



Introduction

Early childhood caries (ECC) remains highly prevalent globally¹ and in city-state Singapore (~40%)² despite nearly seven decades of nation-wide (100%) water fluoridation.³ This paradox highlights the limitations of conventional caries prevention strategies and the importance of early-life developmental environment.^{4,5} Previous studies linking early-life growth to ECC have reported conflicting findings, partly due to reliance on single time-point measures. This study aims to assess potential growth-ECC association across specific developmental windows by employing:

- (1) novel conditional growth model capturing environmentally driven growth
- (2) longitudinal fetal and infant growth markers

Materials and Methods

A. Study Population

Growing Up in Singapore Towards Healthy Outcomes⁶

- Asian, multi-ethnic longitudinal cohort
- Recruited in 2009 to 2010 from two hospitals
 - Included Singaporeans or permanent residents of homogenous ethnicity who intend to stay for ≥5 years
 - Excluded mothers with type I diabetes, history of chemotherapy or psychotropic medications

C. Outcome Assessment

Measured using Modified ICDAS-II¹¹ criteria and WHO 1997 criteria¹²

- Caries experience** (dmft=0/>0)
- Low- or high-caries clusters** (L/HCC) using K-means for longitudinal data (KML)¹³



B. 1 Exposures: (1) Conditional Growth

- Growth beyond what is expected based on:
 - Genetics
 - Earlier Growth
- Measures growth due to environmental conditions

B. 2 Exposures: (2) Change z-Scores

Prenatal: ΔzFetal Abdominal Circumference (FAC)

- Measured at second and third trimester
- Liver size, fat deposition, and nutritional status
- Lower ΔzFAC → Restricted fetal growth
- Higher ΔzFAC → Increased adiposity



Postnatal: ΔzWeight

- Weight measured from birth to 2 years
- Indicates nutritional status and adiposity
- Lower ΔzWeight → growth faltering
- Higher ΔzWeight → rapid growth



ΔzFAC and ΔzWeight categories



Results

N = 737 mother-child dyads Y2 N = 492; Y3 N = 667; Y5 N = 465 High caries cluster n=328

1. Conditional Growth

Table 1: Associations between conditional growth in three periods (early pregnancy, mid-to-late pregnancy, infancy) and childhood caries risk cluster from ages two to five years (n = 328)

Conditional Growth	Risk of being in "high caries" cluster based on ICDAS-II criteria		Risk of being in "high caries" cluster based on WHO criteria	
	RR (95% CI)	p	RR (95% CI)	p
Early Pregnancy	0.87 (0.77 to 0.98)	0.026*	0.80 (0.68 to 0.95)	0.010*
Mid-to-late Pregnancy	0.98 (0.85 to 1.13)	0.767	0.92 (0.73 to 1.15)	0.452
Infancy	1.03 (0.92 to 1.15)	0.649	1.10 (0.94 to 1.28)	0.222

Higher conditional growth in early pregnancy was associated with a lower risk of HCC (Table 1)

2. Change z-Scores (ΔzFAC, ΔzWeight)

Table 2: Associations between early life growth and childhood caries risk at each timepoint from ages two to five years.

		Risk of caries based on ICDAS-II criteria		Risk of caries based on WHO criteria		
		RR (95% CI)	p	RR (95% CI)	p	
Fetal Growth	Y2 dmft >0	1.02 (0.63 to 1.65)	0.942	0.93 (0.24 to 3.63)	0.920	
	Y3 dmft >0	0.86 (0.67 to 1.11)	0.254	0.88 (0.59 to 1.33)	0.554	
	Y5 dmft >0	0.97 (0.8 to 1.17)	0.724	0.85 (0.63 to 1.16)	0.305	
	High caries cluster	0.98 (0.7 to 1.37)	0.926	1.02 (0.64 to 1.63)	0.919	
	Extreme Deceleration (Δ FAC z-score from 2 nd -3 rd trimester ≤ -2) ¹					
	Y2 dmft >0	2.83 (1.16 to 6.87)	0.022*	-	-	
	Y3 dmft >0	1.22 (0.73 to 2.06)	0.446	1.83 (0.98 to 3.41)	0.057	
	Y5 dmft >0	1.03 (0.66 to 1.62)	0.885	0.75 (0.33 to 1.67)	0.478	
	High caries cluster	2.37 (1.32 to 4.26)	0.004*	1.90 (0.70 to 5.17)	0.208	
	Acceleration (Δ FAC z-score from 2 nd -3 rd trimester < 2) ¹					
Y2 dmft >0	0.83 (0.47 to 1.47)	0.530	1.39 (0.41 to 4.74)	0.602		
Y3 dmft >0	0.99 (0.78 to 1.27)	0.967	1.03 (0.68 to 1.56)	0.879		
Y5 dmft >0	1.07 (0.88 to 1.30)	0.514	1.05 (0.77 to 1.41)	0.770		
High caries cluster	1.00 (0.70 to 1.43)	0.995	0.76 (0.43 to 1.35)	0.352		
Extreme Acceleration (Δ FAC z-score from 2 nd -3 rd trimester ≥ 2) ¹						
Y2 dmft >0	1.39 (0.56 to 3.43)	0.473	7.85 (1.62 to 38.09)	0.011*		
Y3 dmft >0	1.45 (0.89 to 2.38)	0.135	2.06 (0.98 to 4.34)	0.058		
Y5 dmft >0	1.35 (1.1 to 1.65)	0.004*	1.98 (1.47 to 2.68)	<0.001*		
High caries cluster	1.89 (1.22 to 2.93)	0.004*	1.49 (0.65 to 3.41)	0.344		

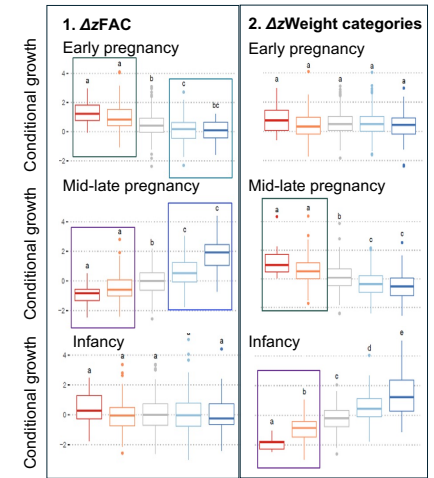
Extreme fetal growth deceleration and acceleration was associated with increased risk of ECC and HCC (Table 2)

Postnatal Weight Gain		Deceleration (-2 < Δ weight z-score from 0-2y ≤ -0.67) ²		Extreme Deceleration (Δ weight z-score from 0-2y ≤ -2) ²	
		RR (95% CI)	p	RR (95% CI)	p
Y2 dmft >0	1.26 (0.69 to 2.32)	0.454	2.88 (0.78 to 10.61)	0.111	
Y3 dmft >0	1.01 (0.76 to 1.36)	0.929	1.36 (0.87 to 2.13)	0.182	
Y5 dmft >0	0.87 (0.68 to 1.11)	0.253	1.07 (0.75 to 1.51)	0.716	
High caries cluster	0.83 (0.53 to 1.31)	0.431	0.84 (0.42 to 1.67)	0.611	
Acceleration (0.67 ≤ Δ weight z-score from 0-2y < 2) ²					
Y2 dmft >0	1.75 (0.36 to 8.59)	0.491	0.58 (0.08 to 4.30)	0.595	
Y3 dmft >0	1.96 (1.35 to 2.86)	<0.001*	3.40 (1.60 to 7.20)	0.001*	
Y5 dmft >0	1.28 (0.82 to 1.99)	0.276	1.48 (0.64 to 3.43)	0.358	
High caries cluster	2.06 (1.15 to 3.70)	0.016*	3.46 (1.57 to 7.62)	0.002*	
Extreme Acceleration (Δ weight z-score from 0-2y ≥ 2) ²					
Y2 dmft >0	1.50 (0.82 to 2.06)	0.257	2.29 (0.75 to 6.95)	0.144	
Y3 dmft >0	1.03 (0.83 to 1.28)	0.759	1.05 (0.72 to 1.52)	0.799	
Y5 dmft >0	1.03 (0.87 to 1.21)	0.741	1.10 (0.84 to 1.43)	0.486	
High caries cluster	1.03 (0.77 to 1.38)	0.857	1.15 (0.75 to 1.75)	0.519	
Extreme Acceleration (Δ weight z-score from 0-2y ≥ 2) ²					
Y2 dmft >0	1.34 (0.70 to 2.56)	0.376	1.03 (0.07 to 15.4)	0.985	
Y3 dmft >0	0.76 (0.48 to 1.19)	0.225	0.90 (0.47 to 1.73)	0.750	
Y5 dmft >0	0.84 (0.59 to 1.18)	0.319	0.84 (0.52 to 1.33)	0.452	
High caries cluster	0.83 (0.48 to 1.44)	0.514	0.90 (0.44 to 1.85)	0.783	

Extreme postnatal weight deceleration was associated with increased risk of ECC and HCC (Table 2)

Reference categories: 1. Fetal growth: -0.67 < ΔzFAC (2nd-3rd trimester) < 0.67
 2. Postnatal growth: -0.67 < Δzweight (0-2 years) < 0.67
 **Under WHO criteria, extreme fetal growth deceleration for Y2 dmft > 0 yielded a non-estimable effect, likely due to small sample size rather than a true null association.

Figure: Difference in conditional growth measures across



ΔzFAC deceleration groups:
 • Higher conditional growth in early pregnancy
 • Lower conditional growth in mid-to-late pregnancy

ΔzFAC acceleration groups (opposite pattern):
 • Lower conditional growth in early pregnancy
 • Higher conditional growth in mid-to-late pregnancy

ΔzWeight ≤ -2:
 • Higher mid-late pregnancy conditional growth acceleration
 • Followed by a marked reduction during infancy



Legend: Extreme Deceleration (red), Deceleration (orange), Normal (green), Acceleration (blue), Extreme Acceleration (purple)

Conclusion

Growth patterns in the first 1000 days in early life are pivotal markers of ECC risk.

- Higher intrauterine growth especially in early pregnancy significantly reduces ECC risk
- Excessive or decreased growth in mid-to-late pregnancy and growth faltering in infancy may increase ECC risk.

These results indicate that deciduous teeth may be a sentinel tissue of early developmental health, bridging oral biology with systemic growth pathways.

