

Supplementary Web-Table 1. Distribution of outcomes and confounders in participants with data on outcomes who were excluded from the analyses due to missing data on exposures or confounders and in complete cases. (3177 participants were excluded due to reported special education needs at any school year).

Variable	N of excluded participants	Mean (SD) in excluded participants	Mean (SD) in complete cases (n=3171)	P for difference
English total score	7123	47.43 (15.25)	53.29 (14.91)	<0.001
Maths total score	7123	81.64 (20.49)	88.61 (20.43)	<0.001
Science total score	7123	98.59 (23.21)	101.93 (22.15)	<0.001
BMI (kg/m ²)	1446	17.57 (3.65)	17.33 (3.29)	0.03
Full WISC-III IQ at age 8.5years	1734	101.45 (18.97)	105.12 (20.49)	<0.001

Variable	N of excluded participants	N (%) in excluded participants	N (%) in complete cases (n=3171)	P for difference
Achieved 5 or more A*-C grades	7123			
No		3209 (45.1)	795 (25.1)	
Yes		3914 (54.9)	2376 (74.9)	<0.001
Achieved 9 or more A*-A grades	7123			
No		6871 (96.5)	2895 (91.3)	
Yes		252 (3.5)	276 (8.7)	<0.001
Did not achieve any A*-C grades	7123			
No		6224 (87.4)	3018 (95.2)	
Yes		899 (12.6)	153 (4.8)	<0.001
Ethnicity	4701			
White		4431 (94.3)	3071 (96.9)	
Non-white		270 (5.7)	100 (3.1)	<0.001
Eligible for free school meals	7119			
No		6307 (88.6)	3048 (96.1)	
Yes		812 (11.4)	123 (3.9)	<0.001
Time spent outdoors in summer during holidays >3h/day	1747			

	No		153 (8.8)	303 (9.6)	
	Yes		1594 (91.2)	2868 (90.4)	0.35
Time spent outdoors in summer during weekends >3h/day		1735			
	No		137 (7.9)	267 (8.4)	
	Yes		1598 (92.1)	2904 (91.6)	0.51
Time spent outdoors in summer during school weekdays >3h/day		1780			
	No		832 (46.7)	1651 (52.1)	
	Yes		948 (53.3)	1520 (47.9)	<0.001
Child normally wears something to cover the skin whilst out in the sun		1758			
	Always		331 (18.8)	440 (13.9)	
	Usually		763 (43.4)	1426 (45.0)	
	Sometimes/Never		664 (37.8)	1305 (41.2)	
Child normally uses sunblock whilst out in the sun		1770			<0.001
	Always		1017 (57.5)	1737 (54.8)	
	Usually		540 (30.5)	1043 (32.9)	
	Sometimes/Never		213 (12.0)	391 (12.3)	
Child normally wears hat whilst out in the sun		1763			0.10
	Always		331 (18.8)	440 (13.9)	
	Usually		664 (37.8)	1305 (41.2)	
	Sometimes		1017 (57.5)	1737 (54.8)	
	Never		78 (4.4)	156 (4.9)	0.001
Child normally avoids midday sun		1755			
	Always		306 (17.4)	457 (14.4)	
	Usually		707 (40.3)	1251 (39.5)	
	Sometimes		603 (34.4)	1193 (37.6)	
	Never		139 (7.9)	269 (8.5)	0.003

Head of household social class		3369			
	i		298 (8.8)	450 (14.2)	
	ii		1296 (38.5)	1480 (46.7)	
	iii non-manual		1011 (30.0)	834 (26.3)	
	iii manual		531 (15.8)	299 (9.4)	
	iv/v		298 (8.8)	450 (14.2)	<0.001
Paternal education level		3503			
	None/CSE		1038 (29.6)	542 (17.1)	
	Vocational		321 (9.2)	267 (8.4)	
	O level		808 (23.1)	769 (24.3)	
	A level		919 (26.2)	945 (29.8)	
	Degree		417 (11.9)	648 (20.4)	<0.001
Maternal education level		3727			
	None/CSE		876 (23.5)	348 (11.0)	
	Vocational		419 (11.2)	257 (8.1)	
	O level		1432 (38.4)	1207 (38.1)	
	A level		707 (19.0)	887 (28.0)	
	Degree		293 (7.9)	471 (14.9)	<0.001

Supplementary Web-Table 2. Univariable associations between potential confounders and age- and gender-adjusted serum 25-hydroxyvitamin D₃, D₂, PTH and calcium concentrations

	Season-adjusted 25(OH)D ₃ (nmol/L)		25(OH)D ₂ (nmol/L)		Phosphate (mmol/L)		Albumin-adjusted calcium (mmol/L)		Parathyroid hormone pmol/L	
	SD change per SD/category change (95%CI)	<i>P</i>	SD change per SD/category change (95%CI)	<i>P</i>	SD change per SD/category change (95%CI)	<i>P</i>	SD change per SD/category change (95%CI)	<i>P</i>	SD change per SD/category change (95%CI)	<i>P</i>
BMI (kg/m ²)	-0.02 (-0.03, -0.01)	<0.001	-0.01 (-0.02, -0.01)	0.001	0.00 (-0.01, 0.01)	0.99	0.00 (-0.01, 0.01)	0.53	0.02 (0.01, 0.02)	<0.001
Non-white ethnicity	-0.67 (-0.79, -0.56)	<0.001	-0.09 (-0.21, 0.02)	0.11	-0.02 (-0.14, 0.10)	0.76	-0.07 (-0.18, 0.05)	0.28	0.34 (0.22, 0.46)	<0.001
Head of household social class										
i	0.02 (-0.05, 0.08)	0.002	-0.04 (-0.10, 0.02)	0.02	0.04 (-0.03, 0.10)	0.01	-0.05 (-0.12, 0.01)	0.16	-0.01 (-0.07, 0.06)	0.58
ii	0.04 (-0.03, 0.11)		0.02 (-0.05, 0.10)		0.00 (-0.08, 0.07)		0.07 (-0.01, 0.14)		0.01 (-0.07, 0.08)	
iii non-manual	-0.01 (-0.09, 0.07)		0.03 (-0.05, 0.12)		-0.07 (-0.15, 0.01)		0.09 (0.00, 0.17)		-0.04 (-0.12, 0.05)	
iii manual	-0.15 (-0.25, -0.04)		0.15 (0.04, 0.25)		-0.12 (-0.23, -0.01)		0.02 (-0.08, 0.13)		0.06 (-0.05, 0.17)	
iv/v	-0.10 (-0.25, 0.05)		0.07 (-0.08, 0.23)		-0.04 (-0.20, 0.11)		0.14 (-0.02, 0.29)		0.05 (-0.10, 0.20)	
Paternal education										
None/CSE	-0.05 (-0.11, 0.01)	0.11	0.08 (0.02, 0.14)	0.02	-0.0 3(-0.09, 0.03)	0.14	0.11 (0.05, 0.17)	0.001	-0.02 (-0.08, 0.04)	0.94
Vocational	0.07 (-0.04, 0.18)		-0.18 (-0.29, -0.06)		0.03 (-0.08, 0.14)		-0.15 (-0.26, -0.04)		0.00 (-0.11, 0.11)	
O level	0.09 (0.01, 0.18)		-0.09 (-0.17, -0.01)		0.03 (-0.05, 0.12)		-0.09 (-0.17, 0.00)		0.05 (-0.04, 0.13)	
A level	0.11		-0.07		0.02		-0.08		-0.01	

	(0.03, 0.18)		(-0.15, 0.01)		(-0.06, 0.10)		(-0.16, 0.00)		(-0.08, 0.07)	
	0.06		-0.14		0.07		-0.18		0.01	
Maternal education	(-0.02, 0.14)		(-0.22, -0.05)		(-0.01, 0.15)		(-0.26, -0.10)		(-0.07, 0.10)	
None/CSE	-0.10	0.09	0.08	0.005	-0.05	0.02	0.06	0.002	0.04	0.93
	(-0.17, -0.03)		(0.01, 0.16)		(-0.13, 0.02)		(-0.01, 0.13)		(-0.04, 0.11)	
Vocational	0.11		-0.10		0.10		0.02		-0.07	
	(0.00, 0.23)		(-0.22, 0.02)		(-0.02, 0.22)		(-0.10, 0.13)		(-0.18, 0.05)	
O level	0.15		-0.06		0.02		-0.04		-0.07	
	(0.07, 0.23)		(-0.15, 0.02)		(-0.07, 0.10)		(-0.13, 0.04)		(-0.16, 0.01)	
A level	0.10		-0.12		0.07		-0.06		-0.03	
	(0.02, 0.19)		(-0.21, -0.04)		(-0.02, 0.16)		(-0.15, 0.03)		(-0.12, 0.05)	
Degree	0.11		-0.13		0.12		-0.14		-0.02	
	(0.02, 0.21)		(-0.22, -0.03)		(0.02, 0.21)		(-0.24, -0.05)		(-0.12, 0.08)	
Child normally wears hat whilst out in the sun										
Always	0.04	0.001	-0.02	0.51	0.01	0.61	0.10	0.003	-0.07	0.02
	(-0.03, 0.10)		(-0.09, 0.05)		(-0.06, 0.08)		(0.03, 0.17)		(-0.14, 0.00)	
Usually	0.03		0.03		-0.01		-0.12		0.06	
	(-0.05, 0.11)		(-0.05, 0.11)		(-0.09, 0.07)		(-0.20, -0.04)		(-0.02, 0.14)	
Sometimes	-0.07		0.01		-0.02		-0.13		0.08	
	(-0.15, 0.01)		(-0.07, 0.09)		(-0.10, 0.07)		(-0.21, -0.05)		(0.00, 0.16)	
Never	-0.18		0.09		-0.03		-0.18		0.15	
	(-0.32, -0.05)		(-0.04, 0.23)		(-0.17, 0.10)		(-0.32, -0.04)		(0.01, 0.28)	
Child normally wears something to cover the skin whilst out in the sun										
Always	0.00	0.34	-0.02	0.51	-0.08	0.18	0.05	0.03	-0.06	0.13
	(-0.07, 0.07)		(-0.09, 0.05)		(-0.15, -0.01)		(-0.02, 0.12)		(-0.13, 0.01)	
Usually	0.01		0.04		0.10		-0.04		0.06	
	(-0.07, 0.09)		(-0.04, 0.13)		(0.01, 0.18)		(-0.13, 0.04)		(-0.03, 0.14)	
Sometimes/	0.03		0.00		0.08		-0.09		0.07	

Never	(-0.05, 0.12)		(-0.09, 0.08)		(0.00, 0.17)		(-0.17, 0.00)		(-0.01, 0.16)	
Child normally uses sunblock whilst out in the sun										
Always	0.05 (0.01, 0.08)	<0.001	0.00 (-0.04, 0.04)	0.67	0.00 (-0.04, 0.03)	0.68	0.02 (-0.02, 0.05)	0.46	-0.01 (-0.05, 0.02)	0.07
Usually	-0.03 (-0.09, 0.03)		-0.03 (-0.10, 0.03)		-0.01 (-0.07, 0.05)		-0.06 (-0.12, 0.00)		-0.02 (-0.08, 0.04)	
Sometimes/ Never	-0.18 (-0.27, -0.10)		0.05 (-0.04, 0.14)		0.03 (-0.05, 0.12)		0.01 (-0.08, 0.10)		0.12 (0.03, 0.20)	
Child normally avoids midday sun										
Always	0.01 (-0.06, 0.08)	0.46	-0.02 (-0.09, 0.05)	0.07	-0.05 (-0.12, 0.02)	0.03	0.03 (-0.04, 0.10)	0.78	-0.02 (-0.09, 0.05)	0.55
Usually	-0.04 (-0.12, 0.05)		0.04 (-0.04, 0.13)		0.05 (-0.03, 0.13)		-0.05 (-0.13, 0.04)		0.04 (-0.04, 0.12)	
Sometimes	0.04 (-0.04, 0.13)		0.00 (-0.08, 0.09)		0.09 (0.00, 0.17)		-0.03 (-0.12, 0.05)		-0.01 (-0.09, 0.08)	
Never	0.08 (-0.04, 0.20)		0.02 (-0.10, 0.14)		-0.04 (-0.16, 0.08)		-0.01 (-0.13, 0.11)		-0.02 (-0.14, 0.10)	
Time spent outdoors in summer during school weekdays >3h/day										
Time spent outdoors in summer during weekends >3h/day	0.03 (-0.03, 0.08)	0.31	0.01 (-0.04, 0.07)	0.66	0.02 (-0.03, 0.08)	0.40	0.04 (-0.02, 0.10)	0.16	-0.02 (-0.08, 0.03)	0.39
Time spent outdoors in summer during holidays >3h/day										
Time spent outdoors in summer during weekends >3h/day	0.22 (0.12, 0.31)	<0.001	0.08 (-0.02, 0.18)	0.112	0.04 (-0.05, 0.14)	0.40	0.05 (-0.04, 0.15)	0.29	-0.03 (-0.13, 0.06)	0.51
Time spent outdoors in summer during holidays >3h/day	0.25 (0.16, 0.34)	<0.001	0.09 (0.00, 0.18)	0.06	0.01 (-0.08, 0.10)	0.79	0.01 (-0.09, 0.10)	0.90	-0.02 (-0.12, 0.07)	0.60

Eligible for free school meals	-0.31 (-0.41, -0.21)	<0.001	0.13 (0.03, 0.23)	0.01	0.07 (-0.04, 0.17)	0.22	0.08 (-0.02, 0.19)	0.11	0.10 (-0.01, 0.20)	0.06
-----------------------------------	-------------------------	--------	----------------------	------	-----------------------	------	-----------------------	------	-----------------------	------

Supplementary Web-Table 3. Univariable associations between potential confounders and KS3 scores

	English total score		Maths total score		Science total score	
	SD change per SD/category change (95%CI)	<i>P</i>	SD change per SD/category change (95%CI)	<i>P</i>	SD change per SD/category change (95%CI)	<i>P</i>
BMI (kg/m ²)	-0.01 (-0.02, 0.00)	0.04	0.00 (-0.01, 0.01)	0.59	-0.02 (-0.03, -0.01)	0.001
Non-white ethnicity	-0.08 (-0.18, 0.02)	0.11	-0.16 (-0.26, -0.06)	0.002	-0.12 (-0.22, -0.02)	0.02
Head of household social class						
i	0.71 (0.64, 0.77)	<0.001	0.31 (0.24, 0.38)	<0.001	0.59 (0.53, 0.66)	<0.001
ii	-0.47 (-0.54, -0.39)		-0.23 (-0.31, -0.15)		-0.41 (-0.49, -0.34)	
iii non-manual	-0.74 (-0.82, -0.66)		-0.32 (-0.40, -0.24)		-0.63 (-0.72, -0.55)	
iii manual	-0.99 (-1.08, -0.90)		-0.40 (-0.50, -0.31)		-0.77 (-0.87, -0.68)	
iv/v	-1.17 (-1.29, -1.06)		-0.40 (-0.52, -0.27)		-0.90 (-1.02, -0.78)	
Paternal education						
None/CSE	-0.30 (-0.34, -0.25)	<0.001	-0.06 (-0.11, -0.01)	<0.001	-0.23 (-0.28, -0.18)	<0.001
Vocational	0.12 (0.03, 0.20)		0.04 (-0.05, 0.13)		0.08 (-0.01, 0.17)	
O level	0.40 (0.33, 0.46)		0.07 (0.00, 0.14)		0.30 (0.24, 0.37)	
A level	0.48 (0.41, 0.54)		0.13 (0.07, 0.19)		0.35 (0.29, 0.42)	
Degree	1.10 (1.03, 1.17)		0.35 (0.28, 0.43)		0.91 (0.84, 0.98)	
Maternal education						
None/CSE	-0.39 (-0.44, -0.34)	<0.001	-0.10 (-0.15, -0.04)	<0.001	-0.27 (-0.32, -0.21)	<0.001
Vocational	0.18 (0.09, 0.26)		0.06 (-0.03, 0.15)		0.09 (0.01, 0.18)	
O level	0.40 (0.34, 0.46)		0.09 (0.03, 0.16)		0.29 (0.23, 0.35)	
A level	0.75 (0.69, 0.82)		0.22 (0.15, 0.30)		0.52 (0.45, 0.58)	
Degree	1.22 (1.14, 1.30)		0.46 (0.37, 0.54)		0.98 (0.90, 1.07)	
Child normally wears hat whilst out in the sun						
Always	0.07 (0.01, 0.14)	0.02	0.10 (0.04, 0.16)	0.60	0.11 (0.05, 0.18)	0.93
Usually	0.13 (0.05, 0.21)		-0.02 (-0.10, 0.05)		0.07 (-0.01, 0.14)	

Sometimes	0.14 (0.06, 0.22)		-0.02 (-0.10, 0.06)		0.07 (-0.01, 0.14)	
Never	0.06 (-0.08, 0.20)		-0.04 (-0.18, 0.10)		-0.11 (-0.25, 0.03)	
Child normally wears something to cover the skin whilst out in the sun						
Always	0.02 (-0.05, 0.08)	0.001	0.04 (-0.02, 0.11)	0.50	0.06 (-0.01, 0.13)	0.35
Usually	0.20 (0.12, 0.28)		0.04 (-0.04, 0.12)		0.15 (0.07, 0.23)	
Sometimes/Never	0.18 (0.10, 0.26)		0.04 (-0.04, 0.12)		0.08 (0.00, 0.16)	
Child normally uses sunblock whilst out in the sun						
Always	0.15 (0.11, 0.19)	0.50	0.07 (0.03, 0.10)	0.38	0.12 (0.08, 0.15)	0.01
Usually	0.11 (0.05, 0.17)		0.03 (-0.03, 0.09)		0.11 (0.05, 0.17)	
Sometimes/Never	-0.05 (-0.13, 0.04)		0.02 (-0.06, 0.11)		0.05 (-0.04, 0.14)	
Child normally avoids midday sun						
Always	0.20 (0.13, 0.27)	<0.001	0.10 (0.03, 0.17)	0.08	0.10(0.03, 0.17)	0.13
Usually	0.06 (-0.02, 0.14)		0.01 (-0.07, 0.09)		0.13 (0.05, 0.21)	
Sometimes	-0.06 (-0.15, 0.02)		-0.06 (-0.14, 0.03)		0.02 (-0.06, 0.11)	
Never	-0.24 (-0.35, -0.12)		-0.05 (-0.17, 0.07)		-0.03 (-0.15, 0.09)	
Time spent outdoors in summer during school weekdays >3h/day						
	-0.33 (-0.38, -0.27)	<0.001	-0.11 (-0.17, -0.06)	<0.001	-0.24 (-0.29, -0.18)	<0.001
Time spent outdoors in summer during weekends >3h/day						
	-0.35 (-0.45, -0.25)	<0.001	-0.13 (-0.22, -0.03)	<0.001	-0.29 (-0.39, -0.19)	<0.001
Time spent outdoors in summer during						
	-0.33 (-0.42, -0.24)	<0.001	-0.11 (-0.20, -0.01)	0.03	-0.26 (-0.35, -0.17)	<0.001

holidays >3h/day

Eligible for free
school meals

-0.67 (-0.73, -0.62)

<0.001

-0.20 (-0.26, -0.14)

<0.001

-0.44 (-0.50, -0.38)

<0.001

Supplementary Web-Table 4. Univariable associations between potential confounders and KS4 outcomes

	Achieved 5 or more A*-C grades (including Maths and English)		Achieved 9 or more A*-A grades		Did not achieve any A*-C grades	
	SD change per SD/category change (95% CI)	<i>P</i>	SD change per SD/category change (95% CI)	<i>P</i>	SD change per SD/category change (95% CI)	<i>P</i>
BMI (kg/m ²)	0.97 (0.95, 0.99)	0.001	0.98 (0.94, 1.01)	0.22	1.05 (1.01, 1.09)	0.006
Non-white ethnicity	0.84 (0.69, 1.01)	0.07	1.27 (0.90, 1.78)	0.18	1.07 (0.78, 1.46)	0.69
Head of household social class						
i	1 (reference)	<0.001	1 (reference)	<0.001	1 (reference)	<0.001
ii	0.50 (0.42, 0.61)		0.31 (0.26, 0.38)		6.02 (2.95, 12.31)	
iii non-manual	0.31 (0.26, 0.38)		0.13 (0.09, 0.17)		10.54 (5.16, 21.51)	
iii manual	0.17 (0.14, 0.21)		0.03 (0.02, 0.07)		21.39 (10.42, 43.91)	
iv/v	0.11 (0.08, 0.14)		0.06 (0.03, 0.13)		34.11 (16.32, 71.30)	
Paternal education						
None/CSE	1 (reference)	<0.001	1 (reference)	<0.001	1 (reference)	<0.001
Vocational	1.47 (1.23, 1.76)		0.92 (0.45, 1.90)		0.63 (0.48, 0.84)	
O level	2.50 (2.18, 2.87)		2.27 (1.46, 3.54)		0.37 (0.29, 0.46)	
A level	3.03 (2.65, 3.45)		3.91 (2.60, 5.88)		0.31 (0.25, 0.39)	
Degree	6.82 (5.73, 8.11)		18.26 (12.39, 26.91)		0.05 (0.03, 0.09)	
Maternal education						
None/CSE	1 (reference)	<0.001	1 (reference)	<0.001	1 (reference)	<0.001
Vocational	1.45 (1.22, 1.74)		1.25 (0.58, 2.71)		0.59 (0.46, 0.77)	
O level	2.37 (2.08, 2.71)		2.88 (1.69, 4.90)		0.37 (0.30, 0.44)	
A level	4.60 (3.96, 5.36)		8.50 (5.07, 14.25)		0.13 (0.10, 0.18)	
Degree	8.37 (6.80, 10.30)		30.40 (18.21, 50.77)		0.06 (0.03, 0.11)	
Child normally wears hat whilst out in the sun						

	Always	1 (reference)	<0.001	1 (reference)	0.25	1 (reference)	0.10
	Usually	1.51 (1.29, 1.76)		1.12 (0.86, 1.47)		0.78 (0.58, 1.05)	
	Sometimes	1.43 (1.23, 1.68)		1.11 (0.85, 1.46)		0.89 (0.66, 1.20)	
	Never	1.00 (0.76, 1.30)		0.70 (0.40, 1.22)		1.41 (0.89, 2.25)	
Child normally wears something to cover the skin whilst out in the sun							
	Always	1 (reference)	<0.001	1 (reference)	0.06	1 (reference)	0.002
	Usually	1.59 (1.35, 1.86)		1.45 (1.07, 1.98)		0.54 (0.41, 0.72)	
	Sometimes/Never	1.36 (1.16, 1.60)		1.49 (1.09, 2.04)		0.61 (0.46, 0.82)	
Child normally uses sunblock whilst out in the sun							
	Always	1 (reference)	0.03	1 (reference)	0.004	1 (reference)	0.17
	Usually	1.20 (1.06, 1.36)		1.43 (1.17, 1.75)		1.02 (0.80, 1.31)	
	Sometimes/Never	0.98 (0.83, 1.17)		0.98 (0.72, 1.34)		1.43 (1.05, 1.95)	
Child normally avoids midday sun							
	Always	1 (reference)	<0.001	1 (reference)	0.02	1 (reference)	0.001
	Usually	1.15 (0.97, 1.35)		1.27 (0.96, 1.68)		0.74 (0.53, 1.03)	
	Sometimes	1.01 (0.85, 1.19)		0.97 (0.72, 1.30)		1.04 (0.76, 1.44)	
	Never	0.71 (0.56, 0.90)		0.79 (0.50, 1.23)		1.62 (1.08, 2.44)	
Time spent outdoors in summer during school weekdays >3h/day							
		0.59 (0.53, 0.66)	<0.001	0.44 (0.36, 0.54)	<0.001	2.27 (1.81, 2.86)	<0.001
Time spent outdoors in summer during weekends >3h/day							
		0.58 (0.46, 0.72)	<0.001	0.43 (0.33, 0.56)	<0.001	2.19 (1.30, 3.71)	0.003
Time spent outdoors in							
		0.60 (0.49, 0.74)	<0.001	0.49 (0.38, 0.64)	<0.001	2.90 (1.65, 5.08)	<0.001

summer during holidays >3h/day Eligible for free school meals	0.24 (0.22, 0.28)	<0.001	0.09 (0.05, 0.18)	<0.001	5.06 (4.43, 5.79)	<0.001
------------------------------------------------------------------------	-------------------	--------	-------------------	--------	-------------------	--------

Supplementary Web-Table 5. Prospective association of unadjusted 25(OH)D₃ concentrations, assessed at mean age 9.8 years) with Key Stage 3 scores (assessed at age 13-14 years) and Key Stage 4 educational attainment (age 15-16 years) (n=3171)

Outcome	Model 1	Model 2	Model 3
SD change in outcome per doubling of exposure (95%CI)			
English total score	0.02 (0.00, 0.04)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)
Maths total score	0.01 (-0.01, 0.03)	0.01 (-0.02, 0.03)	0.01 (-0.02, 0.03)
Science total score	0.02 (0.00, 0.04)	0.02 (-0.01, 0.04)	0.01 (-0.01, 0.04)
Odds ratio per doubling of exposure (95%CI)			
Achieved 5 or more A*-C grades	1.08 (1.02, 1.14)	1.07 (1.01, 1.13)	1.06 (1.00, 1.13)
Achieved 9 or more A*-A grades	1.05 (0.97, 1.13)	1.04 (0.96, 1.13)	1.02 (0.94, 1.12)
Did not achieve any A*-C grades	0.92 (0.83, 1.02)	0.93 (0.84, 1.03)	0.94 (0.84, 1.04)

Model 1 is unadjusted (25(OH)D concentrations exposures are standardised for age and gender)

Model 2 same as Model 1 plus adjustment for ethnicity, head of household social class, mothers and partners education, time spent outdoors during summer (age 8.5 years), use of sunblock, hat, covering clothing, avoidance of midday sun, BMI and eligibility for free school meals

Model 3 same as Model 2 plus adjustment for serum concentrations of phosphate, albumin-adjusted calcium and parathyroid hormone)

Supplementary Web-Table 6. Prospective association of total 25(OH)D (assessed at mean age 9.8 years) with Key Stage 3 scores (assessed at age 13-14 years) and Key Stage 4 educational attainment (age 15-16 years) (n=3171)

Outcome	Model 1	Model 2	Model 3
SD change in outcome per doubling of exposure (95%CI)			
English total score	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)
Maths total score	0.01 (-0.01, 0.03)	0.01 (-0.02, 0.03)	0.01 (-0.01, 0.03)
Science total score	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)
Odds ratio per doubling of exposure (95%CI)			
Achieved 5 or more A*-C grades	1.05 (0.99, 1.11)	1.04 (0.98, 1.11)	1.05 (0.99, 1.11)
Achieved 9 or more A*-A grades	1.02 (0.95, 1.11)	1.02 (0.94, 1.11)	1.02 (0.94, 1.11)
Did not achieve any A*-C grades	0.93 (0.84, 1.04)	0.94 (0.84, 1.04)	0.93 (0.83, 1.04)

Model 1 is unadjusted (25(OH)D concentrations exposures are standardised for age and gender)

Model 2 same as Model 1 plus adjustment for ethnicity, head of household social class, mothers and partners education, time spent outdoors during summer (age 8.5 years), use of sunblock, hat, covering clothing, avoidance of midday sun, BMI and eligibility for free school meals

Model 3 same as Model 2 plus adjustment for serum concentrations of phosphate, albumin-adjusted calcium and parathyroid hormone)

Supplementary Web-Table 7. Sensitivity analyses: Prospective association of 25(OH)D₃, 25(OH)D₂, phosphate, calcium and PTH levels (assessed at mean age 10.1 years) with Key Stage 3 scores (assessed at age 13-14 years) (n=2576), with additional adjustment for IQ (measured at age 8.5 years)

Exposure	Outcome	SD change in outcome per doubling of exposure (95%CI)				
		Model 1	Model 2	Model 2+IQ	Model 3	Model 3+IQ
25(OH)D ₃	English total score	0.02 (-0.01, 0.04)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.04)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)
	Maths total score	0.01 (-0.01, 0.03)	0.01 (-0.02, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.02, 0.03)	0.01 (-0.01, 0.03)
	Science total score	0.01 (-0.01, 0.03)	0.01 (-0.02, 0.03)	0.01 (-0.02, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)
25(OH)D ₂	English total score	-0.07 (-0.10, -0.04)	-0.05 (-0.08, -0.02)	-0.05 (-0.09, -0.02)	-0.05 (-0.08, -0.02)	-0.05 (-0.08, -0.02)
	Maths total score	0.02 (-0.02, 0.05)	0.03 (-0.01, 0.07)	0.03 (-0.01, 0.06)	0.03 (-0.01, 0.06)	0.03 (-0.01, 0.06)
	Science total score	-0.02 (-0.06, 0.02)	-0.01 (-0.05, 0.03)	-0.01 (-0.04, 0.02)	-0.01 (-0.05, 0.03)	-0.01 (-0.05, 0.02)
Albumin-adjusted calcium	English total score	0.00 (-0.02, 0.02)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.04)	0.02 (0.00, 0.04)
	Maths total score	0.00 (-0.02, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)
	Science total score	0.00 (-0.02, 0.03)	0.02 (-0.01, 0.04)	0.02 (0.00, 0.04)	0.01 (-0.01, 0.03)	0.01 (-0.01, 0.03)
Phosphate	English total score	0.01 (-0.01, 0.03)	0.00 (-0.02, 0.02)	0.00 (-0.02, 0.02)	0.00 (-0.02, 0.02)	0.00 (-0.02, 0.02)
	Maths total score	0.00 (-0.02, 0.02)	0.00 (-0.03, 0.02)	-0.01 (-0.03, 0.02)	-0.01 (-0.03, 0.02)	-0.01 (-0.03, 0.01)
	Science total score	0.04 (0.02, 0.06)	0.03 (0.01, 0.05)	0.03 (0.01, 0.05)	0.03 (0.00, 0.05)	0.02 (0.00, 0.05)
Parathyroid hormone	English total score	-0.01 (-0.04, 0.01)	-0.01 (-0.04, 0.01)	-0.02 (-0.04, 0.00)	-0.01 (-0.03, 0.01)	-0.01 (-0.03, 0.01)
	Maths total score	0.00 (-0.02, 0.03)	0.01 (-0.02, 0.03)	0.00 (-0.02, 0.03)	0.01 (-0.02, 0.03)	0.01 (-0.02, 0.03)

score

Science total

score

0.01 (-0.01, 0.04)

0.02 (-0.01, 0.04)

0.01 (-0.01, 0.03)

0.02 (-0.01, 0.04)

0.01 (-0.01, 0.03)

Model 1 is unadjusted (the exposures are standardised for age and gender and 25OHD₃ is adjusted for season and ethnicity)

Model 2 same as Model 1 plus adjustment for ethnicity, head of household social class, mothers and partners education, time spent outdoors during summer (age 8.5 years), use of sunblock, hat, covering clothing, avoidance of midday sun, BMI and eligibility for free school meals

Model 3 same as Model 2 plus adjustment for serum concentrations of other hormones/metabolites which are related 25(OH)D₃ homeostasis (eg. association of 25(OH)D₃ is adjusted for 25(OH)D₂, phosphate, albumin-adjusted calcium and parathyroid hormone)

Supplementary Web-Table 8. Sensitivity analyses: Prospective association of 25(OH)D₃, 25(OH)D₂, phosphate, calcium and PTH levels (assessed at mean age 10.1 years) with Key Stage 4 educational attainment (age 15-16 years, n=2576), with additional adjustment for IQ (measured at age 8.5 years)

Exposure	Outcome	Odds ratio per doubling of exposure (95% CI)				
		Model 1	Model 2	Model 2+IQ	Model 3	Model 3+IQ
25(OH)D ₃	Achieved 5 or more A*-C grades	1.04 (0.99, 1.11)	1.03 (0.97, 1.11)	1.04 (0.97, 1.11)	1.04 (0.97, 1.10)	1.04 (0.97, 1.11)
	Achieved 9 or more A*-A grades	1.04 (0.94, 1.13)	1.04 (0.94, 1.16)	1.04 (0.91, 1.17)	1.04 (0.93, 1.17)	1.03 (0.92, 1.17)
	Did not achieve any A*-C grades	0.93 (0.79, 1.07)	0.94 (0.81, 1.07)	0.93 (0.78, 1.09)	0.95 (0.82, 1.13)	0.94 (0.79, 1.12)
25(OH)D ₂	Achieved 5 or more A*-C grades	0.87 (0.79, 0.95)	0.87 (0.79, 0.96)	0.86 (0.77, 0.95)	0.87 (0.78, 0.97)	0.85 (0.76, 0.94)
	Achieved 9 or more A*-A grades	0.92 (0.83, 1.00)	0.87 (0.73, 1.03)	0.89 (0.73, 1.10)	0.87 (0.72, 1.04)	0.88 (0.72, 1.07)
	Did not achieve any A*-C grades	1.16 (1.02, 1.33)	1.21 (0.97, 1.50)	1.26 (1.01, 1.57)	1.21 (0.97, 1.52)	1.26 (1.00, 1.58)
Albumin-adjusted calcium	Achieved 5 or more A*-C grades	1.01 (0.95, 1.08)	1.05 (0.99, 1.12)	1.06 (0.99, 1.13)	1.04 (0.97, 1.11)	1.05 (0.98, 1.12)
	Achieved 9 or more A*-A grades	0.98 (0.89, 1.07)	1.03 (0.92, 1.15)	1.06 (0.94, 1.18)	1.03 (0.93, 1.16)	1.06 (0.94, 1.20)
	Did not achieve any A*-C grades	0.99 (0.86, 1.14)	0.95 (0.82, 1.12)	0.95 (0.82, 1.12)	0.92 (0.77, 1.09)	0.92 (0.78, 1.10)
Phosphate	Achieved 5 or more A*-C grades	1.07 (1.00, 1.14)	1.06 (1.00, 1.13)	1.06 (0.99, 1.14)	1.06 (0.99, 1.13)	1.06 (0.98, 1.13)
	Achieved 9 or more A*-A grades	1.04 (0.94, 1.16)	1.02 (0.90, 1.13)	1.02 (0.91, 1.15)	1.01 (0.90, 1.13)	1.00 (0.89, 1.12)
	Did not achieve any A*-C grades	1.03 (0.91, 1.17)	1.05 (0.91, 1.21)	1.06 (0.91, 1.24)	1.06 (0.90, 1.26)	1.08 (0.92, 1.27)
Parathyroid hormone	Achieved 5 or more A*-C grades	0.98 (0.93, 1.04)	0.99 (0.93, 1.05)	0.97 (0.91, 1.04)	0.99 (0.93, 1.06)	0.97 (0.91, 1.04)
	Achieved 9 or more A*-A grades	0.99 (0.90, 1.08)	1.00 (0.90, 1.11)	1.00 (0.89, 1.12)	1.00 (0.90, 1.12)	1.01 (0.90, 1.13)
	Did not achieve any A*-C grades	1.08 (0.94, 1.24)	1.07 (0.92, 1.24)	1.08 (0.91, 1.28)	1.04 (0.88, 1.22)	1.07 (0.91, 1.26)

Model 1 is unadjusted (the exposures are standardised for age and gender and 25OHD₃ is adjusted for season and ethnicity)

Model 2 same as Model 1 plus adjustment for ethnicity, head of household social class, mothers and partners education, time spent outdoors during summer (age 8.5 years), use of sunblock, hat, covering clothing, avoidance of midday sun, BMI and eligibility for free school meals

Model 3 same as Model 2 plus adjustment for serum concentrations of other hormones/metabolites which are related 25(OH)D₃ homeostasis (eg. association of 25(OH)D₃ is adjusted for 25(OH)D₂, phosphate, albumin-adjusted calcium and parathyroid hormone)