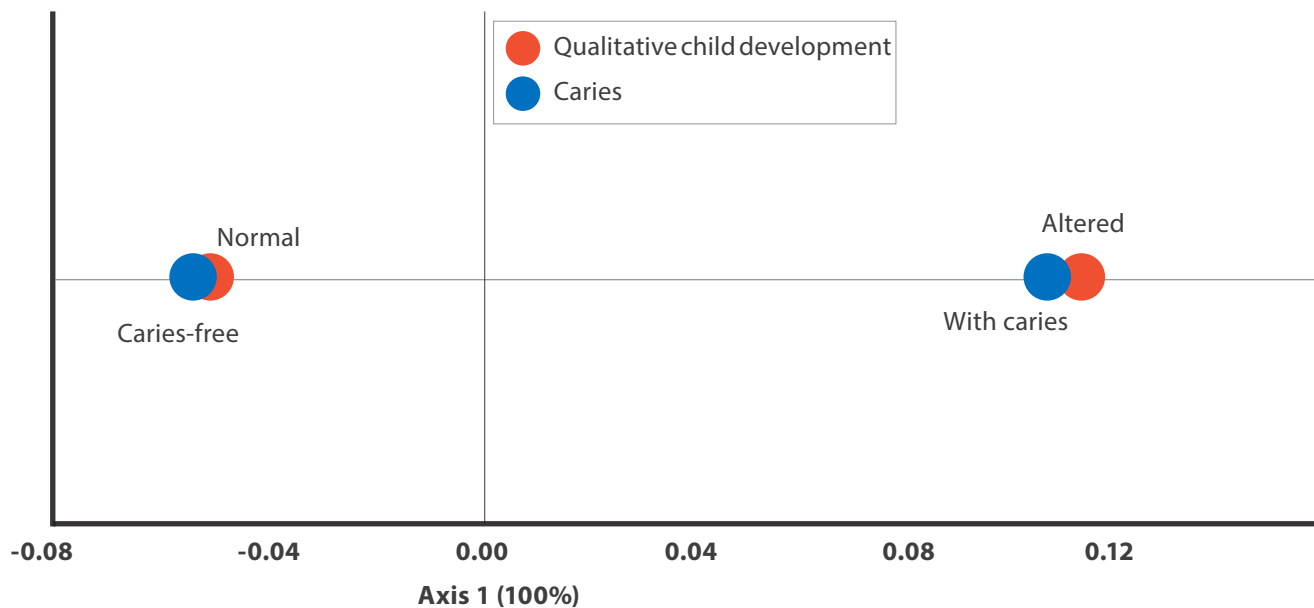
A negative linear correlation ($r=-0.2$, $p=0.004$) between the dmft index and TADI score was observed. Negative linear correlations were observed in language ($r=-0.19$, $p=0.01$), cognition ($r=-0.18$, $p=0.018$) and socio-emotional development ($r=-0.21$, $p=0.005$). A statistically significant correlation was not observed in the motor skills dimension ($r=-0.05$, $p=0.454$).

A significant difference was observed in the average TADI score for the dmft categories ($p=0.009$). Subsequent comparisons by ranges indicated that preschoolers with a very high dmft have a lower total TADI score than those with very low and low dmft. When making comparisons of dmft categories by dimensions of TADI it was noted that language

($p=0.052$) and motor skills ($p=0.62$) showed no significant difference. Regarding cognition, subsequent comparisons indicated that preschoolers with a very high dmft had a lower average cognition score when compared to children with a low dmft ($p=0.014$). Preschoolers with very high dmft had a lower socio-emotional development score than those with a low dmft ($p=0.03$).

No statistically significant differences were found between the level of compromised tissue quantification and normal or altered level of child development ($p=0.49$). Likewise, no statistically significant differences were found in TADI dimensions ($p>0.05$).

Correspondence analysis revealed that caries-free preschoolers were associated with a normal *qualitative* child development. Preschoolers with caries were associated with an

Figure 1. Correspondence analysis of *qualitative* child development and caries.

altered *qualitative* child development (Figure 1). No statistically significant association was observed between caries and *quantitative* child development ($p=0.91$). Similarly, it was not found a statistically significant difference between the degree of compromised tissue quantification and the different levels of child development ($p=0.98$)

DISCUSSION.

The present study assessed the relationship between dental caries and quantitative and qualitative child development. A negative linear correlation was found between the total TADI score and the dmft index. The same was observed for the dimensions of language, cognition and socio-emotional development.

As for the dimensions evaluated by TADI, only motor skills was not correlated with dmft. Current evidence supports indirectly only the relationship between caries and the other dimensions, since caries affect school performance and grades,¹⁸ speech and self-esteem.¹²

Quantitative child development was not found to be associated with caries. This can be explained because only two preschool children with malnutrition and seven at risk of malnutrition were included in this study, making it diffi-

cult to make a comparative analysis. Prevalence of malnutrition in Chile in children under 5 years is 0.5%, which is lower than the prevalence in the present study.¹⁹ Studies establishing an association between caries and *quantitative* child development⁸ have been carried out in countries with a higher prevalence of malnutrition, such as Philippines with 13.1%,²⁰ India, 17.8%²¹ and Suriname, 6%.¹⁹

Evidence of the relationship between caries and *qualitative* child development is limited. In Chile a pilot study addressing this relationship was conducted using the test of psychomotor development (TEPSI), which is commonly applied in Chilean primary care services. A significant correlation between TEPSI score and dmft was observed, however no association was found between caries prevalence and child development measured as dichotomous variables.¹³ There are no other studies assessing the association between caries and child development.

There are some studies describing the impact of caries in factors related to qualitative child development, but not its direct impact on it. In Saudi Arabia,²¹ it was found that treating caries with compromised pulp significantly reduced pain, dental sepsis, lack of appetite and dissatisfaction with teeth and smile. This dissatisfaction undermines the

socio-emotional development of preschoolers, which would explain the differences in the social-emotional dimension among preschool children with high and low dmft found in this study.

A study conducted in California²³ showed that oral health has an impact on the academic performance of children (grades, number of lost school days and work days lost by parents). In turn, research conducted in Brazil¹⁸ showed that children with toothache had difficulty eating certain foods and 26% of them missed school because of tooth caries. Therefore, school absence caused by caries can affect school performance as a proxy variable of cognitive development. This is consistent with the results of this study, where preschoolers with a very high dmft have a lower score in the dimension of cognition than those with low dmft.

Contrasting the relationship between *quantitative* child development and caries with other studies is difficult due to the low prevalence of malnutrition. Most research on this relationship has been conducted in populations with caries and compromised pulp in communities whose caries prevalence is 87.1%⁹ and 82.3%.²⁰

Scientific evidence is still inconclusive. A study in India²¹ reported that children who received a comprehensive dental treatment showed a significant increase in their weight. On the other hand, a study in Suriname⁸ found a negative correlation between caries and body growth; however a statistically significant difference was not found in the development pattern between the experimental and control groups after treatment. These discrepancies may be due to the multifactorial nature of child development.

Relación entre el desarrollo infantil integral y la severidad de caries en preescolares chilenos de 3 años.

Resumen: Determinar la relación entre la severidad de caries y el desarrollo infantil integral en preescolares de tres años de las ciudades Linares y Talca durante el período 2014-2015. Método: Estudio transversal con una muestra de 170 preescolares asistentes a jardines infantiles de Linares y Talca. El test de aprendizaje y desarrollo infantil (TADI) eva-

The cross-sectional design used in this research is not suitable to establish a causal relationship between caries and overall child development. However, this design allows to initially study their relationship, which should be later addressed in longitudinal studies to assess the cause-effect association. Another limitation of this study is the low caries prevalence with compromised pulp and malnutrition in the sample population. The use of a purposive sample is suggested for future research. In addition, the population attending Integra daycare centers has similar socioeconomic conditions, most having a mid-level socioeconomic status. Such homogeneity reduces the risk of bias caused by this confounding factor.

The results of this study could be extrapolated to preschool children with similar characteristics. This study is pioneer in evaluating the relationship between caries and overall child development using a *qualitative* approach. TADI is a new tool offering several advantages: it has a short application time (20-30 minutes), may be administered by different professionals, is standardized in Chile and covers children ranging from 3 months to 6 years of age.

CONCLUSION.

A statistically significant association between caries and *qualitative* child development was observed. As the severity of caries increases, TADI score is negatively affected.

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luó el desarrollo en cuatro dimensiones (lenguaje, cognición, motricidad y socioemocionalidad). El desarrollo nutricional se calculó con el índice peso/talla. Se evaluó la historia de caries mediante ceod y compromiso del tejido dentario. Se realizó análisis estadístico con rho de Pearson, ANOVA, t de student, test exacto de Fisher y Kruskal Wallis. Resultados: Se observó una correlación lineal negativa entre ceod y el puntaje total del TADI ($r=-0,20$, $p=0,00$), y las dimensiones de lenguaje ($r=-0,19$, $p=0,01$), cognición ($r=-0,18$, $p=0,02$) y

socioemocionalidad ($r=-0,21$, $p=0,01$). Los preescolares con ceod $>6,5$ tuvieron un promedio TADI menor que aquellos con ceod $<2,6$ ($p=0,009$). No hubo diferencias estadísticamente significativas entre el compromiso del tejido dentario entre preescolares con desarrollo normal y alterado. No se observó asociación estadísticamente significativa entre ceod

y desarrollo nutricional. Conclusión: Se observó una relación entre la severidad de caries y el desarrollo infantil integral en preescolares de tres años. Se requiere de estudios longitudinales para evaluar su causalidad.

Palabras clave: *Caries Dental; Crecimiento y Desarrollo; Desarrollo Infantil; Preescolar.*

REFERENCES.

1. Organización Mundial de la Salud (OMS); UNICEF. El desarrollo del niño en la primera infancia y la discapacidad: Un documento de debate. Malta: OMS; 2013.
2. Pardo M, Gómez M, Edwards M. Test de Aprendizaje y Desarrollo Infantil (TADI). Para niñas y niños de 3 meses a 6 años. Presentación de un nuevo instrumento chileno para evaluar el desarrollo infantil (Estado de avance). Serie reflexiones Infancia y adolescencia n.14. Chile: UNICEF-Chile; 2013.
3. Walker SP, Wachs TD, Grantham-Mcgregor S, Black MM, Nelson CA, Huffman SL, Baker-Henningham H, Chang SM, Hamadani JD, Lozoff B, Gardner JMM, Powell CA, Rahman A, Richter L. Inequality in early childhood: risk and protective factors for early child development. *Lancet*. 2011;378(9799):1325–38.
4. Engle PL, Fernald L, Alderman H, Behrman J, O’Gara CH, Yousafzai A, de Mello MC, Hidrobo M, Ulkuer N, Ertem I, Iltus S. Global Child Development Steering Group. Strategies for reducing inequalities and improving developmental outcomes for young children in low-income and middle-income countries. *Lancet*. 2011;378(9799):1339–53.
5. Leyton B, Becerra C, Castillo C, Strain H, Santander S. Ministerio de Salud (MINSAL); Gobierno de Chile. Programa Nacional de Salud de la Infancia con Enfoque Integral. Santiago, Chile: Ed Valente; 2013.
6. UNICEF, Argentina. Determinantes sociales y ambientales para el desarrollo de los niños y niñas desde el período del embarazo hasta los 5 años. 1a Ed. Argentina: UNICEF; 2015.
7. Ministerio de Salud (MINSAL); Gobierno de Chile. Guía de Práctica Clínica No GES Salud Oral en Adolescentes de 10 a 19 años. Prevención, Diagnóstico y Tratamiento de Caries, 2013. Chile: MINSAL; 2013.
8. van Gemert-Schriks MC, van Amerongen EW, Aartman IH, Wennink JM, Ten Cate JM, de Soet JJ. The influence of dental caries on body growth in prepubertal children. *Clin Oral Investig*. 2011;15(2):141–9.
9. Alkarimi HA, Watt RG, Pikhart H, Sheiham A, Tsakos G. Dental caries and growth in school-age children. *Pediatrics*. 2014;133(3):e616–23.
10. Sheiham A. Dental caries affects body weight, growth and quality of life in pre-school children. *Br Dent J*. 2006;201(10):625–6.
11. Fitzsimons CP, Herbert J, Schouten M, Meijer OC, Lucassen PJ, Lightman S. Circadian and ultradian glucocorticoid rhythmicity: Implications for the effects of glucocorticoids on neural stem cells and adult hippocampal neurogenesis. *Front Neuroendocrinol*. 2016;41:44–58.
12. Holt K, Barzel R. Oral Health and Learning: When Children’s Health Suffers, So Does Their Ability to Learn. 3rd Ed. Washington, D.C: National Maternal and Child Oral Health Resource Center; 2013.
13. Núñez FL, Sanz BJ, Mejía LG. [Dental caries and early childhood development: a pilot study]. *Rev Chil Pediatr*. 2015;86(1):38–42.
14. Ministerio de Salud (MINSAL); Gobierno de Chile. Referencia OMS Para la Evaluación Antropométrica. Niñas y Niños Menores de 6 Años. Chile: Organización Panamericana de la Salud; 2006.
15. The World Health Organization (WHO) Oral health surveys: basic methods. 5th Ed. France: The World Health Organization (WHO); 2013.
16. Burt B, Eklund S. Dentistry, Dental Practice, and the Community. 6th Ed. USA: Elsevier Saunders; 2005.
17. Instituto Nacional de Estadísticas, Chile. (INE) Estratificación Socioeconómica en Encuestas de Hogares. Chile: Departamento de Estudios Sociales, INE; 2011.
18. Feitosa S, Colares V, Pinkham J. The psychosocial effects of severe caries in 4-year-old children in Recife, Pernambuco, Brazil. *Cad Saude Publica*. 2005;21(5):1550–6.
19. von Grebmer K, Bernstein J, de Waal A, Prasai N, Yin S, Yohannes Y. 2015 Global hunger index: Armed conflict and the challenge of hunger. Bonn, Washington, DC, and Dublin: Welthungerhilfe, International Food Policy Research Institute, and Concern Worldwide; 2015.
20. Benzian H, Monse B, Heinrich-Welzian R, Hobdell M, Mulder J, van Palenstein Helder W. Untreated severe dental decay: a neglected determinant of low Body Mass Index in 12-year-old Filipino children. *BMC Public Health*. 2011;11:558.

21. Gaur S, Nayak R. Underweight in low socioeconomic status preschool children with severe early childhood caries. *J Indian Soc Pedod Prev Dent.* 2011;29(4):305–9.
22. Alkarimi HA, Watt RG, Pikhart H, Jawadi AH, Sheiham A, Tsakos G. Impact of treating dental caries on schoolchildren's anthropometric, dental, satisfaction and appetite outcomes: a randomized controlled trial. *BMC Public Health.* 2012;12:706.
23. Seirawan H, Faust S, Mulligan R. The impact of oral health on the academic performance of disadvantaged children. *Am J Public Health.* 2012;102(9):1729–34.