Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Environmental and child-level correlates of traumatic dental injuries in preschool children attending childcare centres in Selangor, Malaysia: a multicentre cross-sectional study

Bikash Chaurasia

drbikash@lincoln.edu.my

Lincoln University College

Mark Low Jun Fay

Lincoln University College

Fazle Khuda

Lincoln University College

Wan Badrina Binti Wan Bunyamin

Lincoln University College

Goh Michelle

Lincoln University College

Research Article

Keywords: Traumatic dental injury, Preschool children, Childcare centre, Play surface, Falls, Malaysia

Posted Date: November 3rd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11393037/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Aim

To estimate the prevalence and pattern of traumatic dental injuries (TDI) in children aged 1–6 years attending early childhood care and education (ECCE) centres in Selangor, Malaysia, and to examine whether behavioural and childcare-environment factors are associated with TDI beyond child-level factors.

Methods

Children were sampled by cluster from 12 registered ECCE centres in three localities. Calibrated examiners recorded TDI using the Andreasen classification; caregivers completed a questionnaire, and a centre-level checklist recorded the environment. Eleven factors were entered into a mixed-effects logistic regression model with a random intercept for centre; generalised estimating equations (GEE) served as a sensitivity analysis.

Results

Of 372 children enrolled, 367 (98.7%) were analysed. TDI prevalence was 15.5% (95% CI 12.2–19.6%, unadjusted for clustering), higher in boys than girls (20.3% vs 10.3%). TDI prevalence was 29.5% in centres with a hard outdoor play surface and 7.7% in the others. TDI was independently associated with a hard outdoor play surface, a centre-level exposure (aOR 4.41, 95% CI 2.31–8.42; GEE 4.18, 1.84–9.48), ≥ 3 falls in six months (2.72, 1.39–5.33), first-born status (2.84, 1.40–5.76), male sex (1.96, 1.05–3.66) and overjet > 3 mm (2.18, 1.06–4.49). No professional care had been sought for 24 of 57 affected children (42.1%).

Conclusions

TDI was associated with child-level, behavioural and environmental factors. The hard-surface association rests on only 12 centres and may reflect other centre differences, but it suggests that the childcare environment may be a modifiable prevention target. Prospective and intervention studies are warranted.

Introduction

Traumatic dental injuries (TDI) to the teeth and supporting structures are among the most common yet least recognised paediatric oral health problems worldwide. An estimated one billion people have experienced a TDI, with incidence peaking first in early childhood and again in adolescence (Petti et al. 2018). The first peak coincides with the age range served by institutional early childhood care. Falls are

the leading cause of non-fatal childhood injury, and their incidence is highest when children begin walking independently, before their protective reflexes have matured (Bartolomeos 2008). In a prospective Swedish cohort, caregivers sought no professional care for over half of reported injury episodes (Odersjö et al. 2018), so clinic-based series underestimate the population burden and active population-based screening is needed.

A broad range of individual-level risk factors has been proposed. These include morphological determinants such as increased overjet (Arraj et al. 2019) and incompetent lip posture (Wig et al. 2022), anthropometric factors such as elevated body mass index (Soares et al. 2022; Motta-Rego et al. 2022), male sex (Alshayeb et al. 2025) and birth order (Käch et al. 2014), and socioeconomic status, for which the evidence is less consistent (Comim et al. 2024). By contrast, considerably less attention has been paid to the physical environment in which preschool children play and spend prolonged periods each day, although the World Health Organization identifies the physical fall environment as a key determinant of childhood injury (Bartolomeos 2008).

Data specific to Southeast Asia, and to institutional childcare settings in particular, remain sparse. A recent scoping review identified a persistent shortage of population-based, standardised prevalence data for the region and called for rigorous multi-centre studies (Karobari et al. 2025). Recent regional work has concentrated on clinic-based samples, which exclude injuries for which no care is sought (Kulvitit et al. 2025). To our knowledge, published Malaysian dental trauma literature has largely concerned older schoolchildren with permanent teeth (Esa and Abdul Razak 1996), and preschool oral health research has focused mainly on caries rather than trauma (Ramli et al. 2024).

Malaysian early childhood care and education (ECCE) is delivered through two parallel systems: TASKA (childcare centres registered under the Child Care Centre Act 1984 [Act 308] and regulated by the Department of Social Welfare; Malaysia 1984), serving children from infancy to approximately four years, and TADIKA (kindergartens regulated by the Ministry of Education), serving children aged four to six years. A growing number of combined centres span the full range. This study therefore asked which behavioural and environmental exposures, in addition to established child-level factors, are associated with TDI among preschool children attending ECCE centres in Selangor. We aimed to determine the prevalence and clinical pattern of TDI among children aged 1–6 years in ECCE centres in three Selangor localities using the Andreasen classification, which has been recognised by the World Health Organization (Abbott 2022), and to examine child-level, behavioural and environmental factors, with emphasis on potentially modifiable characteristics of the childcare environment.

Materials and methods

Study design

This analytical cross-sectional study of 12 ECCE centres is reported in accordance with the STROBE statement for cross-sectional studies (von Elm et al. 2007; Supplementary File 1).

Ethical considerations

The study was approved by the institutional ethics and review committee (December 2025) and conducted in accordance with the Declaration of Helsinki. Written permission was obtained from the management of each participating centre, and written informed consent from each child's parent or legal guardian before data collection. Developmentally appropriate verbal assent was additionally sought from children aged approximately four years and above. Participation was voluntary, and caregivers could withdraw their child at any point without effect on the child's enrolment at the centre. Data were de-identified using a coded study identifier. With caregiver consent, children found to have untreated dental trauma or other urgent dental needs (pulp exposure, tooth displacement or luxation, avulsion, complicated crown or crown–root fracture, signs of pulpal or periapical infection, persistent pain, swelling, or any condition judged to need prompt care) were referred to the nearest Ministry of Health dental clinic, consistent with the IADT guidelines for primary-dentition injuries (Day et al. 2020).

Setting and participants

The study was conducted in ECCE centres (TASKA, TADIKA and combined centres) in three neighbouring suburban localities of Selangor, Malaysia: Kelana Jaya, Ara Damansara and Lembah Subang. Data were collected over seven months, from January to July 2026. The target population comprised children aged 1–6 years enrolled in centres registered with the Department of Social Welfare (Jabatan Kebajikan Masyarakat, JKM) or the Ministry of Education. The sampling frame does not represent unregistered home-based and informal childcare, so inferences are restricted to registered centres in comparable urban and suburban settings.

Eligibility criteria

Inclusion criteria: (i) children aged 1–6 years enrolled at, and present in, a participating centre on the day of examination; (ii) a centre registered with JKM and/or the Ministry of Education; and (iii) written informed consent from the parent or legal guardian. *Exclusion criteria*: (i) craniofacial syndromes or congenital anomalies materially affecting dental examination (e.g. cleft lip or palate); (ii) special healthcare needs or behavioural conditions precluding a cooperative oral examination; and (iii) a caregiver unavailable or unable to complete the risk-factor questionnaire.

Sample size

The sample size was calculated for a single population proportion using the standard formula for cross-sectional prevalence surveys (Cochran 1977): $n_0 = Z^2\, p\,(1 - p) / d^2$, where Z = 1.96 (95% confidence), p = 0.161 (the TDI prevalence reported in preschool children in Goa, India; Borkar et al. 2024) and d = 0.04 (absolute precision). This gives $n_0 = (1.96^2 \times 0.161 \times 0.839) / 0.04^2 = 324.4$, rounded up to 325 children. Allowing for 14% non-response or incomplete data (325 × 1.14 = 370.5), the target was 372 children,

apportioned equally across the three localities (124 per locality). The sample size was determined for estimating prevalence; the study was not powered for the risk-factor analyses.

Sampling

Children were sampled by cluster, following the general approach recommended for health surveys in defined communities (Bennett et al. 1991), with each locality treated as a separate stratum. A sampling frame of all registered TASKA and TADIKA/preschool centres in each locality was compiled from the regulatory registries. Centres (clusters) were selected at random within each locality and approached sequentially. Within each consenting centre, all eligible children with caregiver consent were invited; where eligible enrolment exceeded the number still required, systematic random sampling (every second or third child on the class roster) was applied. Recruitment continued centre by centre until 124 children per locality had been enrolled.

Eighteen centres were approached and 12 (66.7%) agreed to participate; six declined. The 12 centres contributed about 31 analysed children each on average, with numbers varying by centre (Supplementary Table 1). Precision of the prevalence estimate is therefore lower than for a simple random sample. Clustering was addressed in the analysis rather than by inflating the sample size. Selection probabilities were not equal across centres, and no sampling weights were applied.

Questionnaire and centre-level checklist

Data were collected using a structured, piloted instrument comprising (A) a sociodemographic proforma, (B) a caregiver-administered risk-factor questionnaire (developmental history, oral habits, dental trauma history and falls) together with a centre-level environmental checklist, and (C) a clinical examination proforma (Supplementary File 2). The questionnaire was developed in English, translated into Bahasa Malaysia, back-translated to confirm equivalence, and piloted on 25 caregivers outside the main study sites, who were not included in the analyses. Mandarin and Tamil versions were not developed; where caregivers had difficulty understanding either version, trained research personnel provided verbal clarification without altering the meaning or response options.

Content validity was established by expert-panel review (item-level content validity index ≥ 0.83; scale-level index ≥ 0.90), and piloting confirmed the clarity and cultural appropriateness of the Bahasa Malaysia version. Among the 25 pilot caregivers, Cronbach's α was 0.82 (although the items covered several unrelated risk-factor domains), and the mean Cohen's kappa across categorical items on re-administration after 14 days was 0.84.

The centre-level checklist was completed during structured on-site visits by trained research personnel using a standardised protocol. Four centres were independently reassessed by a second assessor; Cohen's kappa across categorical items was 0.88. Where multiple outdoor surface types were present, classification was based on the surface covering the principal or most frequently used play area.

Exposure variables

Candidate exposures were specified a priori and organised into three conceptual levels, representing the pathway from child characteristics and the childcare environment, through behavioural exposure to falls, to injury (Fig. 1).

Table 1
Andreasen classification of traumatic dental injuries

Code	Injury type	Description
0	No injury	No clinical evidence of trauma
1	Enamel infraction	Crack in enamel with no loss of tooth substance
2	Enamel fracture	Uncomplicated crown fracture confined to enamel
3	Enamel–dentine fracture	Uncomplicated crown fracture, no pulp exposure
4	Complicated crown fracture	Crown fracture with pulp exposure
5	Crown–root fracture	Fracture involving enamel, dentine and cementum, with or without pulp exposure
	Root fracture	Fracture involving dentine, cementum and the pulp
7	Concussion	Tender to touch; no abnormal loosening or displacement
8	Subluxation	Abnormal loosening, no displacement
9	Luxation	Displacement of the tooth (lateral, extrusive or intrusive)
10	Avulsion	Complete displacement of the tooth out of its socket

*Adapted from the Andreasen classification, recognised by the World Health Organization (*Andreasen et al. 2007; Abbott 2022*).*

Level 1 (child characteristics) comprised sex, age group, birth order, overjet, lip competence, body mass index (BMI)-for-age category and age at first independent walking.

Level 2 (behavioural exposure) comprised falls in the preceding six months, dichotomised at ≥ 3 falls (an operational threshold for recurrent falling), and non-nutritive oral habit.

Level 3 (ECCE environment) comprised outdoor play-area surfacing, the presence of elevated playground equipment and the number of children per caregiver, all recorded on the centre-level checklist.

Surfacing was classified as hard (concrete, asphalt, paved tile or other rigid surface, including compacted bare earth) or non-hard (rubber matting, sand, wood-chip, grass or loose soil). The caregiver-

to-child ratio was dichotomised as ≤ 6 versus > 6 children per caregiver, with > 6 representing lower supervisory density; this threshold was a study-defined operational measure, not a regulatory standard. Centre type, household income band, ethnicity and locality were described (Tables 2 and 3) but, because of the limited number of events and centres, were not entered into the multivariable model.

Table 2
Sociodemographic characteristics of the study participants (n = 367)

Characteristic	**Category**	**n**	**%**
Locality	Kelana Jaya	124	33.8
	Ara Damansara	122	33.2
	Lembah Subang	121	33.0
Sex	Male	192	52.3
	Female	175	47.7
Age group	1–<3 years	153	41.7
	3–6 years	214	58.3
Centre type	TASKA	102	27.8
	TADIKA	124	33.8
	Combined	141	38.4
Ethnicity	Malay	98	26.7
	Chinese	153	41.7
	Indian	71	19.3
	Other	45	12.3
Household income band	B40	23	6.3
	M40	275	74.9
	T20	69	18.8

*B40, bottom 40%; M40, middle 40%; T20, top 20% of households, per the national classification (*Department of Statistics Malaysia 2025*).*

Table 3
Prevalence of traumatic dental injuries by sociodemographic subgroup

Subgroup	n examined	n with TDI	Prevalence (%)	95% CI	p-value
Overall	367	57	15.5	12.2–19.6	–
Kelana Jaya	124	22	17.7	12.0–25.4	0.621
Ara Damansara	122	19	15.6	10.2–23.0	
Lembah Subang	121	16	13.2	8.3–20.4	
Male	192	39	20.3	15.2–26.6	0.008*
Female	175	18	10.3	6.6–15.7	
1–<3 years	153	19	12.4	8.1–18.6	0.164
3–6 years	214	38	17.8	13.2–23.4	
TASKA	102	17	16.7	10.7–25.1	0.929
TADIKA	124	19	15.3	10.0–22.7	
Combined centre	141	21	14.9	10.0–21.7	

**p < 0.05 (Pearson's chi-square). p-values are descriptive and do not account for clustering of children within centres; all expected cell counts exceeded 5. Confidence intervals are Wilson score intervals, unadjusted for clustering. Ethnicity and household income band were not analysed against TDI.*

Clinical examination

Two calibrated examiners performed visual–tactile intraoral examinations under portable lighting, using a plain (flat) mouth mirror and a Community Periodontal Index (CPI) probe for tactile confirmation only. The examination followed the WHO Oral Health Surveys: Basic Methods protocol (World Health Organization 2013), adapted to record TDI using the Andreasen classification (Andreasen et al. 2007; Abbott 2022; Table 1) and cross-checked against the IADT guidelines for the primary dentition (Day et al. 2020), which also informed the urgent-management referral threshold. Because some children had erupting permanent incisors, dentition status was recorded for each injured tooth.

Body weight was measured to the nearest 0.1 kg using a calibrated digital scale (light clothing, no shoes). Recumbent length was measured with an infant length board in children aged < 2 years, and standing height to the nearest 0.1 cm with a portable stadiometer in children aged ≥ 2 years. BMI-for-age z-scores were derived using the WHO Child Growth Standards (< 5 years) and the WHO 2007 Growth Reference (5–6 years). Overweight/obesity was defined as BMI-for-age > + 2 SD in children aged < 5 years and > + 1 SD in children aged 5–6 years.

Horizontal overjet was measured with a calibrated periodontal probe or millimetre ruler, with the child in centric occlusion, from the labial surface of the mandibular incisor to the incisal edge of the corresponding maxillary incisor, parallel to the occlusal plane. It was recorded to the nearest millimetre and categorised as ≤ 3 mm or > 3 mm; where the incisors had not erupted sufficiently, overjet was recorded as not assessable rather than estimated. Lips were classified as competent when they met naturally without visible muscular effort with the child seated upright and relaxed, and as incompetent when a persistent interlabial gap was present or closure required evident muscular contraction.

Examiners were blinded to the caregivers' questionnaire responses but, because examinations took place on centre premises, could not be blinded to the physical environment. Examiners were assigned to centres according to a predefined fieldwork schedule distributed across localities to minimise examiner–locality clustering.

Examiner calibration

Before data collection, the two examiners underwent a structured calibration exercise against a reference (gold-standard) examiner using reference photographs and clinical cases. Inter-examiner agreement, assessed on 23 children, was high (Cohen's $\kappa = 0.86$). Intra-examiner reliability, assessed by re-examining a random 10% subsample (n = 37) on the same day, was $\kappa = 0.91$. Both exceeded the pre-specified threshold of $\kappa \geq 0.80$.

Outcome

The primary outcome was the presence or absence of TDI, defined as a clinically detectable injury or sequela of trauma involving the teeth or supporting structures and classified using Andreasen codes 1–10 (Table 1). Caregiver-reported previous injuries were not classified as TDI without corroborating clinical signs. Tooth discolouration was recorded as a traumatic sequela only when history and examination were consistent with previous trauma; it was not assigned a separate Andreasen code, and no child was classified as having TDI on the basis of discolouration alone. Where more than one injury was present in a child, the most severe injury was used for child-level tabulation, and all affected teeth were retained for the descriptive analysis of tooth distribution. Secondary descriptive outcomes were injury type, injury severity and tooth distribution.

Statistical analysis

Data were analysed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). TDI prevalence was calculated with 95% Wilson score confidence intervals. Because children were clustered within 12 centres, cluster-adjusted prevalence and confidence intervals were also obtained from the design effect, calculated from the unconditional (null-model) intraclass correlation coefficient (ICC). Injury patterns were summarised descriptively by injury type, affected tooth, sex and age group. Bivariate associations were explored using Pearson's chi-square test, or Fisher's exact test when expected counts were < 5. Because these tests do not account for clustering, particularly for centre-level exposures, the p-values were interpreted as descriptive rather than confirmatory.

Twelve candidate variables were considered in bivariate analysis. Early independent walking was present in only three children and was excluded from the multivariable model because of the risk of sparse-data bias, leaving eleven variables. Given the small number of clusters, the primary adjusted analysis used a mixed-effects logistic regression model with a random intercept for centre; centre-level exposures (play surface, elevated equipment, children per caregiver) were entered as fixed effects. Adjusted odds ratios (aOR), 95% confidence intervals and the centre-level ICC were reported. Because these exposures vary only between centres (hard surfaces were present at 8 of 12 centres), their estimates rest on few clusters and were interpreted as exploratory.

With only 12 clusters, Wald-based intervals from the mixed-effects model may be too narrow. As a sensitivity analysis, population-averaged estimates were therefore obtained using generalised estimating equations (GEE) with centre as the clustering variable, an exchangeable working correlation and robust sandwich variance with the Mancl–DeRouen small-sample correction. Concordance in direction and magnitude between the two models was used to assess robustness.

Recurrent falls were considered a potential mediator of the associations between child-level or environmental exposures and TDI. The primary model therefore included falls, and a secondary model excluding falls was fitted to explore the total associations of the remaining factors. Because TDI was relatively common, odds ratios were interpreted as measures of association and may overstate prevalence ratios; for the principal exposure a crude prevalence ratio with a Wald interval on the log scale was also calculated. Analyses used a complete-case approach. With 57 children with TDI and eleven variables (about five events per variable), the adjusted analyses are exploratory, and we emphasise effect estimates and 95% confidence intervals rather than statistical significance alone. All tests were two-sided, with $p < 0.05$ considered statistically significant.

Results

Participants

Of 396 children assessed for eligibility, 24 were excluded before enrolment (two outside the age range, 13 meeting other exclusion criteria, four whose caregivers declined consent and five with incomplete data), leaving 372 enrolled from 12 centres, with 124 children enrolled in each locality. A further five children withdrew during data collection, giving a final analytic sample of 367 (98.7% of those enrolled; Fig. 2). Table 2 presents their characteristics. The sample was distributed almost equally across localities and was slightly male-predominant (52.3%). The mean age was 3.46 years (SD 1.23), and 58.3% of children were aged 3–6 years. The largest ethnic group was Chinese (41.7%), and most households were in the middle-income (M40) band (74.9%), with few in the bottom-income (B40) band (6.3%); income bands follow the national classification (Department of Statistics Malaysia 2025).

Prevalence of traumatic dental injuries

The overall prevalence of TDI was 15.5% (57/367; 95% CI 12.2–19.6%, Wilson score method, not adjusted for clustering; cluster-adjusted 95% CI approximately 11.5–20.7%; unconditional ICC = 0.020; design effect = 1.59). Prevalence by locality, sex, age group and centre type is shown in Table 3. It did not differ significantly across localities (17.7%, 15.6% and 13.2%; $\chi^2 = 0.95$, $p = 0.621$) or centre types (16.7%, 15.3% and 14.9%; $\chi^2 = 0.15$, $p = 0.929$). Boys had significantly higher prevalence than girls (20.3% vs 10.3%; $\chi^2 = 7.02$, $p = 0.008$), whereas the difference between children aged 1–<3 years (12.4%) and 3–6 years (17.8%) did not reach statistical significance ($\chi^2 = 1.94$, $p = 0.164$). Centre-level characteristics and prevalence for each centre are given in Supplementary Table 1.

Clinical pattern

Among the 57 children with TDI, the maxillary right central incisor was the most frequently affected tooth (42 children, 73.7%), followed by the maxillary left central incisor (35, 61.4%), maxillary right lateral incisor (12, 21.1%), maxillary left lateral incisor (11, 19.3%), mandibular right central incisor (4, 7.0%), mandibular left central incisor (3, 5.3%), mandibular right lateral incisor (2, 3.5%) and mandibular left lateral incisor (1, 1.8%); a child could have more than one tooth affected. Injured teeth were predominantly primary teeth; injuries involved erupted permanent incisors in six children.

Enamel fracture was the most common injury type (26.3%), followed by luxation (19.3%), enamel–dentine fracture (15.8%) and subluxation (12.3%; Table 4). Hard-tissue injuries (Andreasen codes 1–6) accounted for 63.2% and periodontal-tissue injuries (codes 7–10) for 36.8% of affected children. Tooth discolouration suggestive of previous trauma was observed in 7 of the 57 children (12.3%). Caregivers reported that no professional dental care had been sought for 24 of the 57 children (42.1%). Two children (3.5%), both aged 3–6 years, met the predefined referral criteria (Day et al. 2020) and were referred to the nearest Ministry of Health dental clinic.

Table 4
Distribution of injury type among children with traumatic dental injury (n = 57)

Andreasen code / injury type	n	% of affected children
1 – Enamel infraction	6	10.5
2 – Enamel fracture	15	26.3
3 – Enamel–dentine fracture	9	15.8
4 – Complicated crown fracture	4	7.0
5 – Crown–root fracture	1	1.8
6 – Root fracture	1	1.8
7 – Concussion	0	0.0
8 – Subluxation	7	12.3
9 – Luxation	11	19.3
10 – Avulsion	3	5.3
Total	57	100.0
One injury (the most severe) is tabulated per affected child.		

Factors associated with traumatic dental injury

Table 5 presents crude and mutually adjusted estimates for the twelve candidate factors, grouped by conceptual level; early independent walking was not included in the adjusted model. No data were missing, so the complete-case model included all 367 children. After adjustment, five factors remained independently associated with TDI, spanning all three levels: a hard outdoor play surface (Level 3; aOR 4.41, 95% CI 2.31–8.42), ≥ 3 falls in the preceding six months (Level 2; aOR 2.72, 1.39–5.33), first-born status (Level 1; aOR 2.84, 1.40–5.76), male sex (Level 1; aOR 1.96, 1.05–3.66) and overjet > 3 mm (Level 1; aOR 2.18, 1.06–4.49).

Table 5
Factors associated with traumatic dental injury by conceptual level: crude and mutually adjusted odds ratios

Factor	TDI n (%)	No TDI n (%)	Crude OR (95% CI)	aOR (95% CI)†	p-value
Level 3 – ECCE environment					
Hard outdoor play surface	39 (68.4)	93 (30.0)	5.06 (2.75–9.30)	4.41 (2.31–8.42)	< 0.001*
Elevated playground equipment present	12 (21.1)	48 (15.5)	1.46 (0.72–2.95)	1.31 (0.63–2.73)	0.296
More than 6 children per caregiver	12 (21.1)	47 (15.2)	1.49 (0.73–3.03)	1.34 (0.64–2.81)	0.266
Level 2 – Behavioural exposure					
≥ 3 falls in past 6 months	19 (33.3)	43 (13.9)	3.10 (1.64–5.88)	2.72 (1.39–5.33)	< 0.001*
Non-nutritive oral habit	6 (10.5)	17 (5.5)	2.03 (0.76–5.39)	1.68 (0.60–4.71)	0.146
Level 1 – Child characteristics					
First-born child	45 (78.9)	167 (53.9)	3.21 (1.64–6.31)	2.84 (1.40–5.76)	< 0.001*
Sex – male	39 (68.4)	153 (49.4)	2.22 (1.22–4.06)	1.96 (1.05–3.66)	0.008*
Overjet > 3 mm	14 (24.6)	37 (11.9)	2.40 (1.20–4.81)	2.18 (1.06–4.49)	0.011*
Early independent walking (< 10 months)‡	2 (3.5)	1 (0.3)	9.29 (1.20–71.79)	Not estimated§	0.064
Age < 3 years	19 (33.3)	134 (43.2)	0.66 (0.36–1.19)	0.72 (0.38–1.37)	0.164
Overweight/obese (BMI-for-age)	4 (7.0)	11 (3.5)	2.05 (0.63–6.68)	1.74 (0.50–6.08)	0.266

*Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; OR, odds ratio; TDI, traumatic dental injury. *p < 0.05.*

Crude ORs and p-values (bivariate; Fisher's exact test if expected counts were < 5, otherwise Pearson's chi-square) are unadjusted for clustering and descriptive.

†Mixed-effects logistic regression with a random intercept for centre, including eleven factors.

‡Haldane–Anscombe correction applied to the crude OR and 95% CI; Fisher's exact test used for inference. §Excluded from the multivariable model (only three exposed children; sparse-data bias). Level 3 variables are centre-level exposures: 8 of 12 centres had a hard outdoor play surface; elevated equipment and > 6 children per caregiver applied to 60 and 59 children, respectively.

Factor	TDI n (%)	No TDI n (%)	Crude OR (95% CI)	aOR (95% CI)†	p-value
Level 3 – ECCE environment					
Lip incompetence	6 (10.5)	23 (7.4)	1.47 (0.57–3.78)	1.29 (0.48–3.46)	0.424
*Abbreviations: aOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; OR, odds ratio; TDI, traumatic dental injury. *p < 0.05.*					
Crude ORs and p-values (bivariate; Fisher's exact test if expected counts were < 5, otherwise Pearson's chi-square) are unadjusted for clustering and descriptive.					
†Mixed-effects logistic regression with a random intercept for centre, including eleven factors.					
‡Haldane–Anscombe correction applied to the crude OR and 95% CI; Fisher's exact test used for inference. §Excluded from the multivariable model (only three exposed children; sparse-data bias). Level 3 variables are centre-level exposures: 8 of 12 centres had a hard outdoor play surface; elevated equipment and > 6 children per caregiver applied to 60 and 59 children, respectively.					

Hard outdoor play surfaces were present at 8 of the 12 centres and showed the strongest association with TDI among the environmental factors. TDI prevalence was 29.5% (39/132) among children attending centres with a hard outdoor play surface and 7.7% (18/235) among those attending the other four centres. Of the 57 children with TDI, 39 (68.4%) attended a centre with a hard surface, compared with 93 of 310 children without TDI (30.0%; crude OR 5.06, 95% CI 2.75–9.30; not adjusted for clustering). Because TDI was common, the crude prevalence ratio is a more conservative summary: 3.9 (95% CI 2.3–6.5), an absolute difference of 21.8 percentage points. Elevated playground equipment (aOR 1.31, 0.63–2.73) and more than six children per caregiver (aOR 1.34, 0.64–2.81) were not significantly associated with TDI, but these centre-level characteristics applied to only 60 and 59 children respectively, so these estimates carry little information. Lip incompetence, overweight/obesity, a non-nutritive oral habit and age under 3 years were also not significantly associated with TDI (all adjusted 95% CIs included 1). Early independent walking (< 10 months) was reported for only three children; its crude estimate was very imprecise (OR 9.29, 95% CI 1.20–71.79; Fisher's exact p = 0.064), no adjusted estimate was obtained, and it is not interpreted further.

Sensitivity analyses

The centre-level ICC from the mixed-effects model was 0.035. In the GEE model with Mancl–DeRouen correction, the aOR for a hard outdoor play surface was 4.18 (95% CI 1.84–9.48), and estimates for the other principal factors were similar in direction and magnitude: recurrent falls, aOR 2.61 (1.25–5.45); first-born status, 2.70 (1.30–5.61); male sex, 1.91 (1.01–3.62); and overjet > 3 mm, 2.10 (1.01–4.39). In the secondary model excluding falls, the aOR for a hard outdoor play surface was 4.72 (95% CI 2.50–8.92).

Discussion

In this study of 367 children attending ECCE centres in three Selangor localities, 15.5% had a TDI (95% CI 12.2–19.6%, unadjusted for clustering). In addition to established child-level correlates, namely male sex and increased overjet, TDI was associated with recurrent falls (≥ 3 in the preceding six months) and with a centre-level characteristic, a hard outdoor play surface. The latter showed the strongest adjusted association (aOR 4.41, 95% CI 2.31–8.42), but it was measured at centre level across only 12 centres and should be interpreted cautiously.

The childcare environment: hard outdoor play surfaces

Children attending centres with a hard outdoor play surface had approximately four times the adjusted odds of TDI, although the estimate is imprecise because only 12 centres contributed (eight hard, four non-hard). The association is biologically plausible. Falls are a major cause of non-fatal injury in childhood, and the severity of injury after a fall is influenced partly by the characteristics of the impact surface. Impact-attenuating surfacing is therefore incorporated into established playground safety standards: EN 1177 specifies methods for assessing the impact attenuation and critical fall height of playground surfaces (European Committee for Standardization 2023), and ASTM F1292 sets minimum impact-attenuation requirements for surfacing within playground equipment use zones to reduce the risk of severe head injury (ASTM International). Although these standards are directed mainly at head injury, the same principle may apply to facial and dental impact, but this has not been shown. Because surface type can be inspected and changed, it is a potentially modifiable target.

This finding needs cautious interpretation. We could not establish that surface type caused the injuries: the exposure was recorded at the time of the survey whereas TDI history is cumulative, the injuries may have occurred at home or elsewhere, and each child's duration of attendance was not taken into account. With only four non-hard-surface centres, a single centre could influence the estimate, and the estimate may partly reflect other differences between centres, such as provider type (government or private), fees, location, age mix and household characteristics, which could not be adjusted for. We therefore regard the result as supporting, not proving, a contribution of environmental characteristics to TDI risk, and as a basis for prospective and intervention studies.

Falls and behavioural exposure

Three or more falls in the preceding six months were independently associated with TDI (aOR 2.72, 95% CI 1.39–5.33), in keeping with the established role of falls as the main injury mechanism in this age group (Bartolomeos 2008). Falls are likely to lie on the pathway through which both child-level and environmental factors act (Fig. 1), so the adjusted estimates for those factors should be read as associations after accounting for falls; the secondary model excluding falls gave a slightly larger estimate for play surface (aOR 4.72), consistent with this. Because falls were recorded over six months whereas TDI history is cumulative, reverse causation cannot be excluded. Falls were dichotomised and caregiver-reported, so dose–response could not be examined and recall error is possible. More than six

children per caregiver was not significantly associated with TDI (aOR 1.34, 95% CI 0.64–2.81), but this exposure applied to only 59 children, and the wide interval is compatible with a modest effect.

Child-level factors

Male sex carried approximately twice the odds of TDI (aOR 1.96, 95% CI 1.05–3.66), similar to a recent study of Syrian schoolchildren (adjusted OR 2.10, 95% CI 1.40–3.17), although that study involved older children (Alshayeb et al. 2025). Overjet > 3 mm was also associated with TDI (aOR 2.18, 1.06–4.49), consistent in direction with pooled evidence from a dedicated meta-analysis (Arraj et al. 2019). Overjet was assessed at the same visit as injury, and injury to the incisors can itself alter overjet, so reverse causation cannot be excluded. Increased overjet is a potentially modifiable occlusal characteristic only in the longer term; in this age group it identifies children who may merit closer monitoring.

First-born status was associated with TDI (aOR 2.84, 1.40–5.76), consistent with earlier work on birth order (Käch et al. 2014). Birth order is unlikely to be a biological risk factor; it may reflect differences in parental supervision and experience with childproofing, in children's risk-taking, in caregiver reporting, or in family structure, none of which we measured, and residual confounding is possible. Lip incompetence (Wig et al. 2022), overweight/obesity (Soares et al. 2022; Motta-Rego et al. 2022), a non-nutritive oral habit and age under 3 years were not significantly associated with TDI, in contrast to some, though not all (Comim et al. 2024), of the international literature; the confidence intervals for several were wide, so moderate associations cannot be excluded.

Prevalence and clinical pattern in context

The prevalence of 15.5% is close to the 16.1% reported in preschool children in Goa (Borkar et al. 2024) and falls within the range reported in Brazilian (Kramer et al. 2003) and Jordanian (ElKarmi et al. 2015) preschool surveys, a range known to be sensitive to ascertainment method, age band and diagnostic threshold (Glendor 2008; Lam 2016). This similarity should not be over-interpreted, because the Goa estimate also informed our sample-size calculation. Much of the older foundational literature derives from school-age children with permanent dentition (Naidoo et al. 2009), and regional Southeast Asian series are often drawn from patients who have already sought care (Kulvitit et al. 2025), which excludes injuries that never reach clinical attention. By sampling directly from ECCE centres, we reduced this source of ascertainment bias, addressing a gap highlighted by a recent regional scoping review (Karobari et al. 2025).

The maxillary right central incisor was the most frequently affected tooth and enamel fracture the commonest injury type, a distribution consistent with the characteristic forward-fall mechanism (Bartolomeos 2008) and with a large Chinese hospital series (Wang et al. 2025) and a recent retrospective cohort of children aged 0–14 years (Peker Gonulal and Sarı 2026). Periodontal-tissue injuries (36.8%) were less common than hard-tissue injuries (63.2%) but still made up over a third of affected children. The predominance of fractures over luxations differs from the pattern often described for the primary dentition in clinic series, in which periodontal injuries typically predominate. This may

partly reflect community-based sampling, which is more likely than clinic-based sampling to identify minor enamel and enamel–dentine fractures that do not prompt professional care.

Care-seeking and awareness

A substantial share of childhood dental trauma never reaches clinical attention. In a Swedish cohort, caregivers sought no professional care for over half of injury episodes (Odersjö et al. 2018), a problem made worse by limited caregiver (Fadel et al. 2025) and educator (Rouijel et al. 2024) first-aid knowledge, with downstream consequences for dental fear and anxiety (Jurišić Kvesić et al. 2023) and oral health-related quality of life (Milani et al. 2021; Leo et al. 2025). In the present study, no professional dental care had been sought for 24 of the 57 children with clinically detected TDI (42.1%). In addition, 7 of 57 children (12.3%) showed tooth discolouration consistent with possible previous trauma. These findings suggest that reliance on caregiver-reported trauma history alone may underestimate the burden of TDI identified by clinical examination.

Implications for practice and policy

The findings suggest that prevention of TDI in preschool children may need to extend beyond individual behavioural counselling to the physical childcare environment. For ECCE regulators and providers, the following measures merit consideration and evaluation: inclusion of outdoor play-surface type and condition in routine ECCE safety inspections, and evaluation of impact-absorbing surfacing under and around play equipment; fall-prevention practice and active supervision during outdoor play, particularly for children with recurrent falls; training of childcare staff in IADT-recommended emergency first aid for dental trauma (Day et al. 2020) with a clear referral pathway to dental services; and integration of simple trauma screening into existing preschool oral health programmes, which have so far concentrated on caries (Ramli et al. 2024). Their effectiveness and cost should be assessed in prospective or intervention studies before adoption as standards.

Strengths and limitations

Strengths include sampling from ECCE centres rather than treatment-seeking populations, examiner calibration to a pre-specified reliability threshold, standardised Andreasen-based recording that allows comparison with other studies, a risk-factor assessment spanning child, behavioural and centre-level domains organised by an explicit conceptual framework, and analysis that took account of clustering by centre, although with few clusters.

The study also has limitations. First, the cross-sectional design cannot establish temporality or causation. TDI history is cumulative, exposures were measured at the time of the survey, the place of injury and each child's duration of attendance were not ascertained, and trauma and fall histories relied on caregiver recall. Second, centre-level exposures such as play surface are shared by all children in a centre. With only 12 centres, four of them without a hard surface, the effective sample size for these exposures is small, the estimates are imprecise, and the play-surface estimate may be confounded by other centre characteristics, including provider type, fees, age mix and household socioeconomic profile.

Third, with 57 events and eleven variables (about five events per variable), the multivariable model is exploratory, and sparse-data bias is likely for rare exposures; early walking could not be modelled. Centre type, provider, ethnicity and household income were not adjusted for, age was analysed in only two bands so age-specific risk across narrower developmental stages could not be described, and mixed dentition in older children may affect injury classification. We did not model sequential exposure blocks, interactions or injury severity; these need larger samples. Fourth, environmental characteristics were recorded during a single assessment per centre and did not capture the duration or frequency of outdoor play, which may have caused exposure misclassification; inter-rater reliability of the checklist rested on four centres; and examiners were blinded to questionnaire responses but not to the centre environment. Examinations were conducted under portable lighting without radiographs, so subtle injuries such as enamel infractions, concussion and periodontal-only injuries may have been under-detected, particularly in younger children. The questionnaire was available only in Bahasa Malaysia and English in a multi-ethnic sample.

Fifth, the sampling frame was restricted to registered centres in three suburban Selangor localities, and six of the 18 centres approached declined to take part. Unregistered centres, rural settings and low-income households (6.3% in the B40 band) were under-represented. Children unable to cooperate with examination were excluded, and the requirement that a caregiver complete the questionnaire may have favoured more engaged families. National generalisability is therefore limited.

Conclusions

Among children aged 1–6 years attending ECCE centres in three Selangor localities, 15.5% (95% CI 12.2–19.6%, unadjusted for clustering) had experienced a TDI, predominantly involving the maxillary anterior teeth, with enamel fracture the commonest type. TDI was associated with child-level (male sex, first-born status, overjet > 3 mm), behavioural (≥ 3 falls) and environmental factors. The association with a hard outdoor play surface, a centre-level exposure observed in only 12 centres, suggests that the physical ECCE environment may be a modifiable prevention target. No professional dental care had been sought for 24 of the 57 children with clinically detected TDI (42.1%). Given the cross-sectional design, these associations cannot establish temporality or causality, but they support further investigation of environmental characteristics as determinants of TDI. Prospective and intervention studies are warranted, including review of play-surface safety, fall prevention and staff education.

Declarations

Ethics approval

informed consent, funding, competing interests, data availability, author contributions and acknowledgements are provided in the separate Title Page file to preserve anonymity during peer review.

Author Contribution

B.C: concept, design, review of literature, methodology, validation of instrument, calibration of examiners, data collection, statistical analysis, manuscript writing, editing and review of the original draft.M.L.J.F: review of literature, methodology, validation of instrument, calibration of examiners (reference examiner), statistical analysis, manuscript writing, editing and review of the original draft.F.K: design, review of literature, methodology, validation of instrument, calibration of examiners, statistical analysis, manuscript writing, editing and review of the original draft.W.B.B.W.B: design, review of literature, methodology, data collection (examiner), manuscript writing, editing and review of the original draft.G.M: design, review of literature, methodology, data collection (examiner), manuscript writing, editing and review of the original draft.

Acknowledgement

The authors thank all teachers, caregivers, parents and children for their participation and support.

Data Availability

The de-identified dataset analyzed during the study is available from the corresponding author on reasonable request.

References

1. Abbott PV (2022) The World Health Organization recognizes the Andreasen classification of traumatic dental injuries. Dent Traumatol 38:169. https://doi.org/10.1111/edt.12755
2. Alshayeb L, Al-Shiekh MN, Dashash M (2025) Prevalence and risk factors of traumatic dental injuries among conflict-affected schoolchildren in Syria (2023–2024). J Epidemiol Glob Health 15:73. https://doi.org/10.1007/s44197-025-00424-8
3. Andreasen JO, Andreasen FM, Andersson L (eds) (2007) Textbook and color atlas of traumatic injuries to the teeth, 4th edn. Blackwell Munksgaard, Oxford
4. Arraj GP, Rossi-Fedele G, Doğramacı EJ (2019) The association of overjet size and traumatic dental injuries—a systematic review and meta-analysis. Dent Traumatol 35:217–232. https://doi.org/10.1111/edt.12481
5. ASTM International. ASTM F1292-26: Standard specification for impact attenuation of surfacing materials within the use zone of playground equipment as tested in a laboratory. ASTM International, West Conshohocken, PA
6. Bartolomeos K (2008) Falls. In: Peden M, Oyegbite K, Ozanne-Smith J et al (eds) World report on child injury prevention. World Health Organization, Geneva
7. Bennett S, Woods T, Liyanage WM, Smith DL (1991) A simplified general method for cluster-sample surveys of health in developing countries. World Health Stat Q 44:98–106

8. Borkar RR, Barretto ES, Swamy DF, Fijardo EV (2024) Prevalence of traumatic dental injuries and associated risk factors among preschool children in Goa: a cross-sectional study. Cureus 16: e73894. https://doi.org/10.7759/cureus.73894
9. Cochran WG (1977) Sampling techniques, 3rd edn. Wiley, New York
10. Comim LD, Marquezan PK, Knorst JK, Zanatta FB, Zenkner JEA, Alves LS (2024) Association between socioeconomic status and traumatic dental injury in permanent teeth: a systematic review with meta-analysis. Community Dent Oral Epidemiol 52:424–430. https://doi.org/10.1111/cdoe.12933
11. Day PF, Flores MT, O'Connell AC, Abbott PV, Tsilingaridis G, Fouad AF et al (2020) International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 3. Injuries in the primary dentition. Dent Traumatol 36:343–359. https://doi.org/10.1111/edt.12576
12. Department of Statistics Malaysia (2025) Household income survey report 2024 (Malaysia & states). Department of Statistics Malaysia, Putrajaya. https://www.dosm.gov.my/portal-main/release-content/household-income-survey-report--malaysia--states-2024
13. ElKarmi RF, Hamdan MA, Rajab LD, Abu-Ghazaleh SB, Sonbol HN (2015) Prevalence of traumatic dental injuries and associated factors among preschool children in Amman, Jordan. Dent Traumatol 31:487–492. https://doi.org/10.1111/edt.12183
14. Esa R, Abdul Razak I (1996) Traumatised anterior teeth in a sample of 12–13-year-old Malaysian schoolchildren. Ann Dent Univ Malaya 3:5–9. https://doi.org/10.22452/adum.vol3no1.2
15. European Committee for Standardization (2023) EN 1177:2018 + A1:2023. Impact attenuating playground surfacing—methods of test for determination of impact attenuation. CEN, Brussels
16. Fadel HT, Mousa SK, Al-Malik MI, Al-Badawi EA, Al-Sebaei MO, Al-Harbi T (2025) Parental knowledge of traumatic dental injuries explained by first aid training and education: a cross-sectional study. J Clin Pediatr Dent 49:40–47. https://doi.org/10.22514/jocpd.2025.125
17. Glendor U (2008) Epidemiology of traumatic dental injuries—a 12 year review of the literature. Dent Traumatol 24:603–611. https://doi.org/10.1111/j.1600-9657.2008.00696.x
18. Jurišić Kvesić A, Hrelja M, Lovrić Ž, Šimunović L, Špiljak B, Supina N et al (2023) Possible risk factors for dental fear and anxiety in children who suffered traumatic dental injury. Dent J (Basel) 11:190. https://doi.org/10.3390/dj11080190
19. Käch M, Krastl G, Zitzmann NU, Kühl S, Filippi A (2014) Birth order—a risk factor for dental trauma? Dent Traumatol 30:118–121. https://doi.org/10.1111/edt.12061
20. Karobari MI, Snigdha NT, Fareed M, Hoang V, Porntaveetus T, Sivaramakrishnan G et al (2025) Navigating the epidemiology and complexities of dental trauma in Southeast Asia: a multi-disciplinary scoping review. Dent Traumatol 41(Suppl 2):S66–S75. https://doi.org/10.1111/edt.70001
21. Kramer PF, Zembruski C, Ferreira SH, Feldens CA (2003) Traumatic dental injuries in Brazilian preschool children. Dent Traumatol 19:299–303. https://doi.org/10.1046/j.1600-9657.2003.00203.x

22. Kulvitit S, Termteerapornpimol K, Kanpittaya P, Prommanee S, Thongchotchat V, Nantanee R et al (2025) Prevalence, aetiology and treatment patterns of traumatic dental injuries in permanent teeth: a cross-sectional study at a Thai university dental hospital. Dent Traumatol 41(Suppl 2): S20–S33. https://doi.org/10.1111/edt.70020
23. Lam R (2016) Epidemiology and outcomes of traumatic dental injuries: a review of the literature. Aust Dent J 61(Suppl 1):4–20. https://doi.org/10.1111/adj.12395
24. Leo G, Nyamuryekung'e K, Kahabuka FK (2025) Impact of traumatic dental injuries on oral health-related quality of life among primary school children in Dar es Salaam. Clin Exp Dent Res 11: e70105. https://doi.org/10.1002/cre2.70105
25. Malaysia (1984) Child Care Centre Act 1984 (Act 308). Department of Social Welfare (Jabatan Kebajikan Masyarakat), Malaysia
26. Milani AJ, Castilho T, Assaf AV, Antunes LS, Antunes LAA (2021) Impact of traumatic dental injury treatment on the oral health-related quality of life of children, adolescents, and their family: systematic review and meta-analysis. Dent Traumatol 37:735–748. https://doi.org/10.1111/edt.12697
27. Motta-Rego T, Soares MEC, Souto-Souza D, Souza EA, Paiva SM, Ramos-Jorge ML et al (2022) Association of the prevalence and severity of untreated traumatic dental injuries with body mass index among Brazilian preschool children. Dent Traumatol 38:206–212. https://doi.org/10.1111/edt.12734
28. Naidoo S, Sheiham A, Tsakos G (2009) Traumatic dental injuries of permanent incisors in 11- to 13-year-old South African schoolchildren. Dent Traumatol 25:224–228. https://doi.org/10.1111/j.1600-9657.2008.00749.x
29. Odersjö ML, Robertson A, Koch G (2018) Incidence of dental traumatic injuries in children 0–4 years of age: a prospective study based on parental reporting. Eur Arch Paediatr Dent 19:107–111. https://doi.org/10.1007/s40368-018-0334-z
30. Peker Gonulal O, Sarı M (2026) Epidemiological and clinical characteristics of traumatic dental injuries in pediatric patients aged 0–14 years: a retrospective study. J Clin Pediatr Dent 50:166–175. https://doi.org/10.22514/jocpd.2026.101
31. Petti S, Glendor U, Andersson L (2018) World traumatic dental injury prevalence and incidence, a meta-analysis—one billion living people have had traumatic dental injuries. Dent Traumatol 34:71–86. https://doi.org/10.1111/edt.12389
32. Ramli MZ, Azmi NS, Ismail AF (2024) Caries status, caries severity, and oral health-related quality of life of preschool children in Kuantan. medRxiv [Preprint]. https://doi.org/10.1101/2024.07.04.24309980
33. Rouijel S, Bouchouk M, Zidane FE, Toure B (2024) Awareness, knowledge and attitudes toward management of avulsed permanent incisors among primary school teachers. Clin Cosmet Investig Dent 16:267–272. https://doi.org/10.2147/CCIDE.S456351

34. Soares MEC, Primo-Miranda EF, Galo R, Mourão LS, Ramos-Jorge J, Ramos-Jorge ML (2022) Association between obesity and traumatic dental injuries in pre-school children—a case-control study. Dent Traumatol 38:123–128. https://doi.org/10.1111/edt.12718
35. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative (2007) The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet 370:1453–1457. https://doi.org/10.1016/S0140-6736(07)61602-X
36. Wang Y, Chang H, Chen C, Yang X, Quan M, Liao X et al (2025) Traumatic dental injuries in children and adolescents presenting to a tertiary children's hospital in Shenzhen, China. BMC Oral Health 25:1102. https://doi.org/10.1186/s12903-025-06435-y
37. Wig M, Kumar A, Chaluvaiah MB, Yadav V, Shyam R (2022) Lip incompetence and traumatic dental injuries: a systematic review and meta-analysis. Evid Based Dent. https://doi.org/10.1038/s41432-022-0258-7
38. World Health Organization (2013) Oral health surveys: basic methods, 5th edn. World Health Organization, Geneva

Figures

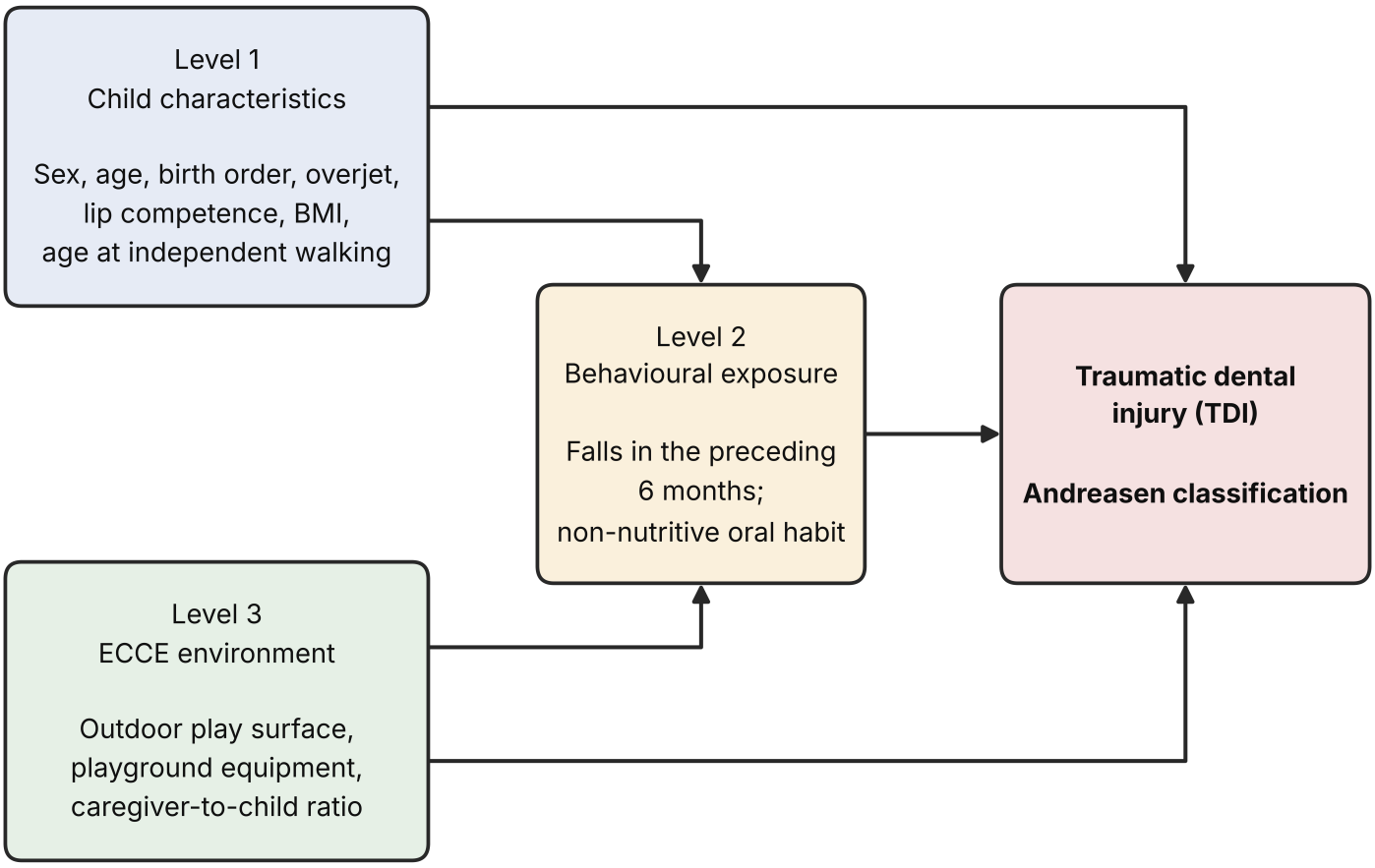


Figure 1

Conceptual framework guiding variable selection and interpretation in the study of traumatic dental injury (TDI) among preschool children attending early childhood care and education (ECCE) centres.

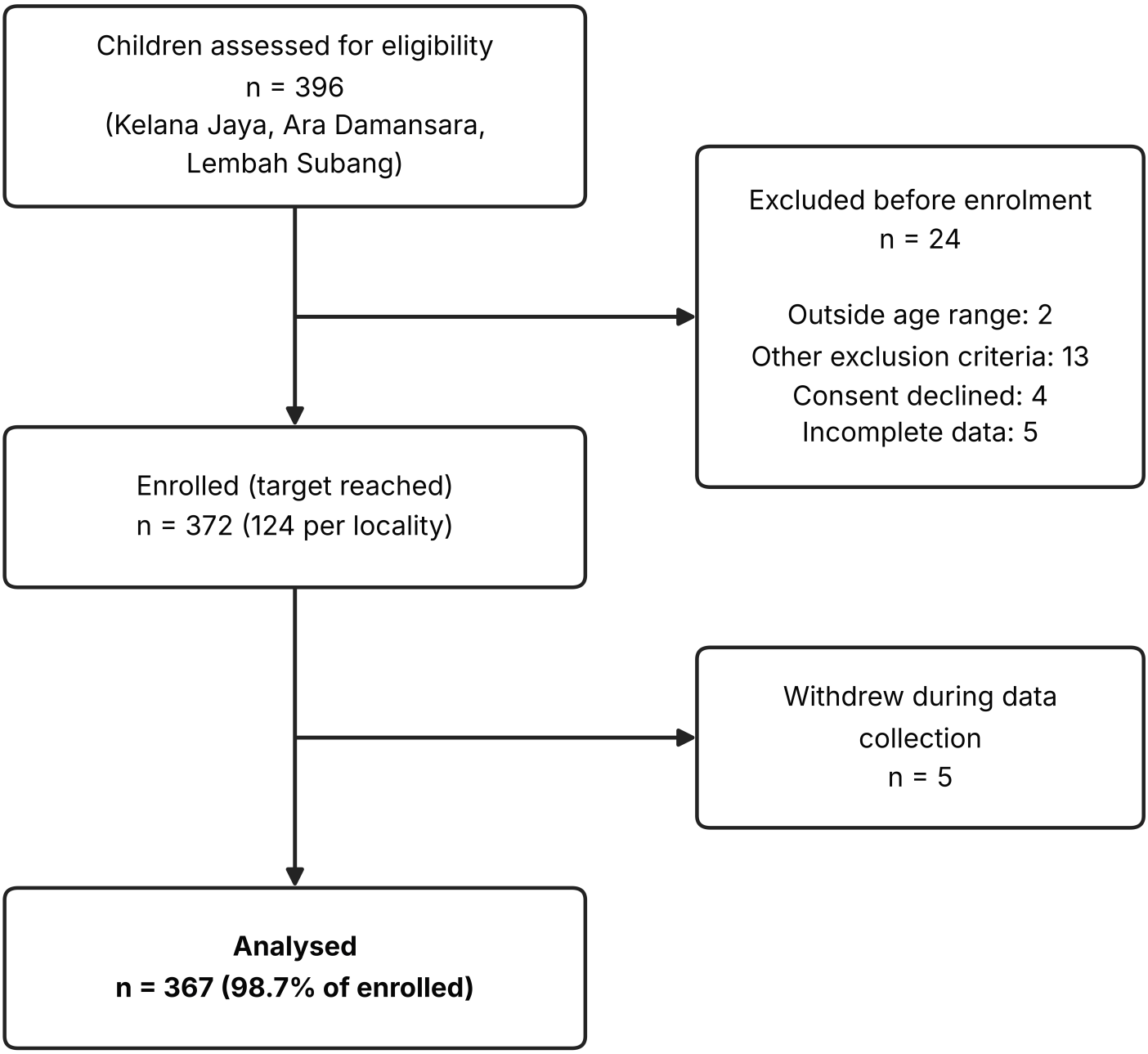


Figure 2

Flow of participants through the study across the three localities (Kelana Jaya, Ara Damansara and Lembah Subang).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryFile2.docx
- SupplementaryFile1.docx
- SupplementaryTable1.docx