SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Note: all numbers are rounded to nearest 10, and all percentages to one decimal place, in compliance with statistical disclosure rules. This may result in rounding error.

A number of events in cohorts 2 and 3 were observed in the data, which, if they were first events, could be used in cumulative incidence calculations. It was not known, however, whether each event was truly a first event as there was a period for each cohort that was unobserved (i.e., left-censored). It was therefore necessary to estimate how many events observed among cohorts 2 and 3 were actually recurrent events and discount these from the numerators.

Referrals: cohort 2

In order to estimate the number of referrals at each year in cohort 2's observation period that were likely recurrent, it was first necessary to calculate the probability of re-referral in each of the years following the index referral. To do so, we used cohort 1 (born in 2011/12) and calculated the probability of referral 0 years (i.e., within the same year) and 1, 2, 3, 4 and 5 years following index referral. These cumulative and yearly probabilities are shown in Table S4.1. To illustrate, of children included in this analysis who were referred in 2011/12, 5,220 (13.0%) were re-referred within the same year; 6,650 (16.5%) were re-referred the following year; 8,840 (9.0%) were re-referred in the next year; and so on.

These observed recurrence probabilities were only calculated directly up to age 5. However, it was necessary to know the probability to age 17. These probabilities were estimated by applying a taper based on the observed decline in recurrence risk up to age 5. In other words, it was assumed, based on the observed downward trend in risk of recurrence over time, that the risk or recurrence would decline further up to age 17. For example, the average relative rate of change year-to-year in referrals was 0.62 (i.e., on average, the risk of re-referral from one year to the next decreased by 0.62 times). These estimated re-referral risks to age 17 are also shown in Table S4.1, along with recurrence risk for assessment, child in need episodes and child protection plans which are used later.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.1. Observed and estimated recurrence probabilities (expressed as percentages)

Year	Nth year	Referral N (%)	Assessments N (%)	Need N (%)	CPP N (%)
Observed					
2011/12	0	5220 (13.0%)	3860 (10.5%)	2490 (8.5%)	840 (9.3%)
2012/13	1	6650 (16.5%)	5890 (16.1%)	3730 (12.8%)	670 (7.3%)
2013/14	2	3620 (9.0%)	3360 (9.1%)	2140 (7.3%)	330 (3.7%)
2014/15	3	2160 (5.4%)	2080 (5.7%)	1420 (4.8%)	240 (2.6%)
2015/16	4	1450 (3.6%)	1450 (3.9%)	1040 (3.6%)	190 (2.1%)
2017/17	5	900 (2.2%)	890 (2.4%)	740 (2.5%)	150 (1.6%)
Average relative change		*0.62*	*0.63*	*0.67*	*0.70*
Estimated					
	6	1.36%	1.50%	1.67%	1.14%
	7	0.82%	0.94%	1.12%	0.79%
	8	0.50%	0.59%	0.75%	0.56%
	9	0.30%	0.37%	0.50%	0.39%
	10	0.19%	0.23%	0.33%	0.27%
	11	0.11%	0.14%	0.22%	0.19%
	12	0.07%	0.09%	0.15%	0.13%
	13	0.04%	0.06%	0.10%	0.09%
	14	0.03%	0.04%	0.07%	0.06%
	15	0.02%	0.02%	0.04%	0.04%
	16	0.01%	0.01%	0.03%	0.03%
	17	0.01%	0.01%	0.02%	0.02%

Years are financial years ending. CPP child protection plan.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Next, for cohort 2, which was followed from age 6 to age 12, we used these re-referral probabilities to estimate the number of referrals at ages 1 to 12 that were likely recurrent. To do so, we used the observed number of referrals in cohort 1 aged 0 to 5 as an estimate of the number of first referrals at the same ages in cohort 2. The results of this can be seen in Table S4.2. This Table shows that, for example, of the 60,530 referrals at age 0 (including pre-birth referrals), we would expect 10,000 re-referrals at age 1, 5,450 re-referrals at age 2, and so on. At age 6, it can be seen that a certain number of re-referrals are expected from those referred at age 0, 1, 2, 3, 4 and 5. The sum of these is the total number of expected re-referrals at age 6. It is only the period from age 6 to 12 which is relevant to cohort 2, and which is therefore highlighted in grey. It is the sum of expected re-referrals at ages 6 to 12 in the grey section and highlighted in bold that were used as the discount of the numerator (Table S5.2).

The above method makes two assumptions. The first was that the unobserved number of referrals aged 0-5 in cohort 2 was the same as that in cohort 1. The second was that re-referral rates are constant regardless of age at the index referral. For example, if referred at age 0, the re-referral probability at age 1 (year 1) was 16.5%; at age 2 (year 2), 9.0%. Likewise, if referred at 5 for the first time, the model assumes that the re-referral risk at age 5 (year 1) is 16.5% and at age 6 (year 2) is 9.0%. Given Troncoso's analysis of re-referral rates by age, this assumption is reasonable.

Referrals: cohort 3

The method of estimating the number of expected referrals in cohort 3 (ages 13 to 17) was essentially the same as that of cohort 2 except that it was necessary to estimate the number of re-referrals where children were referred in the period birth to 12, instead of birth to 5. The same numbers of index referrals aged birth to 5 were used for cohort 3 as cohort 2. For the period age 6 to 12, we used the corrected number of referrals from cohort 2. The results of this analysis are presented in Table S4.3.

Assessments, need episodes and child protection plans

The same process was followed for assessments, need episodes and child protection plans. The estimated recurrent events are given in Tables S4.4 to S4.9.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.2. Estimated number of recurrent children referred ages 1 to 12 from cohort 2's unobserved period (age birth to 5)

		Re-referral at age											
	N	1	2	3	4	5	6	7	8	9	10	11	12
Re-referral risk:		16.5%	9.0%	5.4%	3.6%	2.2%	1.36%	0.82%	0.50%	0.30%	0.19%	0.11%	0.07%
Index age													
-1/0	60530	10000	5450	3260	2190	1350	820	500	300	180	110	70	40
1	22620		3740	2040	1220	820	500	310	190	110	70	40	30
2	18390			3040	1660	990	670	410	250	150	90	60	30
3	17650				2920	1590	950	640	390	240	150	90	50
4	16960					2800	1530	910	610	380	230	140	80
5	10480						1730	940	560	380	230	140	90
Total		10000	9180	8330	7980	7550	**6200**	**3710**	**2310**	**1450**	**880**	**540**	**330**

Re-referral risks as presented in Table S4.1. Grey shaded area represents the observed period for cohort 2. The totals in bold were used as the discount in Table S6.2.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.3. Estimated number of recurrent children referred ages 1 to 17 from cohort 3's unobserved period (age birth to 12)

		Re-referrals at age																
	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Re-referral risk:		16.5%	9.0%	5.4%	3.6%	2.2%	1.36%	0.82%	0.50%	0.30%	0.19%	0.11%	0.07%	0.04%	0.03%	0.02%	0.01%	0.01%
Index age																		
-1/0	60530	10000	5450	3260	2190	1350	820	500	300	180	110	70	40	30	20	10	10	c
1	22620		3740	2040	1220	820	500	310	190	110	70	40	30	20	10	10	c	c
2	18390			3040	1660	990	670	410	250	150	90	60	30	20	10	10	c	c
3	17650				2920	1590	950	640	390	240	150	90	50	30	20	10	10	c
4	16960					2800	1530	910	610	380	230	140	80	50	30	20	10	10
5	10480						1730	940	560	380	230	140	90	50	30	20	10	10
6	13610							2250	1230	730	490	300	180	110	70	40	30	20
7	12950								2140	1170	700	470	290	180	110	60	40	20
8	11890									1960	1070	640	430	270	160	100	60	40
9	10260										1700	920	550	370	230	140	80	50
10	9850											1630	890	530	360	220	130	80
11	9290												1540	840	500	340	210	130
12	9160													1510	820	490	330	200
Total		10000	9180	8330	7980	7550	6200	5960	5670	5310	4840	4500	4200	**4000**	**2370**	**1470**	**930**	**570**

Re-referral risks as presented in Table S4.1. Grey shaded area represents the observed period for cohort 3. The totals in bold were used as the discount in Table S6.2. c suppressed due to low cell counts.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.4. Estimated number of recurrent children assessed ages 1 to 12 from cohort 2's unobserved period (age birth to 5)

		Assessed at age											
	N	1	2	3	4	5	6	7	8	9	10	11	12
Re-assessment risk:		16.1%	9.2%	5.7%	4.0%	2.4%	1.50%	0.95%	0.59%	0.37%	0.23%	0.15%	0.09%
Index age													
-1/0	55590	8920	5090	3140	2200	1350	840	530	330	210	130	80	50
1	20670		3320	1890	1170	820	500	310	200	120	80	50	30
2	17370			2790	1590	980	690	420	260	170	100	60	40
3	16790				2690	1540	950	660	410	260	160	100	60
4	16100					2580	1470	910	640	390	240	150	100
5	10290						1650	940	580	410	250	160	100
Total		8920	8400	7820	7650	7270	**6100**	**3780**	**2420**	**1550**	**960**	**600**	**380**

Re-assessment risks as presented in Table S4.1. Grey shaded area represents the observed period for cohort 2. The totals in bold were used as the discount in Table S6.3.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.5. Estimated number of recurrent children assessed ages 1 to 17 from cohort 3's unobserved period (age birth to 12)

		Assessed at age																
	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Re-assessment risk:		16.1%	9.2%	5.7%	4.0%	2.4%	1.50%	0.95%	0.59%	0.37%	0.23%	0.15%	0.09%	0.06%	0.04%	0.02%	0.01%	0.01%
Index age																		
-1/0	55590	8920	5090	3140	2200	1350	840	530	330	210	130	80	50	30	20	10	10	c
1	20670		3320	1890	1170	820	500	310	200	120	80	50	30	20	10	10	c	c
2	17370			2790	1590	980	690	420	260	170	100	60	40	30	20	10	10	c
3	16790				2690	1540	950	660	410	260	160	100	60	40	20	20	10	10
4	16100					2580	1470	910	640	390	240	150	100	60	40	20	10	10
5	10290						1650	940	580	410	250	160	100	60	40	20	10	10
6	12340							1980	1130	700	490	300	190	120	70	50	30	20
7	11940								1920	1090	670	470	290	180	110	70	40	30
8	10980									1760	1000	620	430	270	170	100	70	40
9	9890										1590	900	560	390	240	150	90	60
10	9650											1550	880	550	380	230	150	90
11	9140												1470	840	520	360	220	140
12	8960													1440	820	510	350	220
Total		8920	8400	7820	7650	7270	6100	5760	5460	5100	4720	4450	4200	**4010**	**2460**	**1570**	**1010**	**630**

Re-assessment risks as presented in Table S4.1. Grey shaded area represents the observed period for cohort 3. The totals in bold were used as the discount in Table S6.3. c suppressed due to low cell counts.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.6. Estimated number of recurrent children in need ages 1 to 12 from cohort 2's unobserved period (age birth to 5)

		Child in need at age											
	N	1	2	3	4	5	6	7	8	9	10	11	12
Re-need risk:		12.8%	7.3%	4.8%	3.6%	2.5%	1.67%	1.12%	0.75%	0.50%	0.33%	0.22%	0.15%
Index age -1/0	43870	5590	3220	2120	1570	1110	740	500	330	220	150	100	70
1	14830		1890	1090	720	530	370	250	170	110	80	50	30
2	12070			1540	880	580	430	300	200	140	90	60	40
3	11580				1480	850	560	410	290	200	130	90	60
4	10910					1390	800	530	390	270	180	120	80
5	7830						1000	570	380	280	200	130	90
Total		5590	5110	4750	4650	4460	**3900**	**2570**	**1760**	**1220**	**830**	**550**	**370**

Re-need risks as presented in Table S4.1. Grey shaded area represents the observed period for cohort 2. The totals in bold were used as the discount in Table S6.4.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.7. Estimated number of recurrent children in need ages 1 to 17 from cohort 3's unobserved period (age birth to 12)

		Child in need at age																
	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Re-need risk:		12.8%	7.3%	4.8%	3.6%	2.5%	1.67%	1.12%	0.75%	0.50%	0.33%	0.22%	0.15%	0.10%	0.07%	0.04%	0.03%	0.02%
Index age -1/0	43870	5590	3220	2120	1570	1110	740	500	330	220	150	100	70	40	30	20	10	10
1	14830		1890	1090	720	530	370	250	170	110	80	50	30	20	20	10	10	c
2	12070			1540	880	580	430	300	200	140	90	60	40	30	20	10	10	10
3	11580				1480	850	560	410	290	200	130	90	60	40	30	20	10	10
4	10910					1390	800	530	390	270	180	120	80	60	40	20	20	10
5	7830						1000	570	380	280	200	130	90	60	40	30	20	10
6	9830							1250	720	480	350	250	170	110	70	50	30	20
7	9950								1270	730	480	360	250	170	110	80	50	30
8	8340									1060	610	400	300	210	140	90	60	40
9	7280										930	530	350	260	180	120	80	60
10	6680											850	490	320	240	170	110	80
11	6540												830	480	320	230	160	110
12	6920													880	510	340	250	170
Total		5590	5110	4750	4650	4460	3900	3820	3750	3490	3200	2950	2760	**2680**	**1740**	**1190**	**830**	**560**

Re-need risks as presented in Table S4.1. Grey shaded area represents the observed period for cohort 3. The totals in bold were used as the discount in Table S6.4. c suppressed due to low cell counts.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.8. Estimated number of recurrent children on child protection plans ages 1 to 12 from cohort 2's unobserved period (age birth to 5)

		On CPP at age											
	N	1	2	3	4	5	6	7	8	9	10	11	12
Re-CPP risk:		7.3%	3.7%	2.6%	2.1%	1.6%	1.14%	0.79%	0.56%	0.39%	0.27%	0.19%	0.13%
Index age													
-1/0	13440	980	500	340	290	220	150	100	70	50	40	20	20
1	3830		280	140	100	80	60	40	30	20	10	10	10
2	3400			250	130	90	70	50	40	30	20	10	10
3	3130				230	120	80	70	50	40	20	20	10
4	3000					220	110	80	60	50	30	20	20
5	2130						160	80	50	50	30	20	20
Total		980	780	740	740	720	**630**	**430**	**310**	**230**	**160**	**110**	**80**

Re-CPP risks as presented in Table S4.1. Grey shaded area represents the observed period for cohort 2. The totals in bold were used as the discount in Table S6.5. c suppressed due to low cell counts.

SUPPLEMENTARY FILE 4 - NUMERATOR ADJUSTMENTS

Table S4.9. Estimated number of recurrent children on child protection plans ages 1 to 17 from cohort 3's unobserved period (age birth to 12)

		CPP at age																
	N	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Re-CPP risk:		7.3%	3.7%	2.6%	2.1%	1.6%	1.14%	0.79%	0.56%	0.39%	0.27%	0.19%	0.13%	0.04%	0.02%	0.02%	0.01%	0.01%
Index age																		
-1/0	13440	980	500	340	290	220	150	100	70	50	40	20	20	10	10	10	c	c
1	3830		280	140	100	80	60	40	30	20	10	10	10	c	c	c	c	c
2	3400			250	130	90	70	50	40	30	20	10	10	10	c	c	c	c
3	3130				230	120	80	70	50	40	20	20	10	10	10	c	c	c
4	3000					220	110	80	60	50	30	20	20	10	10	10	c	c
5	2130						160	80	50	50	30	20	20	10	10	10	c	c
6	1710							120	60	40	40	30	20	10	10	10	c	c
7	2060								150	80	50	40	30	20	20	10	10	10
8	2180									160	80	60	50	40	20	20	10	10
9	2110										150	80	50	50	30	20	20	10
10	2010											150	70	50	40	30	20	20
11	2000												150	70	50	40	30	20
12	1760													130	70	50	40	30
Total		980	780	740	740	720	630	550	520	510	490	470	450	**430**	**280**	**210**	**150**	**110**

Re-CPP risks as presented in Table S4.1. Grey shaded area represents the observed period for cohort 3. The totals in bold were used as the discount in Table S6.5. c suppressed due to low cell counts.