Caries Progression Rates Revisited: A Systematic Review

R. Hummel, N.A.E. Akveld, J.J.M. Bruers, W.J.M. van der Sanden, N. Su, G.J.M.G. van der Heijden

Appendix

Appendix Table 1. Scoring form for the quality assessment of eligible studies

Relevance of evidence		
1.1	The results were described for a cohort of children or adolescents spanning an age range of no more than two years - yes: 1 point - no: 0 points - not described or unclear: 0 points	**Relevance of evidence:** High – ≥ 3 points Moderate – 2 points Low – 0-1 points
1.2	The cohort had used fluoridated toothpaste, and/or their drinking water had been sufficiently fluoridated (> 1.0 ppm) for the entire study period - yes: 1 point - no: 0 points - not described or unclear: 0 points	
1.3	The cohort had had regular access to oral healthcare services (whether preventive, restorative or both) throughout the study period - yes: 1 point - no: 0 points - not described or unclear: 0 points	
1.4	The study had been conducted in Western Europe, North-America, Australia or New Zealand - yes: 1 point - no: 0 points - not described or unclear: 0 points	
Risk of bias		
2.1	The number of drop outs had been stated - yes: 1 point - not described or unclear: 0 points	**Risk of bias:** Low – 3 points Moderate – 1-2 points High – 0 points
2.2	The reasons for dropping out had been provided - yes or the main reason: 1 point - not described or unclear: 0 points	
2.3	The investigator had been blinded to the clinical history of the participants and/or blinded to the group allocation in case of interventions - yes: 1 point - no: 0 points - not described or unclear: 0 points	

Appendix Table 2. References of publications excluded after quality assessment

Excluded for high risk of bias

1. Batchelor PA, Sheiham A. 2006. The distribution of burden of dental caries in schoolchildren: a critique of the high-risk caries prevention strategy for populations. BMC Oral Health. 6:3.
2. Disney JA, Graves RC, Stamm JW, Bohannan HM, Abernathy JR. 1989. Comparative effects of a 4-year fluoride mouthrinse program on high and low caries forming grade 1 children. Community Dent Oral Epidemiol. 17(3):139-143.
3. Petersen PE, Razanamihaja N. 1999. Carbamide-containing polyol chewing gum and prevention of dental caries in schoolchildren in Madagascar. Int Dent J. 49(4):226-230.
4. ter Pelkwijk A, van Palenstein Helderman WH, van Dijk JW. 1990. Caries experience in the deciduous dentition as predictor for caries in the permanent dentition. Caries Res. 24(1):65-71.
5. Vered Y, Zini A, Livny A, Mann J, Sgan-Cohen HD. 2008. Changing dental caries and periodontal disease patterns among a cohort of Ethiopian immigrants to Israel: 1999-2005. BMC Public Health. 8:345.

Excluded for high risk of bias and low relevance of evidence

1. Alvarez JO. 1995. Nutrition, tooth development, and dental caries. Am J Clin Nutr. 61(2):410s-416s.
2. Batchelor PA, Sheiham A. 2004. Grouping of tooth surfaces by susceptibility to caries: a study in 5-16 year-old children. BMC Oral Health. 4(1):2.

Excluded for low relevance of evidence

1. Beiswanger BB, Boneta AE, Mau MS, Katz BP, Proskin HM, Stookey GK. 1998. The effect of chewing sugar-free gum after meals on clinical caries incidence. J Am Dent Assoc. 129(11):1623-1626.
2. Chen CJ, Ling KS, Esa R, Chia JC, Eddy A, Yaw SL. 2010. A school-based fluoride mouth rinsing programme in Sarawak: a 3-year field study. Community Dent Oral Epidemiol. 38(4):310-314.
3. Delgado-Angulo EK, Hobdell MH, Bernabé E. 2013. Childhood stunting and caries increment in permanent teeth: a three and a half year longitudinal study in Peru. Int J Paediatr Dent. 23(2):101-109.

4. Dülgergil CT, Colak H. 2012. Do the more caries in early primary dentition indicate the more caries in permanent dentition? Results of a 5-years follow-up study in rural-district. J Int Soc Prev Community Dent. 2(2):48-52.
5. Frencken JE, Borsum-Andersson K, Makoni F, Moyana F, Mwashaenyi S, Mulder J. 2001. Effectiveness of an oral health education programme in primary schools in Zimbabwe after 3.5 years. Community Dent Oral Epidemiol. 29(4):253-259.
6. Louw AJ, Carstens IL, Hartshorne JE, Blignaut RJ. 1995. Effectiveness of two school-based caries preventive programmes. J Dent Assoc S Afr. 50(2):43-49.
7. Lu HX, Wong MC, Lo EC, McGrath C. 2011. Trends in oral health from childhood to early adulthood: a life course approach. Community Dent Oral Epidemiol. 39(4):352-360.
8. Machiulskiene V, Nyvad B, Baelum V. 2001. Caries preventive effect of sugar-substituted chewing gum. Community Dent Oral Epidemiol. 29(4):278-288.
9. MacKeown JM, Cleaton-Jones PE, Fatti P. 2003. Caries and micronutrient intake among urban South African children: a cohort study. Community Dent Oral Epidemiol. 31(3):213-220.
10. MacKeown JM, Cleaton-Jones PE, Edwards AW. 2000. Energy and macronutrient intake in relation to dental caries incidence in urban black South African preschool children in 1991 and 1995: the Birth-to-Ten study. Public Health Nutr. 3(3):313-319.
11. Mäkinen KK, Hujoel PP, Bennett CA, Isokangas P, Isotupa K, Pape HR Jr, Mäkinen PL. 1998. A descriptive report of the effects of a 16-month xylitol chewing-gum programme subsequent to a 40-month sucrose gum programme. Caries Res. 32(2):107-112.
12. Noro LR, Roncalli AG, Teixeira AK. 2015. Contribution of cohort studies in the analysis of oral health in children and adolescents in Sobral, Ceara. Rev Bras Epidemiol. 18(3):716-719.
13. Pajari U, Yliniemi R, Möttönen M. 2001. The risk of dental caries in childhood cancer is not high if the teeth are caries-free at diagnosis. Pediatr Hematol Oncol. 18(3):181-185.
14. Paula JS, Cruz JND, Ramires TG, Ortega EMM, Mialhe FL. 2017. Longitudinal impact of clinical and socioenvironmental variables on oral health-related quality of life in adolescents. Braz Oral Res. 31:e70.
15. Richards A, Machiulskiene V, Nyvad B, Baelum V. 2013. Saliva fluoride before and during 3 years of supervised use of fluoride toothpaste. Clin Oral Investig. 17(9):2057-2063.
16. Rupf S, Merte K, Eschrich K, Kneist S. 2006. Streptococcus sobrinus in children and its influence on caries activity. Eur Arch Paediatr Dent. 7(1):17-22.

17. Sánchez-Pérez L, Golubov J, Irigoyen-Camacho ME, Moctezuma PA, Acosta-Gio E. 2009. Clinical, salivary, and bacterial markers for caries risk assessment in schoolchildren: a 4-year follow-up. Int J Paediatr Dent. 19(3):186-192.
18. Scheinin A, Bánóczy J, Szöke J, Esztári I, Pienihäkkinen K, Scheinin U, Tiekso J, Zimmermann P, Hadas E. 1985. Collaborative WHO xylitol field studies in Hungary. I. Three-year caries activity in institutionalized children. Acta Odontol Scand. 43(6):327-347.
19. Scheutz F, Matee MI, Poulsen S, Frydenberg M. 2007. Caries risk factors in the permanent dentition of Tanzanian children: a cohort study (1997-2003). Community Dent Oral Epidemiol. 35(6):500-506.
20. Schwarz E, Lo EC, Wong MC. 1998. Prevention of early childhood caries--results of a fluoride toothpaste demonstration trial on Chinese preschool children after three years. J Public Health Dent. 58(1):12-18.
21. Tagliaferro EP, Pereira AC, Meneghim Mde C, Ambrosano GM. 2006. Assessment of dental caries predictors in a seven-year longitudinal study. J Public Health Dent. 66(3):169-173.
22. Tagliaferro EP, Ambrosano GM, Meneghim Mde C, Pereira AC. 2008. Risk indicators and risk predictors of dental caries in schoolchildren. J Appl Oral Sci. 16(6):408-413.
23. van Palenstein Helderman WH, Munck L, Mushendwa S, van 't Hof MA, Mrema FG. 1997. Effect evaluation of an oral health education programme in primary schools in Tanzania. Community Dent Oral Epidemiol. 25(4):296-300.

Appendix Table 3. References of publications set aside because they represented the same cohorts as other included publications

1. Masood M, Yusof N,Hassan MI, Jaafar N. 2014. Longitudinal study of dental caries increment in Malaysian school children: a 5-year cohort study. Asia Pac J Public Health. 26(3):260-267.
2. Page LA, Thomson WM. 2011. Dental caries in Taranaki adolescents: a cohort study. N Z Dent J. 107(3):91-96.
3. Vermaire JH, van Loveren C. 2015. Caries prevention strategies for 6-year-olds. A randomized controlled study. Ned Tijdschr Tandheelkd. 122(4):200-208.
4. Vermaire JH, van Loveren C, Brouwer WB, Krol M. 2014. Value for money: economic evaluation of two different caries prevention programmes compared with standard care in a randomized controlled trial. Caries Res. 48(3):244-253.

Appendix Table 4. Study characteristics and results of the annual declines in the percentage of caries-free children in the primary dentition (d_3) ordered by age at baseline

First author and year of publication	Age at base-line	N	Caries-free at base-line (%)	Caries-free at follow-up (%)	Decline in caries-free partici-pants (%)	Follow-up (years)	Mean decline in caries-free partici-pants per year (%)	Decade	Country	RoB/ RoE (*)	Additional information
Pienihäkkinen et al. 2004	2	226	97	77	20	3	6.7	1990s	Finland	m/h	Observational study.
Karjalainen et al. 2001	3	135	91.9	71.9	20	3	6.7	?	Finland	m/h	Observational study.
Tickle et al. 2017	3	1,096	100	63.5	36.5	3	12.2	2010s	UK	l/h	Intervention study. At baseline selection of caries-free children. Preventive intervention extra fluoride (50% (**)).
Holt 1995	5	1,006	63	48	15	4	3.8	?	UK	m/m	Observational study.
van Rijkom et al. 2004	5	676	100	57	43	4	10.8	1990s	the Netherlands	l/h	Intervention study. At baseline selection of caries-free children. Preventive intervention extra fluoride (50%). Used bitewing radiographs.
Vermaire et al. 2014	6	179	45.3	33	12.3	3	4.1	2000s	the Netherlands	l/h	Intervention study. Preventive intervention extra fluoride (70%).

(*) RoB is risk of bias; RoE is relevance of evidence; l is low; m is moderate; h is high.
(**) This refers to the percentage of participants in the cohort that had received a preventive intervention exceeding preventive care as usual.

Appendix Table 5. Study characteristics and results of the annual increments in dmfs (d_3) ordered by age at baseline

First author and year of publication	Age at base-line	N	Mean dmfs at base-line (SD)	Mean dmfs at follow-up (SD)	Incre-ment in dmfs (SD)	Follow-up (years)	Mean incre-ment in dmfs per year	Decade	Country	RoB/ RoE (*)	Additional information
Tickle et al. 2017	3	1,096	0 (0)	3.09 (5.08)	3.09	3	1.0	2010s	UK	l/h	Intervention study. At baseline selection of caries-free children. Preventive intervention extra fluoride (50% (**)). Data as reported for subgroups have been pooled.
Holt 1995	5	1,006	2.2 (5.47)	4.0 (6.9)	1.8	4	0.5	?	UK	m/m	Observational study.
van Rijkom et al. 2004	5	676	0 (0)	1.59	1.59 (2.87)	4	0.4	1990s	the Netherlands	l/h	Intervention study. At baseline selec-tion of caries-free children. Preventive intervention extra fluoride (50%). Used bitewing radiographs. Data as reported for subgroups have been pooled.
Margolis et al. 1994	6	2,185	6.12 (9.0)	8.4	2.28 (4.0)	3	0.8	1980s	USA	m/m	Observational study. Data as reported for subgroups have been pooled.
Petersen et al. 2004	6	666	8.1	5.0	-3.1	3	-1.0	1990s	China	m/m	Intervention study. Preventive intervention school-based education program (50%). Data as reported for subgroups have been pooled.
Vermaire et al. 2014	6	179	5.53 (7.97)	6.09 (6.6)	0.57 (6.0)	3	0.2	2000s	the Netherlands	l/h	Intervention study. Preventive intervention extra fluoride (70%). Data as reported for subgroups have been pooled. SDs were requested from the author.
Sánchez-Pérez et al. 2010	7	88	5.23 (7.26)	2.52 (4.86)	-2.71	4	-0.7	?	Mexico	l/m	Observational study.

(*) RoB is risk of bias; RoE is relevance of evidence; l is low; m is moderate; h is high.
(**) This refers to the percentage of participants in the cohort that had received a preventive intervention exceeding preventive care as usual.

Appendix Table 6. Study characteristics and results of the annual increments in dmft ($_3$) ordered by age at baseline

First author and year of publication	Age at base-line	N	Mean dmft at base-line (SD)	Mean dmft at follow-up (SD)	Incre-ment in dmft (SD)	Follow-up (years)	Mean incre-ment in dmft per year	Decade	Country	RoB/ RoE (*)	Additional information
Karjalainen et al. 2001	3	135	0.19 (0.82)	0.94 (1.93)	0.75	3	0,3	?	Finland	m/h	Observational study.
Holt 1995	5	1,006	1.3 (2,5)	1.7 (2.28)	0.4	4	0,1	?	UK	m/m	Observational study.
Heinemann et al. 2017	7	505	2.5 (3.0)	1.6 (1.9)	-0.9	3	-0,3	2000s	Germany	m/h	Observational study.
Sánchez-Pérez et al. 2010	7	88	2.7 (3.19)	1.46 (2.01)	-1.24	4	-0,3	?	Mexico	l/m	Observational study.

(*) RoB is risk of bias; RoE is relevance of evidence; l is low; m is moderate; h is high.

Appendix Table 7. Study characteristics and results of the annual declines in the percentage of caries-free children and adolescents in the permanent dentition (D_3) ordered by age at baseline

First author and year of publication	Age at base-line	N	Caries-free at base-line (%)	Caries-free at follow-up (%)	Decline in caries-free partici-pants (%)	Follow-up (years)	Mean decline in caries-free partici-pants per year (%)	Decade	Country	RoB/ RoE (*)	Additional information
van Rijkom et al. 2004	5	676	100	83	17	4	4.3	1990s	the Netherlands	l/h	Intervention study. At baseline selection of caries-free children. Preventive intervention extra fluoride (50% (**)). Used bitewing radiographs. Data as reported for subgroups have been pooled.
Masood et al. 2012	6	1,830	95.4	70	25.4	5	5.1	2000s	Malaysia	l/h	Observational study.
Peres et al. 2016	6	302	97	28.1	68.9	12	5.7	1990s	Brazil	m/h	Observational study. The reported results were adjusted for oversampling of low birth weight children, the unadjusted results were requested from the author.
Vermaire et al. 2014	6	179	97.1	81.6	15.5	3	5.2	2000s	the Netherlands	l/h	Intervention study. Preventive intervention extra fluoride and sealants (70%).
Virtanen 2001	6	453	98.7	17.2	81.5	12	6.8	1990s	Finland	m/h	Observational study. We only included the cohort 80-81.
Heinemann et al. 2017	7	505	92.3	70.5	21.8	3	7.3	2000s	Germany	m/h	Observational study.

Karjalainen et al. 1994	7	206	70.9	46.1	24.8	3	8.3	?	Finland	m/h	Intervention study. Preventive intervention extra fluoride (46%). Data as reported for subgroups have been pooled.
Sánchez-Pérez et al. 2010	7	88	97.7	72.7	25.5	4	6.4	?	Mexico	l/m	Observational study.
van Palenstein Helderman et al. 2001	7	62	68	32	36	4	9	?	the Netherlands	m/m	Observational study. Used bitewing radiographs.
Ruiken et al. 1986	8	355	52.4	29	23.4	4	5.9	1980s	the Netherlands	m/h	Observational study. Preventive intervention school-based education program (100%).
Lenkkeri et al. 2012	10	496	82.7	41.9	40.8	4	10.2	2000s	Finland	l/h	Intervention study. Preventive intervention xylitol and other polyalcohols (80%). Follow-up data provided for clinical as well as clinical and radiographical assessments; baseline was only assessed clinically, therefore we used only the clinical data at follow-up.
David et al. 2006	12	112	37	8	29	6	4.8	1990s	Norway	m/h	Observational study. Used bitewing radiographs.
Li et al. 2017	12	282	74.5	37.9	36.6	6	6.1	2010s	Hong Kong	m/m	Observational study. Exclusion of children with severe systemic diseases and/or a history of orthodontic treatment.
Basha et al. 2017	13	764	75.8	66	9.8	3	3.3	2000s	India	m/m	Observational study.
Foster Page and Thomson 2012	13	255	31.8	20.8	11	3	3.7	2000s	New Zealand	m/h	Observational study.
Ekbäck et al. 2016	14	423	50.4	41.4	9	3	3	1990s	Sweden	m/h	Observational study. Used bitewings radiographs (individually indicated).

Kruger et al. 1998	15	649	14.5	7.9	6.6	3	2.2	1980s	New Zealand	m/h	Observational study.
Swedberg, Fredén, and Norén 1997	15	4,380	8	4.9	3.1	4	0.8	1980s	Sweden	m/h	Observational study. Same study population as in Swedberg, Fredén, Norén, and Johnsson 1997. Data as reported for subgroups have been pooled. Baseline caries experience based on DMFT provided in Swedberg, Fredén, Norén, and Johnsson 1997.

(*) RoB is risk of bias; RoE is relevance of evidence; l is low; m is moderate; h is high.

(**) This refers to the percentage of participants in the cohort that had received a preventive intervention exceeding preventive care as usual.

Appendix Table 8. Study characteristics and results of the annual increments in DMFS (D_3) ordered by age at baseline

First author and year of publication	Age at base-line	N	Mean DMFS at base-line (SD)	Mean DMFS at follow-up (SD)	Incre-ment in DMFS (SD)	Follow-up (years)	Mean incre-ment in DMFS per year	Decade	Country	RoB/ RoE (*)	Additional information
Schmoeckel et al. 2015	5	170	0.11 (0.53)	4.98 (6.59)	4.87	11	0.44	1990s	Germany	l/m	Observational study. We set the follow-up on 11 years, this was based on the mean ages at baseline and follow-up.
van Rijkom et al. 2004	5	676	0 (0)	0.27	0.27 (0.76)	4	0.07	1990s	the Netherlands	l/h	Intervention study. At baseline selection of caries-free children. Preventive intervention extra fluoride (50% (**)). Used bitewing radiographs. Data as reported for subgroups have been pooled.
Petersen et al. 2004	6	666	0.1	0.3	0.2	3	0.07	1990s	China	m/m	Intervention study. Preventive intervention school-based education program (50%). Data as reported for subgroups have been pooled.
Tai et al. 2009	6	661	0.08 (0.50)	0.3	0.22 (0.09)	3	0.07	2000s	China	l/h	Intervention study. We included only the intervention group. Preventive intervention program (education) (100%).
Vermaire et al. 2014	6	179	0.04 (0.25)	0.37 (0.89)	0.33 (0.85)	3	0.11	2000s	the Netherlands	l/h	Intervention study. Preventive intervention extra fluoride and sealants (70%). Data as reported for subgroups have been pooled. SDs were requested from the author.
Virtanen 2001	6	453	0.02	6.41	6.39	12	0.53	1990s	Finland	m/h	Observational study. We included only the cohort 80-81.

Poulsen 1987	7	316	1.53	7.24	5.71	7	0.82	1970s	Denmark	m/h	Observational study. We included only grade 8. At baseline exclusion of children with extremely high levels of caries experience. Data as reported for subgroups have been pooled.
Sánchez-Pérez et al. 2010	7	88	0.02 (0.15)	0.82 (1.8)	0.8	4	0.2	?	Mexico	l/m	Observational study.
Ruiken et al. 1986	8	355	1.44 (1.9)	3.25 (2.81)	1.81	4	0.45	1980s	the Netherlands	m/h	Observational study. Preventive intervention school-based education program (100%). Data as reported for subgroups have been pooled.
Alanen et al. 2000	10	567	2.01 (3.16)	4.7 (4.92)	2.69	3	0.9	1990s	Estonia	l/m	Intervention study. Preventive intervention xylitol and other polyalcohols (74%). Data as reported for subgroups have been pooled.
Lenkkeri et al. 2012	10	496	0.32 (0.9)	1.84	1.52 (2.1)	4	0.38	2000s	Finland	l/h	Intervention study. Preventive intervention xylitol and other polyalcohols (80%). Data as reported for subgroups have been pooled. Follow-up data was provided for clinical as well as clinical and radiographical assessments; baseline was only assessed clinically, therefore we used only the clinical data at follow-up.
Truin and van 't Hof 2005	10	516	0 (0)	1.04	1.04 (1.88)	4	0.26	1990s	the Netherlands	m/h	Intervention study. At baseline selection of caries-free children. Preventive intervention extra fluoride (51%). Used bitewing radiographs. Data as reported for subgroups have been pooled.

Hanachowicz 1984	11	473	5.36 (4.72)	10.66	5.3 (4.45)	3	1.77	1980s	France	l/m	Intervention study. We included only the intervention group. Preventive intervention – (the intervention group used fluoridated toothpaste which is care as usual). Used bitewing radiographs.
Isogangas et al. 1993	11	165	2.83 (2.98)	7.01	4.18	7	0.6	1980s	Finland	m/h	Intervention study. At baseline exclusion of children with high caries risks; preventive intervention xylitol and other polyalcohols (58%). Data as reported for subgroups have been pooled.
Sköld et al. 1994	11	124	1.9 (1.9)	4.2 (4.3)	2.3	4	0.58	1980s	Sweden	m/h	Intervention study. Exclusion of children with fixed orthodontic appliances. Preventive intervention extra fluoride (52%). Used bitewing radiographs. Data as reported for subgroups have been pooled.
Bruno Ambrosius et al. 2005	12	162	1.68 (2.85)	3.79 (5.13)	2.11	3	0.7	2000s	Sweden	m/h	Observational study. Used bitewing radiographs.
David et al. 2006	12	112	2.7 (3.5)	8.7 (9.4)	6.0	6	1.0	1990s	Norway	m/h	Observational study. Used bitewing radiographs.
Heidmann and Poulsen 1997	12	2,765	2.27 (3.13)	5.47	3.2 (4.8)	3	1.07	1990s	Denmark	m/h	Intervention study. Preventive intervention – (this study compared two dentifrices, which is care as usual). Data as reported for subgroups have been pooled.
Heyduck et al. 2006	12	434	2.79 (4.07)	6.94 (8.34)	3.7	3	1.23	2000s	Germany	l/h	Observational study.
Källestål 2005	12	903	2.81 (3.39)	6.76 (6.61)	3.95 (5.25)	5	0.79	1990s	Sweden	m/h	Intervention study. At baseline selection of children with high caries-risks. Preventive intervention extra fluoride (49%). Used bitewing radiographs.

Morgan et al. 1998	12	445	3.43 (3.82)	5.11 (5.6)	1.68	3	0.56	1990s	Australia	m/h	Intervention study. Selection of children with high levels of caries experience and low SES. Preventive intervention extra fluoride and sealants (47%); preventive program (education) (100%). Data as reported for subgroups have been pooled.
Forgie et al. 2000	13	987	6.75 (7.02)	13.36	6.61 (6.6)	4	1.65	1990s	UK	l/m	Intervention study. At baseline selection of children that had past caries experience and were MS-positive. Preventive intervention chlorhexidine varnish (22%). Used bitewing radiographs. Data as reported for subgroups have been pooled.
Foster Page and Thomson 2012	13	255	2.9 (4.7)	3.6 (4.7)	0.7	3	0.23	2000s	New Zealand	m/h	Observational study.
Sköld et al. 2001	13	118	2.78 (3.1)	5.09 (4.36)	2.31	3	0.77	1990s	Sweden	l/h	Intervention study. Preventive intervention extra fluoride (49%). Used bitewing radiographs. Data as reported for subgroups have been pooled.
Kruger et al. 1998	15	649	5.1 (4.25)	7.68 (6.64)	2.58	3	0.86	1980s	New Zealand	m/h	Observational study. Data as reported for subgroups have been pooled.
Holmén et al. 2013	16	10,068	2.83	4.12	1.29	3	0.43	2000s	Sweden	m/h	Observational study. Used bitewing radiographs (individually indicated). Data as reported for subgroups have been pooled.

(*) RoB is risk of bias; RoE is relevance of evidence; l is low; m is moderate; h is high.

(**) This refers to the percentage of participants in the cohort that had received a preventive intervention exceeding preventive care as usual.

Appendix Table 9. Study characteristics and results of the annual increments in DMFT (D_3) ordered by age at baseline

First author and year of publication	Age at base-line	N	Mean DMFT at base-line (SD)	Mean DMFT at follow-up (SD)	Incre-ment in DMFT (SD)	Follow-up (years)	Mean incre-ment in DMFT per year	Decade	Country	RoB/ RoE (*)	Additional information
Masood et al. 2012	6	1,830	0.06 (0.31)	0.57 (1.1)	0.51	5	0.1	2000s	Malaysia	l/h	Observational study.
Peres et al. 2016	6	302	0.06 (0.4)	2.1 (2.3)	2.04	12	0.17	1990s	Brazil	m/h	Observational study. The reported results were adjusted for oversampling of low birth weight children, the unadjusted results were requested from the author. SDs were not provided and have been calculated based on provided SEs for DMFT at age 6 yr and on the provided frequency table for DMFT at age 18 yr.
Tai et al. 2009	6	661	0.07 (0.31)	0.26	0.19 (0.07)	3	0.06	2000s	China	l/h	Intervention study. We included only the intervention group. Preventive intervention program (education) (100% (**)).
Virtanen 2001	6	453	0.02	4.04	4.02	12	0.34	1990s	Finland	m/h	Observational study. We included only the cohort 80-81.
Heinemann et al. 2017	7	505	0.1 (0.5)	0.6 (1.1)	0.5	3	0.17	2000s	Germany	m/h	Observational study.
Karjalainen et al. 1994	7	206	0.61 (1.2)	1.33	0.72 (1.1)	3	0.24	?	Finland	m/h	Intervention study. Preventive intervention extra fluoride (46%). Data as reported for subgroups have been pooled
Sánchez-Pérez et al. 2010	7	88	0.01 (0.11)	0.54 (1.01)	0.53	4	0.13	?	Mexico	l/m	Observational study.

Zimmer et al. 1999	7	253	0.41 (0.76)	1.64 (1.71)	1.23	3	0.41	1990s	Germany	m/h	Intervention study. Selection of children with high caries levels at baseline and low SES. Preventive intervention extra fluoride (26%). Data as reported for subgroups have been pooled.
Bruno Ambrosius et al. 2005	12	162	1.47 (2.27)	2.56 (2.95)	1.09	3	0.36	2000s	Sweden	m/h	Observational study. Used bitewing radiographs.
David et al. 2006	12	112	1.9 (2.2)	6.1 (4.4)	4.2	6	0.7	1990s	Norway	m/h	Observational study. Used bitewing radiographs.
Heyduck et al. 2006	12	434	1.78 (2.15)	3.97 (3.68)	2.19	3	0.73	2000s	Germany	l/h	Observational study.
Li et al. 2017	12	282	0.46 (0.94)	2.13 (2.48)	1.67	6	0.28	2010s	Hong Kong	m/m	Observational study. Exclusion of children with severe systemic diseases and/or a history of orthodontic treatment.
Julihn et al. 2009	13	15,538	1.28 (1.84)	3.39 (3.54)	2.11	6	0.35	1980s	Sweden	m/h	Observational study. Used bitewing radiographs.
Swedberg, Fredén, Norén, and Johnsson 1997	15	4,380	5.5 (3.46)	7.05 (4.17)	1.55	4	0.39	1980s	Sweden	m/h	Observational study. We included only the longitudinal group. Data as reported for subgroups have been pooled. SDs were not reported and have been recalculated based on reported CIs.

(*) RoB is risk of bias; RoE is relevance of evidence; l is low; m is moderate; h is high.

(**) This refers to the percentage of participants in the cohort that had received a preventive intervention exceeding preventive care as usual.

Appendix Table 10. Output of the hierarchical, multivariable meta-regression analyses of the relationship between caries incidence rate per person-year at risk (D_3) in the permanent dentition and follow-up

Caries incidence rate per person-year at risk [(*)] (number of studies: 15; number of participants: 10,768)					
Unadjusted					
Variable	**Regression Coefficient**	**SE**	**P**	**95% CI**	
Follow-up time (year)	-0.00	0.00	0.85	-0.01	0.01
Intercept	0.12	0.02	< 0.01	0.07	0.16
Adjusted for group 1					
Follow-up time (year)	0.00	0.00	0.47	-0.00	0.01
Intercept	0.02	0.04	0.68	-0.06	0.09
Bitewing radiographs					
no	reference				
yes	0.01	0.03	0.86	-0.05	0.06
Age at baseline (year)	0.01	0.00	< 0.01	0.00	0.02
Adjusted for groups 1 and 2					
Follow-up time (year)	0.00	0.00	0.19	-0.00	0.01
Intercept	0.00	0.04	0.91	-0.07	0.08
Bitewing radiographs					
no	reference				
yes	-0.00	0.03	0.93	-0.05	0.05
Age at baseline (year)	0.01	0.00	0.02	-0.05	0.02
Caries experience at baseline					
low	reference				
moderate	0.05	0.02	0.04	0.00	0.09
high	-0.00	0.04	0.92	-0.08	0.07
Adjusted for groups 1, 2 and 3					
Follow-up time (year)	-0.00	0.01	0.95	-0.02	0.02
Intercept	-0.02	0.05	0.63	-0.12	0.08
Bitewing radiographs					
no	reference				
yes	-0.04	0.06	0.51	-0.15	0.07
Age at baseline (year)	0.01	0.01	0.06	-0.00	0.03
Caries experience at baseline					
low	reference				
moderate	0.01	0.07	0.88	-0.12	0.14
high	-0.07	0.14	0.63	-0.34	0.21
Decade					
2000s or 2010s	reference				
1990s	0.05	0.08	0.53	-0.11	0.21
1980s	0.03	0.09	0.70	-0.13	0.20
Preventive intervention					
no	reference				
yes	0.01	0.03	0.73	-0.05	0.08
Adjusted for groups 1, 2, 3 and 4					
Follow-up time (year)	-0.02	0.02	0.26	-0.05	0.01
Intercept	-0.02	0.05	0.62	-0.12	0.07
Bitewing radiographs					
no	reference				
yes	-0.15	0.10	0.15	-0.34	0.05

Age at baseline (year)	0.03	0.01	0.03	0.00	0.06
Caries experience at baseline					
low	reference				
moderate	-0.10	0.10	0.32	-0.29	0.09
high	-0.38	0.26	0.15	-0.89	0.13
Decade					
2000s or 2010s	reference				
1990s	0.22	0.15	0.15	-0.08	0.52
1980s	0.21	0.15	0.18	-0.10	0.51
Preventive intervention					
no	reference				
yes	-0.06	0.07	0.33	-0.19	0.06
Risk of bias					
low	reference				
moderate	-0.06	0.05	0.29	-0.16	0.05
Relevance of evidence					
high	reference				
moderate	-0.06	0.04	0.15	-0.15	0.02

(*) Caries incidence rate per person-year at risk is the number of participants acquiring a first dentine lesion in a population at risk (population with only caries-free persons) divided by the total caries-free time of all participants during follow-up.

Appendix Table 11. Output of the hierarchical, multivariable meta-regression analyses of the relationship between increment in DMFS (D_3) and follow-up

DMFS increment per year (number of studies: 22; number of participants: 11,300)					
Unadjusted					
Variable	**Regression Coefficient**	**SE**	**P**	**95% CI**	
Follow-up time (year)	0.43	0.20	0.03	0.04	0.83
Intercept	0.85	0.91	0.35	-0.93	2.62
Adjusted for group 1					
Follow-up time (year)	0.64	0.17	< 0.01	0.31	0.96
Intercept	-4.13	1.50	0.01	-7.07	-1.19
Bitewing radiographs					
no	reference				
yes	0.76	0.59	0.20	-0.40	1.92
Age at baseline (year)	0.38	0.11	< 0.01	0.16	0.59
Adjusted for groups 1 and 2					
Follow-up time (year)	0.37	0.17	0.03	0.04	0.70
Intercept	-1.92	1.49	0.20	-4.84	1.00
Bitewing radiographs					
no	reference				
yes	0.75	0.50	0.13	-0.22	1.73
Age at baseline (year)	0.14	0.14	0.31	-0.13	0.41
Caries experience at baseline					
low	reference				
moderate	1.43	0.80	0.07	-0.14	3.00
high	2.95	0.98	< 0.01	1.02	4.87
Adjusted for groups 1, 2 and 3					
Follow-up time (year)	0.36	0.19	0.06	-0.02	0.73
Intercept	-1.92	1.75	0.27	-5.35	1.51
Bitewing radiographs					
no	reference				
yes	0.72	0.60	0.23	-0.46	1.91
Age at baseline (year)	0.13	0.15	0.37	-0.16	0.43
Caries experience at baseline					
low	reference				
moderate	1.60	0.99	0.11	-0.35	3.54
high	3.27	1.35	0.02	0.62	5.92
Decade					
2000s	reference				
1990s	-0.00	0.85	1.00	-1.67	1.66
1980s	-0.46	0.98	0.64	-2.38	1.46
Preventive intervention					
no	reference				
yes	0.10	0.68	0.89	-1.24	1.44
Adjusted for groups 1, 2, 3 and 4					
Follow-up time (year)	0.46	0.19	0.02	0.08	0.83
Intercept	-3.27	1.82	0.07	-6.85	0.30
Bitewing radiographs					
no	reference				
yes	0.70	0.57	0.22	-0.43	1.82
Age at baseline (year)	0.29	0.17	0.08	-0.04	0.62
Caries experience at baseline					

low	reference				
moderate	1.24	0.97	0.20	-0.66	3.14
high	1.59	1.59	0.32	-1.52	4.69
Decade					
2000s	reference				
1990s	0.31	0.86	0.72	-1.38	1.99
1980s	0.44	1.09	0.68	-1.70	2.59
Preventive intervention					
no	reference				
yes	-0.14	0.69	0.84	-1.49	1.22
Risk of bias					
low	reference				
moderate	-1.03	0.86	0.23	-2.71	0.66
Relevance of evidence					
high	reference				
moderate	0.68	0.91	0.46	-1.11	2.47

Appendix Table 12. Output of the hierarchical, multivariable meta-regression analyses of the relationship between increment in DMFT (D_3) and follow-up

DMFT increment per year (number of studies: 13; number of participants: 24,753)					
Unadjusted					
Variable	**Regression Coefficient**	**SE**	**P**	**95% CI**	
Follow-up time (year)	0.18	0.11	0.10	-0.04	0.40
Intercept	0.56	0.58	0.33	-0.58	1.70
Adjusted for group 1					
Follow-up time (year)	0.18	0.08	0.03	0.02	0.35
Intercept	-0.98	0.81	0.22	-2.56	0.60
Bitewing radiographs					
no	reference				
yes	0.65	0.57	0.25	-0.46	1.76
Age at baseline (year)	0.15	0.07	0.05	0.00	0.29
Adjusted for groups 1 and 2					
Follow-up time (year)	0.23	0.09	0.01	0.06	0.40
Intercept	-1.06	0.77	0.17	-2.56	0.44
Bitewing radiographs					
no	reference				
yes	0.37	0.57	0.52	-0.75	1.49
Age at baseline (year)	0.10	0.08	0.22	-0.06	0.25
Caries experience at baseline					
low	reference				
moderate of high	0.74	0.54	0.16	-0.31	1.79
Adjusted for groups 1, 2 and 3					
Follow-up time (year)	0.07	0.16	0.65	-0.24	0.39
Intercept	-1.36	1.19	0.25	-3.68	0.96
Bitewing radiographs					
no	reference				
yes	0.43	0.57	0.45	-0.68	1.54
Age at baseline (year)	0.24	0.12	0.05	-0.01	0.48
Caries experience at baseline					
low	reference				
moderate of high	-0.16	0.99	0.87	-2.09	1.78
Decade					
2000s or 2010s	reference				
1990s	1.29	0.98	0.19	-0.64	3.22
1980s	-0.54	0.77	0.48	-2.06	0.97
Preventive intervention					
no	reference				
yes	-0.48	0.74	0.52	-1.94	0.98
Adjusted for groups 1, 2, 3 and 4					
Follow-up time (year)	-0.04	0.15	0.79	-0.34	0.26
Intercept	-1.48	1.02	0.15	-3.48	0.53
Bitewing radiographs					
no	reference				
yes	0.72	0.51	0.16	-0.29	1.73
Age at baseline (year)	0.40	0.14	< 0.01	0.12	0.67
Caries experience at baseline					
low	reference				
moderate of high	-1.35	1.09	0.22	-3.49	0.80

Decade					
00s or 10s	reference				
90s	2.69	1.12	0.02	0.50	4.88
80s	-0.09	0.72	0.90	-1.50	1.33
Preventive intervention					
no	reference				
yes	-0.58	0.64	0.37	-1.83	0.68
Risk of bias					
low	reference				
moderate	-0.99	0.52	0.05	-2.00	0.02
Relevance of evidence					
high	reference				
moderate	-0.51	0.57	0.37	-1.63	0.61

Appendix Table 13. Description of the covariates included in the hierarchical, multivariate meta-regression analyses caries incidence rate per person-year at risk and increments in DMFS and DMFT (D_3, permanent dentition)

	Caries incidence rate per person-year at risk (*)	**Increment in DMFS**	**Increment in DMFT**
	N studies = 15 N persons = 10,768	N studies = 22 N persons = 11,300	N studies = 13 N persons = 24,753
	Ruiken et al. 1986, Karjalainen et al. 1994, Swedberg, Fredén, and Norén 1997, Kruger et al. 1998, Virtanen 2001, van Rijkom et al. 2004, David et al. 2006, Sánchez-Pérez et al. 2010, Foster Page and Thomson 2012, Lenkkeri et al. 2012, Masood et al. 2012, Vermaire et al. 2014, Peres et al. 2016, Heinemann et al. 2017, Li et al. 2017	Hanachowicz 1984, Ruiken et al. 1986, Isogangas et al. 1993, Sköld et al. 1994, Heidmann and Poulsen 1997, Kruger et al. 1998, Morgan et al. 1998, Alanen et al. 2000, Forgie et al. 2000, Sköld et al. 2001, van Rijkom et al. 2004, Bruno Ambrosius et al. 2005, Källestål 2005, Truin and van 't Hof 2005, David et al. 2006, Heyduck et al. 2006, Tai et al. 2009, Sánchez-Pérez et al. 2010, Foster Page and Thomson 2012, Lenkkeri et al. 2012, Vermaire et al. 2014, Schmoeckel et al. 2015	Karjalainen et al. 1994, Swedberg, Fredén, Norén, and Johnsson 1997, Zimmer et al. 1999, Bruno Ambrosius et al. 2005, David et al. 2006, Heyduck et al. 2006, Julihn et al. 2009, Tai et al. 2009, Sánchez-Pérez et al. 2010, Masood et al. 2012, Peres et al. 2016, Heinemann et al. 2017, Li et al. 2017
	N studies / N persons	**N studies / N persons**	**N studies / N persons**
Follow-up (years)			
3	5 / 1,794	11/ 6,708	6 / 2,221
4	5 / 5,995	7 / 3,242	2 / 4,468
5	1 / 1,830	1 / 903	1 / 1,830
6	2 / 394	1 / 112	3 / 15,932
7	-	1 / 165	-
11	-	1 / 170	-
12	2 / 755	-	1 / 302
Group 1			
Bitewing radiographs			
No or not described (**)	13/ 9,980	13/ 7,229	10/ 8,941
Yes	2 / 788	9 / 4,071	3 / 15,812
Age at baseline			
5	1 / 676	2 / 846	-
6	4 / 2,764	2 / 840	3 / 2,793
7	3 / 799	1 / 88	4 / 1,052
8	1 / 355	1 / 355	-
10	1 / 496	3 / 1,579	-
11	-	3 / 762	-
12	2 / 394	6 / 4,821	4 / 990

13	1 / 255	3 / 1,360	1 / 15,538
15	2 / 5,029	1 / 649	1 / 4,380
Group 2			
Caries experience at baseline			
Low (**)	9 / 4,811	6 / 2,616	6 / 3,668
Moderate	4 / 928	12/ 6,405	6 / 16,705 (****)
High	2 / 5,029	4 / 2,279	1 / 4,380 (****)
Group 3			
Decade			
2000s or 2010s (**)	7 / 3,635 (***)	7 / 2,275	7 / 3,962 (***)
1990s	5 / 1,749	10/ 7,259	4 / 873
1980s	3 / 5,384	5 / 1,766	2 / 19,918
Preventive intervention			
No (**)	10/ 8,856	9 / 5,108	10/ 23,633
Yes	5 / 1,912	13/ 6,192	3 / 1,120
Group 4			
Risk of bias			
Low (**)	5 / 3,269	11/ 4,849	4 / 3,013
Moderate	10/ 7,499	11/ 6,451	9 / 21,740
Relevance of evidence			
High (**)	13/ 10,398	17/ 9,015	11/ 24,383
Moderate	2/ 370	5 / 2,285	2 / 370

(*) Caries incidence rate per person-year at risk is the number of participants acquiring a first dentine lesion in a population at risk (population with only caries-free persons) divided by the total caries-free time of all participants during follow-up.

(**) Reference category.

(***) Only one study (Li et al., 2017) was performed in the 2010s. Hence, the decades 2000 and 2010 were merged.

(****) For the DMFT, only one study (Swedberg, Fredén, Norén, and Johnsson 1997) consisted of a population with high caries experience at baseline. Hence, the categories for baseline caries experience moderate and high were merged for the meta-regression analysis on DMFT.

Appendix Table 14. PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both. Caries progression rates revisited: a systematic review.	 1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number. **Background** – Caries progression seems to follow universal, predictable rates, depending largely on the caries severity in populations: the higher the caries severity, the higher the progression rates. Quantification of these rates would allow prediction of future caries increments. **Objectives** – In this research, we first systematically review studies reporting on follow-up in Western-like populations of children and adolescents for annual progression of caries in the primary and permanent dentition. Secondly, using meta-analyses, we provide an estimate for the caries incidence rate in the permanent dentition. Thirdly, using meta-regression methods we assess the impact of study methods to explore the possible bias in the reported caries progression rates. **Data sources** – MEDLINE-PubMed, Embase, Cinahl and the Cochrane library. **Study eligibility criteria** – reporting empirical data from at least 2 full-mouth dental caries examinations in a closed cohort during a follow-up of at least three years; a first examination after 1974; a second examination before the age of 22; caries assessed as dentine caries (d_3/D_3); caries reported in dmfs, dmft, DMFS, DMFT or in caries-free participants. **Participants** – children and adolescents. **Interventions** – n/a. **Study appraisal and synthesis methods** – Study appraisal by scoring items on relevance of evidence and risk of bias. The relevance of evidence was based on Western situations. The synthesis methods were a meta-analysis on the caries incidence rate in the permanent dentition; and hierarchical meta-regression analyses to assess the impact of study methods and explore the possible bias in the reported caries progression rates.	 3 3 4 4 3 n/a 5 3

		Results – The annual decline in caries-free children ranged from 3.8% to 12.2% in the primary dentition and from 0.8% to 10.2% in the permanent dentition. The annual increment in DMFS ranged from 0.07 to 1.77, in DMFT from 0.06 to 0.73. Pooled caries progression rates were not achievable for the primary dentition due to the limited number of included studies and the non-standardized approaches of exfoliated teeth. For the permanent dentition our pooled findings on caries progression in populations were a caries incidence rate of 0.11 (0.09-0.13) per person-year at risk; an increment in DMFS of 0.43 per year of follow-up; and an increment in DMFT of 0.18 per year of follow-up. **Limitations** – Wide variation in study methods between included studies, the follow-up of at least 3 years might have been too long for primary teeth, inclusions of studies with complete cases only. **Conclusions** – We described caries progression rates in the primary and permanent dentition in Western-like populations, and pooled the rates for the permanent dentition in a caries incidence rate among others. So far, the caries incidence rate measure has rarely been used in longitudinal oral health research, but seemed fairly stable and therefore most promising. When using our progression rates for the prediction of caries increments caution is justified, because these measures were influenced by methods of the studies included. For better insight in caries progression rates in populations and usefulness for policy makers, more standardization of measuring- and study methods in (epidemiological) research is essential. **Implications of key findings** – Our findings for the permanent dentition provide indications for caries progression rates in populations. These rates could be used for planning, targeted use of preventive care and evaluation of (preventive) oral healthcare services. **Systematic review registration number** – n/a	8,9 10,11 11 11 n/a
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Dental caries is one of the most prevalent chronic diseases in the world, affecting 60-90% of schoolchildren (WHO 2012). There are disparities in caries onset and caries progression rates between and within populations. This is due to differences in behavioral and socio-demographic conditions that interact with the etiology of dental caries (Fejerskov 2004). Nevertheless, progression of dental caries seemed to follow predictable rates that depended largely on the caries severity in a population; the higher the caries severity, the higher the progression rates (Broadbent et al. 2013). Other studies also described fixed patterns for caries progression, and suggested that these were universal, both for the permanent and the primary dentition (Massler et al. 1954; Sheiham and Sabbah 2010). If these patterns are indeed universal, it would be possible to predict future caries increments in a population. This would have several advantages. As well as improving the planning of oral health services and targeted use of	 3

		preventive care (Sheiham and Sabbah 2010), it would also indicate which improvements in oral health are achievable. While many studies have described the incidence, prevalence and progression of caries, we do not know of systematic reviews or meta-analyses reporting on caries progression from pooled findings of longitudinal studies.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS). **Participants** – children and adolescents **Interventions** – n/a **Comparisons** – n/a **Outcomes** – number or percentage of caries-free participants, mean dmfs/dmft/DMFS/DMFT **Study design** – studies with follow-up	3, 4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number. We did not use a review protocol.	n/a
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale. **Study characteristics** • a closed cohort and results reported for complete cases (for the number of events to calculate the caries incidence rate) • a follow-up of at least three years (as it takes a relatively long period for enamel lesions to develop into dentine lesions) • at least two examinations of dental caries (otherwise there was no follow-up) • a second caries examination before the age of 22 (our scope was limited to children and adolescents up to the age of 21) • caries assessed as dentine caries (d_3/D_3) (as this is the stage at which restorative interventions are generally indicated) • caries reported in decayed, missing and filled surfaces or teeth (dmfs or dmft for the primary dentition; DMFS or DMFT for the permanent dentition) or in number or percentage of caries-free participants (the DMF-index is	4, 11 4 4 4, 3 4, 3 4, 3

		the leading index in research for decades (Larmas 2010; Ekbäck et al. 2016)) • the results presented full-mouth examinations **Report characteristics** • first examination after 1974 (as the use of fluoridated toothpastes became common practice from the mid-1970s (ten Cate 2013) and we opted for a follow-up period of at least three years, we excluded studies published before 1978 (1975+3 years) • the results of the cohort concerned an age range of not more than three years (to ensure not too much spreading in the variable "age at baseline") • the publication was written in English, Dutch or German language • prospective, retrospective, cohort and intervention studies were all supposed eligible, but cross-sectional and case-control studies were not (we needed studies with follow-up and corrected for interventions in the meta-regression analyses)	4 4 4, 5 4 4, 10
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched. Searched databases were MEDLINE-PubMed, Embase, Cinahl and the Cochrane library. All databases were last searched on 16 April 2018. Reviews and systematic reviews were evaluated for their relevance, and were used to identify additional studies that had not yet been found in our search.	 4 5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated. Search strategy MEDLINE-PubMed #1 Search (child*[tw] OR adolescen*[tw]) #2 Search ("Tooth Demineralization"[Mesh] OR (tooth[tiab] AND demineralization[tiab]) OR caries[tiab] OR carious[tiab] OR "DMF Index"[Mesh] OR DMF[tiab]) #3 Search ("Disease Progression"[Mesh] OR prognos*[tiab] OR progres*[tiab] OR incidence[Mesh] OR incidence[tiab] OR "cohort studies"[Mesh] OR cohort*[tiab] OR follow-up[tiab] OR prospect*[tiab] OR longitudinal[tiab]) #4 Search #1 AND #2 AND #3	 Table 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	

		Screening - Two researchers (RH and NA) independently screened titles and abstracts for meeting the eligibility criteria for full-text reading. If the eligibility was unclear, the full text was read. **Eligibility** - Full texts were reviewed independently for confirmation of eligibility (by RH and NA). All disagreements on inclusion of studies were discussed and resolved by mutual agreement. Hence, results are based on full agreement. **Inclusion in systematic review** - Studies with insufficient quality, i.e. a low relevance of evidence and/or a high risk of bias, were excluded. All other studies were included. Disagreements on the quality of study methods were discussed until consensus was reached. **Inclusion in meta-analyses** - These analyses were carried out for the permanent dentition. In the analyses of the caries incidence rate, we only included studies that reported caries-free survival as well as the mean DMFS or DMFT, as these indices were needed to determine baseline caries experiences. In the analyses of increments in DMFS and DMFT, only studies that reported measures for data distribution were included.	5 5 5 7
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators. A data-extraction form was developed that comprised nine variables: number of years of follow-up; use of bitewing radiographs (no or not described/yes); age at baseline (is age at the start of the study); year in which the study started; collective preventive intervention (no/yes); risk of bias (low/moderate); relevance of evidence (high/moderate); dmfs-, dmft-, DMFS- and DMFT-scores with standard deviations and percentage of caries-free participants at baseline; idem at follow-up. One investigator (RH) extracted the data from the included studies. The data were checked by the other investigator (NA) and initial disagreements were resolved by consensus discussion. We contacted a few authors by mail to ask for additional information on spreading measures and unadjusted results.	6 appendix
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made. Variables for which data were sought were: number of years of follow-up; use of bitewing radiographs (no or not described/yes); age at baseline (is age of the participants at the start of the study); decade in which the study had been performed (based on year in which the study started and number of years of follow-up); collective preventive intervention (no/yes); risk of bias (low/moderate); relevance of evidence (high/moderate); mean increment in dmfs-, dmft-, DMFS- and DMFT-scores with standard deviations; decline in percentage of caries-free participants during follow-up; number of events (number of caries-free participants who developed caries during follow-up).	6 7 6

		Preventive interventions that might have influenced caries progression were recorded if they had been collectively provided to all or part of the study population and were considered as additional to care as usual in general dental practices.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis. Three dichotomous (yes/no) items on the study level were used to assess the risk of bias: 1) the number of dropouts; 2) the reasons for dropping out; and 3) the investigator had been blinded for the clinical history of the participants and/or blinded for the group allocation in case of interventions. The risk of bias was considered high if none of the items were met, moderate if 1 or 2 items were met, and low if all 3 items were met. Studies with a high risk of bias were excluded. We assessed the impact of the risk of bias in the hierarchical meta-regression analyses to explore the possible bias in the reported caries progression rates.	5 3

Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means). The principal summary measures are: annual decline in percentage of caries-free children and adolescents, annual increment in dmfs/dmft/DMFS/DMFT, and caries incidence rate per year at risk.	3
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis. These analyses were carried out for the permanent dentition. The meta-analysis on the caries incidence rate was performed with the package “metamean” from R software (3.3, Development Core Team, Vienna, Austria). We used a random effects model weighted by total person-years. A forest plot was made to show the estimated effect across studies. The I-square was 100%. Then we performed multivariate, hierarchical, linear meta-regression analyses using the R package “metaphor”. The random effects model assumption was used to explore the impact of covariates on the pooled caries incidence rate and DMFS- and DMFT increments.	7
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies). We included different types of study designs, but explored the impact of these different study designs on the	3, 10

		estimates in meta-regression analyses.	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified. Our additional analyses consisted of hierarchical meta-regression analyses. First, all covariates, notably study design features, were categorized into four hierarchical groups based on an a priori expectation of effect on the estimates. Group 1 consisted of the use of bitewing radiographs and age at baseline; group 2 of caries experience at baseline; group 3 of decade and preventive intervention; and group 4 of risk of bias and relevance of evidence. Next, the meta-regressions were conducted starting with crude analyses on follow-up years. Subsequently, we added group by group to the analyses.	7, 8
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram. The number of studies screened was 6,343; 410 studies were assessed for eligibility; 43 studies were included in the systematic review and 32 studies in the meta-regression analyses. The overview of the numbers and reasons for exclusions at each stage are provided in a flow diagram (figure 1).	figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations. The characteristics of each included study are provided in the tables in the appendix.	appendix
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12). The risk of bias (low or moderate) of each included study is provided in the tables in the appendix.	appendix
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot. The results per study per outcome considered are provided in the tables in the appendix. Standard deviations are presented if spreading measures were provided in the included studies. The pooled caries incidence rate is presented in a forest plot (figure 2).	appendix figure 2
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	

		The results of the caries incidence rate are described in the results section and presented in a forest plot (figure 2). In the legend of figure 2 we described the following: Forest plot of the caries incidence rate per person-year at risk (D_3) in the permanent dentition and the 95% confidence interval (95% CI).The caries incidence rate (first caries events (D_3) per person-year at risk) could be recalculated for 15 studies. These reported on 1,995 caries events for a total of 10,768 participants with a total follow-up time of 22,292 person-years. The data were pooled using a random effects model, because the reported caries incidence rates showed marked heterogeneity (I-Square is 100%). The studies were weighted by the number of total person-years. The weight of the studies ranged from 6.5 to 6.7%, the median was 6.7%.	9, figure 2
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15). The risk of bias across studies was assessed in meta-regression analyses [see further Item 23].	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]). The results of the meta-regression analyses are described in the results section, summarized in tables 3 and 4, and fully provided in the appendix. The caries incidence rate was constant over time as the unadjusted regression coefficient for follow-up was zero. Adjusting for the covariates did not affect the estimate. Only in the last step, when risk of bias and relevance of evidence were added, the estimate changed into -0.02. So, the pooled caries incidence rate of 0.11 is probably an overestimation. The unadjusted increment in DMFS per year of follow-up was 0.43. Adjusting for group 1 (bitewing radiographs and age at baseline) increased the regression coefficient for annual increment to 0.64. Adding group 2 (caries experience at baseline) decreased this estimate to 0.37 and adding group 3 (decade and preventive intervention) to 0.36. Adding group 4 (risk of bias and relevance of evidence) increased the estimate again to 0.46. The estimate of the annual increment in DMFS ranged probably from 0.36 to 0.64 and was affected by covariates. The unadjusted increment in DMFT per year of follow-up was 0.18. Adjusting for group 1 (bitewing radiographs and age at baseline) did not change the estimate. Adding group 2 (caries experience at baseline) increased the estimate to 0.23. Adding group 3 (decade and preventive intervention) showed a large decrease to 0.07. Adding group 4 (relevance of evidence and risk of bias) led to a remarkable, negative increment of -0.04. The estimate of the annual increment in DMFT was highly influenced by covariates.	9, tables 3 and 4, appendix
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	

		Our findings for the permanent dentition provide indications for caries progression rates in populations. These rates could be used for planning, targeted use of preventive care and evaluation of (preventive) oral healthcare services. They provide a starting point for further research. They could also be used by general dental practitioners for reflections on the caries progression rates in their patient populations. And last but not least, they emphasize the importance of preventing caries at early ages as progression rates for DMFS/T were higher in populations with higher baseline caries experiences.	11
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias). Some aspects of this review warrant further attention. First, the wide variations in study methods. For future research adequate study designs and standardized methods of data collection are desirable. Harmonization of study designs can contribute to reduction of the uncertainties that the meta-regression analyses demonstrated. The inclusion of both intervention and observational studies might cause some confusion. Our aim was to find data on caries progression in studies with follow-up for cohorts with or without collective, uniform, preventive interventions. We corrected for such interventions in the meta-regression analyses. Yet, we found that this did not elucidate the variation in outcomes. Secondly, the filled component of the DMF-index was probably influenced by lesion thresholds of dentists to intervene restoratively. Thirdly, the assessment of dental caries is complex and methods for assessment were varied like use of bitewing radiographs, drying of teeth, etc. This would have resulted in differences in the diagnosis of dental caries. However, these differences were probably reduced as the included studies used the same methods for the baseline and follow-up measurements. Fourthly, meta-analyses were not possible for the primary dentition as a result of the limited number of included studies, and the inconsistent results due to exfoliated teeth. A follow-up of three years might not have been necessary for the primary dentition, caries lesions in primary teeth generally progress faster than in permanent teeth. Finally, another source of bias may have been the inclusion of studies with only results of complete cases, i.e. the results at baseline and at follow-up were for the same participants. This might have caused a selective follow-up. Nonetheless, we needed complete cases to determine the number of events for the caries incidence rates.	10, 11
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	11

		In this systematic review we described caries progression rates in the primary and permanent dentition in Western-like populations. Pooled caries progression rates were not achievable for the primary dentition due to the limited number of included studies and the non-standardized approaches of exfoliated teeth. For the permanent dentition our pooled findings on caries progression in populations were a caries incidence rate of 0.11 (0.09-0.13) per person-year at risk; an increment in DMFS of 0.43 per year of follow-up; and an increment in DMFT of 0.18 per year of follow-up. So far, the caries incidence rate measure has rarely been used in longitudinal oral health research, but seemed fairly stable and therefore most promising. When using our progression rates for the prediction of caries increments caution is justified, because these measures were influenced by methods of the studies included. For better insight in caries progression rates in populations and usefulness for policy makers, more standardization of measuring- and study methods in (epidemiological) research is essential.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review. This study received no funding.	12

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097.

For more information, visit: www.prisma-statement.org.