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Schreuder, A.; Klaveren, D. van; Nieuwenhuijzen, M. van; Kraaij, W.; Houweling, T.A.J.

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Predicting youth care between 0 to 4 years of age: a 2015–2019 Dutch population register data study

Anton Schreuder [a,b,*], David van Klaveren [b], Maroesjka van Nieuwenhuijzen [c,d], Wessel Kraaij [a,e], Tanja A.J. Houweling [b]

[a] Leiden Institute of Advanced Computer Science, Leiden University, Leiden, Netherlands
[b] Department of Public Health, Erasmus MC, University Medical Center Rotterdam, Rotterdam, Netherlands
[c] Expect Jeugd, Amsterdam, Netherlands
[d] Research Institute Child Development and Education, University of Amsterdam, Amsterdam, Netherlands
[e] Netherlands Organisation for Applied Scientific Research, Leiden, Netherlands

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ABSTRACT

Purpose: Youth care services support families facing problems with raising children. Use of such services may be avoided if preventative support were offered. We developed youth care risk prediction models to enable risk stratification approaches.

Methods: We used Dutch registry data of births between 2015–2019, including neighbourhood characteristics, socioeconomic status, parental health and behaviours, past birth outcomes, current birth outcomes, and household characteristics. The primary outcome was use of youth care services between the ages of 0–4 years. Multivariable Cox regression models were derived for assessment moments one year before birth, at birth, one year after birth, and two years after birth (models 1–4, respectively).

Results: The full cohort consisted of 776,559 Dutch births, of which 32,290 underwent at least one youth care trajectory (4.2 %). Each full model performed equivalently to the respective parsimonious model. Parsimonious model 1 achieved an area under the receiver operating characteristic curve (AUC) of 0.760 (95 % confidence interval = 0.757–0.763). Model performance improved minimally at each subsequent assessment moment, reaching an AUC of 0.798 (0.794–0.801) for parsimonious model 4. The strongest predictors included prior youth care, parental educational level, maternal psychiatric medication prescription, and maternal job status. When classifying 10 % of the cohort with the highest risk of any youth care as positive, the negative predictive value was high (≥0.972) and the positive predictive value was low (≤0.164).

Conclusion: If the consequences of false positive tests can be mitigated, then screening may offer relief to families before involvement of the over-encumbered youth care services.

1. Introduction

Early life, from conception to two years of age, is a sensitive period for child development across all domains (Roseboom, 2023; Siddiqi et al., 2007). Although there will always be unknown genetic influences, those who are exposed to unfavourable environmental conditions in early life are at increased risk of adverse health, social, and economic outcomes later in life (Cantor et al., 2019; Osher et al., 2020; Schoon et al., 2015). In severe cases, unfavourable conditions can materialize as problems in the family or behavioural issues of the child. To counteract this, youth care interventions can be mandated to support such children and their families. However, given the lengthy delay time between the start of problems and the start of youth care, there may be benefits to earlier detection and preventative support.

In the Netherlands, youth care is an overarching term for youth assistance, youth protection, and juvenile rehabilitation, which can co-occur (Jeugdautoriteit, 2023). Youth assistance represents over 90 % of youth care, providing professional support for youths (age < 18 years) related to family conflicts and psychological or behavioural problems, for example. Youth protection measures are court orders for the involvement of supervision of the child's upbringing. Approximately 10 % of the more severe youth care interventions involve out of home

* Corresponding author at: Department of Public Health, Erasmus MC, University Medical Center Rotterdam, 3000 CA, Rotterdam, Netherlands.
E-mail address: antoniusschreuder@gmail.com (A. Schreuder).

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placements. Finally, juvenile rehabilitation can be forced upon youths of at least 12 years who have committed a crime.

There is a continuous increase in the usage of youth care over time while the number of providers remains limited, regardless of the nationwide reform that was implemented in 2015 to reverse this trend (Jeugdautoriteit, 2023). About 10.5 % of youths in the Netherlands received support from youth care services in 2022, compared to 3.7 % in 2000 (Dodge, 2019). Simultaneously, about 20 % of providers with a revenue above €2 million made losses. The potential collapse of large providers poses a serious risk for the continuity of such services. One way to relieve the system may be to reduce the demand for youth care through a screening program aimed towards prevention rather than curation.

Many determinants of life course outcomes have been established (Houweling & Grünberger, 2023). Yet, it remains unknown how well youth care can be predicted when information about multiple determinants is combined into a risk prediction model. In other words, how well can we predict that an individual child will encounter youth care in the future? We aimed to develop and evaluate multivariable risk models to predict youth care up to the age of four years in the Netherlands. This was done by using Dutch registry data on predictors at the child, parent, household, and neighbourhood level for the entire Dutch population (Prins, 2017).

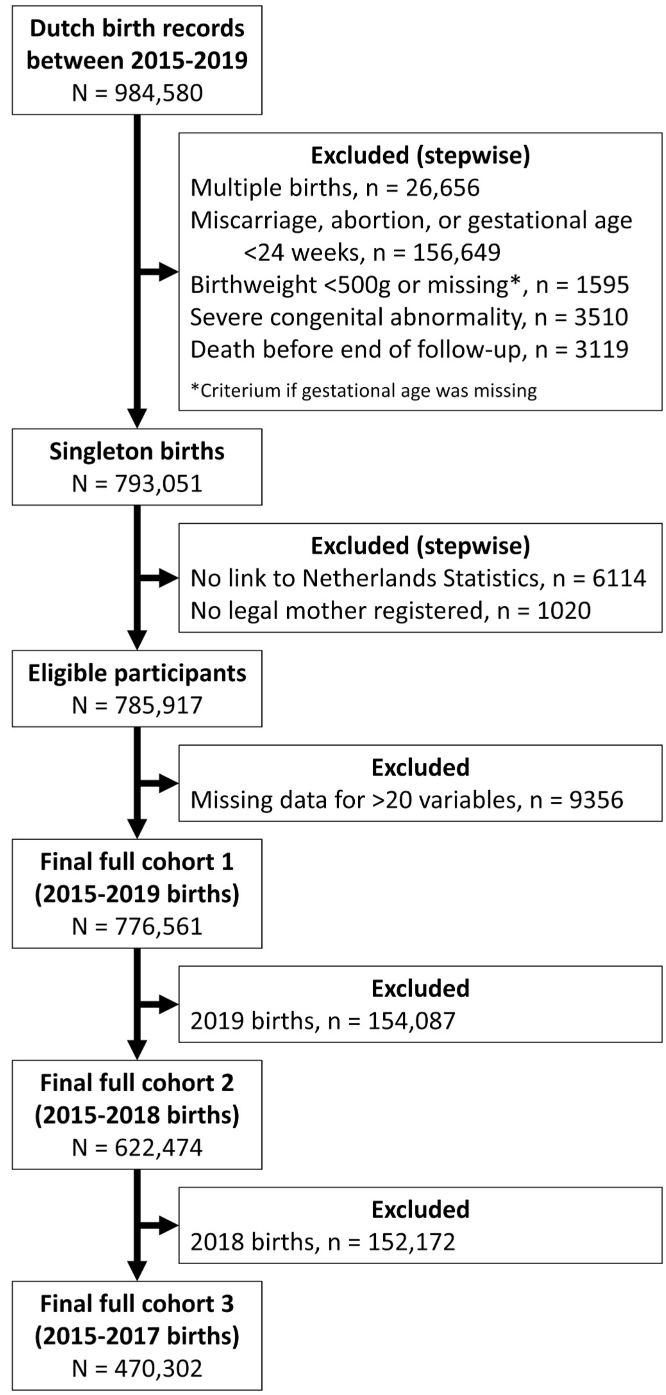


Fig. 1. Selection flowchart.

2. Methods

2.1. Study population and data sources

All births in the Netherlands between 1 January 2015 and 31 December 2019 were included in our study (Fig. 1). This represents the period when youth care became decentralised in the Netherlands, and before the COVID-19 pandemic (which disrupted the normal provision and reporting of youth care services). The following exclusion criteria were applied: no legal mother registered, death, multiple birth, gestational age < 24 weeks, and – if gestational age was missing – missing birthweight or birthweight < 500 g (de Kluiver et al., 2013; Van de Voorde et al., 2021). The end of follow-up was either the day before their fifth birthday or 31 December 2019. Children whose end of follow-up was before the assessment moment of interest were excluded from those specific analyses.

The individual-level data were pseudonymized by Statistics Netherlands (CBS) and organized as a linked data-infrastructure (DIAPER, Data-InfrAstructure for ParEnts and childRen) and made available in the protected working environment of CBS (Prins, 2017; Scheefhals et al., 2023; Perined, 2021). Besides the plethora of data on Dutch society, the data-infrastructure also included birth data from the Netherlands Perinatal Registry (Perined) – estimated to cover 97 % of all births in the Netherlands (Perined, 2021). All data are assigned an identification number to enable linkage within individuals as well as between individuals and their parents, partners, households, and addresses.

2.2. Variables

The primary outcome was the child starting a youth care trajectory between birth and four years of age. This was defined as the date that a certified institute initiates youth assistance or a youth protection measure with the child in question. The secondary outcome was starting a residential youth care trajectory, i.e., a youth care variant which involves (temporary) out of home placements. A child could be assigned youth care trajectories multiple times.

All potential predictors were screened based on a data map and assessed by an expert panel. Variables were included when they were a potential determinant of the outcome while not being highly correlated with another selected variable. Ultimately, 51 predictors were selected (Table S1); these can be summarized into the following groups: neighbourhood characteristics, parental and household characteristics, past birth outcomes, and current birth outcomes.

Time-dependent predictors were extracted for four assessment moments: one year before birth, at birth, one year after birth, and two years after birth (Table 1). Note that at CBS, most time-dependent predictors are summarized by calendar year, which does not necessarily fit perfectly with the assessment moments. To reduce the number of variables in the models while also considering information from the past, variables related to debt, medication, crime, were summarized across all assessment moments (Table S1). I.e., the predictor was considered present if it occurred at any time between the year before birth and the risk assessment moment under investigation.

Missing values were handled differently per variable, as described in

Table 1
Overview of risk assessment moments.

Model	Assessment moment	Event prediction period	Predictors considered	Total population	Median follow-up time, days (min–max)	Total youth care trajectories[a]	Subjects with at least one youth care trajectory (%)	Total residential youth care trajectories	Subjects with at least one residential youth care trajectory, %
1	One year before birth	0 to 4 years of age	Neighbourhood characteristics, socioeconomic status, parental and household characteristics, and past birth outcomes	776,561	942 (29–1824)	61,763	32,290 (4.2)	7470	3865 (0.5)
2	At birth	0 to 4 years of age	Model 1 + current birth outcomes, parental death	776,561	942 (29–1824)	61,763	32,290 (4.2)	7470	3865 (0.5)
3	One year after birth	1 to 4 years of age	Model 2 + prior youth care, number of addresses, and post-birth parental divorce	622,474	759 (29–1459)	43,291	24,022 (3.9)	3817	2351 (0.4)
4	Two years after birth	2 to 4 years of age	Equivalent to Model 3	470,302	547 (29–1094)	31,240	18,134 (3.9)	2203	1537 (0.3)

[a] Each child may undergo more than one youth care trajectory within the follow-up period.

Table S2. For some variables, the known value from the nearest time point was used. If the child was a mother's first birth, then variables related to past birth outcomes were assigned the reference value (indicating lowest risk; usually the mode). A dummy variable was included to indicate when no father was registered; when this applied, all other father-related variables were assigned reference values. This step was necessary to allow father-less families to be included in the analyses. The remaining missing values were either assigned a value based on highest likelihood – usually according to the most prevalent value – or through multiple imputations using 10 iterations (van Buuren & Groothuis-Oudshoorn, 2011). Multiple imputations could not be performed to handle all missing data due to computational limitations of the CBS servers.

2.3. Statistical analyses

Models were derived for both outcomes and for each of the four assessment moments, namely one year before birth, at birth, one year after birth, and two years after birth; these assessment moments were respectively coded as 1, 2, 3, and 4 for model nomenclature. Besides updating the time-dependent predictors, later risk assessment moments also included new variables, i.e., compared to model 1, model 2 adds birth outcomes and parental death; models 3 and 4 additionally included post-birth information, i.e., post-birth divorce (parents), number of registered addresses (child), and number of previous youth care interventions (child). Statistical software R version 4.2.3 was used for the statistical analyses (R Core Team, 2020).

Multivariable Cox proportional hazards regression with Breslow's baseline hazard estimator was used to create the risk models, with marginalized clustering for recurring events (Liu et al., 2012). The best-fitting first-degree fractional polynomial transformation (p-value < 0.05 based on a difference in deviances) was selected for each continuous predictor (Zhang, 2016). A full model (i.e., including all potential predictors) and a parsimonious model (i.e., only significant predictors selected) were derived for each outcome and assessment moment. The parsimonious models were determined by using backwards elimination until all remaining predictors had a Wald statistic p-value < 0.001. For the parsimonious models, all predictors were also tested for interaction terms with parental education and child's sex; significant interaction terms were included ($p < 0.001$).

The reported outputs are the hazard ratios (HR, the average relative increase in hazard of youth care when a factor is present compared to when it is not present), area under the receiver operating characteristic curve (AUC, the model's ability to correctly rank a random case with youth care with a higher risk than a random case without youth care, i.e., true positive rate [sensitivity] against false positive rate [1-specificity]) (Robin et al., 2011), and performance metrics across various probability thresholds (i.e., sensitivity, specificity, positive predictive value [PPV], and negative predictive value [NPV]). HR confidence intervals were calculated using robust standard errors; AUC confidence intervals were calculated using 100 bootstraps. Internal validation was performed using 5-fold cross validation.

All models were verified for the proportional hazards assumption using Schoenfeld residuals against time. The linear predictor and baseline hazard estimate were used to predict each child's probability of encountering youth care before their fifth birthday. The linear predictor is the sum of the coefficients of the present explanatory variables; for continuous variables, the value is multiplied by the coefficient. The baseline hazard is the time-dependent hazard rate when all variables are set to their reference values (or the mean value for continuous variables) (Zhang, 2016)].

3. Results

776,561 children were included with a total of 61,763 youth care interventions before their fifth birthday, of which 12.1 % (7470/61,763) residential (Fig. 1, Table 1). 32,290 (4.2 %) children received any youth care at least once (24,022 [3.9 %] after 1 year of age, 18,134 [3.9 %] after 2 years of age) and 3865 (0.5 %) received residential youth care at least once (2351 [0.4 %] after 1 year of age, 1537 [0.3 %] after 2 years of age). Descriptive statistics are given in Table 2, and a calculator is provided to estimate the absolute risk according to each model, including coefficients from interaction terms (Supplementary File 2).

The AUC range of the full and parsimonious models predicting any youth care was 0.759 to 0.798; the range for residential youth care was 0.934 to 0.953 (Table 3). This indicates that the residential youth care models had a superior discriminatory ability than the models for predicting any youth care. The parsimonious models performed equivalently to their respective full models, and cross validation did not show indications for overfitting (Table 3).

Predictors that were included across all parsimonious models were parental educational level, maternal job status, insurance debt, maternal psychiatric medication prescription, crime suspect, maternal age, parity, family composition, missing father, and population density. Compared to parsimonious model 1 (AUC = 0.760), parsimonious model 2′s improved performance (AUC = 0.780) can be attributed to information on birth outcomes, primarily child's sex, gestational age, Hoftiezer percentile, and Apgar score (Tables 4 and S4-S6). The performance improvement from parsimonious model 2 to parsimonious model 3 (AUC = 0.795) can be attributed to the addition of the variable "prior youth care interventions". There was no substantial difference in performance between parsimonious models 3 and 4 (AUC = 0.798).

Table 2
Description of imputed study population.

	No youth care between 0–4 years of age		Youth care between 0–4 years of age			
			Any youth care		Residential youth care	
Population characteristics	Mean / n	SD / %	Mean / n	SD / %	Mean / n	SD / %
Total population	744,271	100	32,290	4.2	3865	0.5
Birth year						
2015	143,820	19.3 %	12,175	37.7 %	1278	33.1 %
2016	149,270	20.1 %	9052	28.0 %	961	24.9 %
2017	150,113	20.2 %	5872	18.2 %	756	19.6 %
2018	148,630	20.0 %	3542	11.0 %	546	14.1 %
2019	152,438	20.5 %	1649	5.1 %	324	8.4 %
NEIGHBORHOOD CHARACTERISTICS						
Population density (/km^2)	5863.9	4931.4	6581.7	4953.0	6017.1	4444.5
Average house price (€1000)	212.9	81.0	184.4	70.8	175.2	67.6
Percent with low income (%)	40.1	14.3	45.6	14.7	47.9	13.9
Percent with high income (%)	19.8	10.8	16.2	10.0	14.5	9.2
Percent inhabitant-owned housing (%)	56.2	21.0	48.5	21.2	47.1	20.5
Percent corporation-owned housing (%)	30.1	20.1	37.7	21.7	39.3	21.5
PARENTAL & HOUSEHOLD CHARACTERISTICS						
Missing father	23,248	3.1 %	3877	12.0 %	1091	28.2 %
Age mother (years)	31.4	4.6	30.0	5.8	27.3	6.8
Age mother < 20 years	3027	0.4 %	1116	3.5 %	512	13.2 %
Age mother > 34 years	186,583	25.1 %	7396	22.9 %	617	16.0 %
Age father > 39 years	113,335	15.7 %	5389	19.0 %	448	16.1 %
Death of a parent[a]	86	0.0 %	16	0.0 %	7	0.2 %
Family composition						
At least one married parent	358,486	48.2 %	11,166	34.6 %	603	15.6 %
Two unmarried parents	241,755	32.5 %	6676	20.7 %	476	12.3 %
One unmarried parent	144,030	19.4 %	14,448	44.7 %	2786	72.1 %
Household members with income (n)	1.9	0.7	1.8	0.8	1.7	0.9
Household income (percentile)	57.1	28.9	36.8	29.3	20.4	21.1
Income benefits (%)	7.6	19.3	25.8	32.6	47.1	35.3
Homeowner	482,102	64.8 %	11,955	37.0 %	581	15.0 %
Received rental allowance	87,004	11.7 %	10,746	33.3 %	1922	49.7 %
Number of addresses (n)[b]	1.1	0.4	1.3	0.6	1.6	0.8
Parental divorce	64,529	8.7 %	4395	13.6 %	479	12.4 %
Post-birth divorce[b]	967	0.2 %	164	0.7 %	19	0.8 %
Parental education						
Both high ISCED	236,161	31.7 %	4171	12.9 %	92	2.4 %
High & medium ISCED	181,691	24.4 %	5668	17.6 %	392	10.1 %
High & low ISCED	36,924	5.0 %	3550	11.0 %	887	22.9 %
Both medium ISCED	163,298	21.9 %	6317	19.6 %	387	10.0 %
Medium & low ISCED	87,322	11.7 %	7308	22.6 %	942	24.4 %
Both low ISCED	38,875	5.2 %	5276	16.3 %	1165	30.1 %
Job status, mother						
[Self-]employed	591,182	79.4 %	15,673	48.5 %	633	16.4 %
Unemployment benefits	53,703	7.2 %	8310	25.7 %	1843	47.7 %
Sickness benefits	14,656	2.0 %	1475	4.6 %	151	3.9 %
Student	22,634	3.0 %	2872	8.9 %	770	19.9 %
No income or pensioned	62,096	8.3 %	3960	12.3 %	468	12.1 %
Job status, father[c]						
[Self-]employed[c]	644,569	89.4 %	19,554	68.8 %	1080	38.9 %
Unemployment benefits[c]	34,477	4.8 %	4757	16.7 %	1000	36.0 %
Sickness benefits[c]	7771	1.1 %	784	2.8 %	115	4.1 %
Student[c]	7457	1.0 %	848	3.0 %	206	7.4 %
No income or pensioned[c]	26,749	3.7 %	2470	8.7 %	373	13.4 %
Insurance debt	30,985	4.2 %	5426	16.8 %	1199	31.0 %
Debt restructuring	2875	0.4 %	411	1.3 %	67	1.7 %
CVD meds, mother	23,359	3.1 %	1437	4.5 %	145	3.8 %
Diabetes mellitus meds, mother	6516	0.9 %	513	1.6 %	45	1.2 %
Epilepsy meds, mother	4413	0.6 %	473	1.5 %	89	2.3 %
Migraine meds, mother	12,992	1.7 %	661	2.0 %	68	1.8 %
Psychiatric meds, mother	38,409	5.2 %	4853	15.0 %	965	25.0 %
Psychiatric meds, father[c]	29,269	4.1 %	2709	9.5 %	427	15.4 %
Mental health care, mother	607	0.1 %	75	0.2 %	11	0.3 %
Mental health care, father[c]	308	0.0 %	32	0.1 %	5	0.2 %
Crime victim	79,937	10.7 %	5729	17.7 %	1023	26.5 %
Violent crime victim	9472	1.3 %	1998	6.2 %	572	14.8 %
Crime suspect	16,897	2.3 %	3615	11.2 %	1018	26.3 %
Violent crime suspect	4607	0.6 %	1301	4.0 %	382	9.9 %
Detainment	3173	0.4 %	977	3.0 %	311	8.0 %

(*continued on next page*)

Table 2 (*continued*)

Population characteristics	No youth care between 0–4 years of age		Youth care between 0–4 years of age Any youth care		Residential youth care	
	Mean / n	SD / %	Mean / n	SD / %	Mean / n	SD / %
Any prior youth care intervention[b]	6611	1.1 %	3717	15.5 %	1189	50.6 %
PAST BIRTH OUTCOMES						
Parity						
Nulliparous	324,446	43.6 %	15,275	47.3 %	1760	45.5 %
Primiparous	273,902	36.8 %	9627	29.8 %	967	25.0 %
Multiparous	145,923	19.6 %	7388	22.9 %	1138	29.4 %
Prior adverse birth outcome	78,268	10.5 %	4435	13.7 %	664	17.2 %
CURRENT BIRTH OUTCOMES						
Child sex, male	379,371	51.0 %	18,640	57.7 %	2078	53.8 %
Gestational age (weeks)	39.1	1.8	38.5	2.4	38.3	2.2
Hoftiezer percentile (percentile)	50.3	29.1	43.3	30.0	36.9	29.1
Apgar score (range 0–10)	9.7	0.8	9.5	1.1	9.5	1.1
Non-vertex presentation	81,729	11.0 %	3770	11.7 %	425	11.0 %
Primary c-section	61,041	8.2 %	3091	9.6 %	327	8.5 %
Secondary c-section	57,784	7.8 %	3073	9.5 %	355	9.2 %
NICU admission	13,724	1.8 %	1710	5.3 %	202	5.2 %
Postpartum haemorrhage	46,368	6.2 %	1880	5.8 %	186	4.8 %
Severe perineal tear	16,099	2.2 %	466	1.4 %	28	0.7 %

Continuous variables' units are given in brackets and are reported as means and standard deviation; categorical variables are reported as counts and column percentages. For time-dependent variables, the descriptive statistics are reported at the earliest applicable timepoint (i.e., at one year before birth unless otherwise specified).

Abbreviations: ISCED = International Standard Classification of Education; n = count; NICU = neonatal intensive care unit; SD = standard deviation.

[a] Variable only applicable from child's year of birth onwards.

[b] Variable only applicable from child's first birthday onwards.

[c] Cases for which the father was missing were excluded from the summary calculation of father-related variables.

Table 3

Models' validation area under the receiver operating characteristic curve.

Assessment moment	Full model	Parsimonious model	Full residential model	Parsimonious residential model
1 (one year before birth)	0.759 (0.0004)	0.760 (0.0004)	0.934 (0.0007)	0.935 (0.0005)
2 (at birth)	0.779 (0.0004)	0.780 (0.0004)	0.942 (0.0008)	0.943 (0.0005)
3 (one year after birth)	0.792 (0.0006)	0.795 (0.0004)	0.948 (0.0017)	0.949 (0.0005)
4 (two years after birth)	0.796 (0.0007)	0.798 (0.0003)	0.952 (0.0015)	0.951 (0.0005)

The optimism is given in brackets, i.e., the average difference between the model performance and the validation performance.

Notably, parsimonious models 3 and 4 excluded 15 variables which had been included in parsimonious models 1 and 2; this means that the discriminative ability of the variable "prior youth care interventions" alone is equivalent to the discriminative ability of these 15 variables combined.

Fig. 2 shows the proportions of true positives, false negatives, true negatives, and false positive cases across the probability thresholds. For example, a threshold at the 90th percentile indicates the scenario where 10 % of the children with the highest risk scores are labelled as "positive". The results from parsimonious model 1 were placed next to that of parsimonious model 4 to visually demonstrate that the differences between models are small. In the example where 10 % of children are labelled as high-risk, the metrics from parsimonious model 4 improved compared to parsimonious model 1 for any youth care: sensitivity from 0.395 to 0.463, specificity from 0.913 to 0.915, PPV from 0.164 to 0.179, and NPV from 0.972 to 0.977.

For predicting residential youth care, the changes between parsimonious models 1 and 4 were: sensitivity from 0.827 to 0.865, specificity from 0.904 to 0.903, PPV from 0.041 to 0.028, and NPV from 0.999 to 1.000 (Table S3). If all Dutch children would undergo preventative interventions, then 5 out of 1000 children might avoid residential youth care, at best. Instead, applying such an intervention to a high-risk group (10 % of the population) during pregnancy – stratified using parsimonious model 1 – would increase the proportion of those who may benefit to 41 out of 1000 children.

There is a wide range in absolute risk probabilities across the reported percentile thresholds. For example, in parsimonious model 4, the bottom 10 % of children had less than 2.9 % probability of any youth care, compared with at least 22.2 % probability among the top 10 % of children. Although the discriminative ability of the models is good, the PPV is low due to the rarity of the outcome.

4. Discussion

4.1. Interpretation

To the best of our knowledge, this is the first study to derive risk models for predicting any youth care and residential youth care for children aged 0 to 4 years. Based on the AUC metric, all models for predicting any youth care performed moderately. Whereas the residential youth care models had a much higher overall discriminatory performance, it is deemed misleading in comparison to the less imbalanced dataset (i.e., for any youth care) because the outcome was very rare. The parsimonious models performed as well as the full models, which is probably due to the inclusion of interaction terms in the former and not the latter. The inclusion of new predictors at follow-up moments led to small, stepwise improvements in performance. Already at preconception, a substantial proportion of children who end up using youth care between age 0 to 4 years old can be identified at the 90th percentile risk threshold. Yet, due to the low prevalence of the outcome, this comes at the expense of a large proportion of false positives.

Information on birth outcomes becomes available from the moment of birth onwards. The parsimonious models for predicting any youth

Table 4
Parsimonious multivariable Cox proportional regression models predicting any youth care.

Parsimonious model	1 (one year before birth)	2 (at birth)	3 (one year after birth)	4 (two years after birth)
Variable	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)	HR (95 % CI)
Birth year (ref. = 2015)	1 (ref.)	1 (ref.)		
2016	1.01 (0.98–1.04)	1.02 (0.98–1.05)		
2017	1.06 (1.01–1.10)	1.08 (1.04–1.12)		
2018	1.11 (1.06–1.17)	1.14 (1.09–1.20)		
2019	1.15 (1.08–1.23)	1.18 (1.10–1.26)		
Population density (/km^2)	1.03 (1.02–1.04)[a]	0.99 (0.98–1.00)[j]	1.04 (1.02–1.05)[a]	0.98 (0.97–0.98)[j]
Average house price (€1000)	1.84 (1.52–2.23)[b]	1.25 (1.14–1.38)[k]		
Percent with low income (%)	1.37 (1.26–1.49)[c]			
Percent with high income (%)	1.47 (1.32–1.62)[d]	1.50 (1.22–1.85)[g]		
Percent inhabitant-owned housing (%)		0.40 (0.33–0.48)[g]		
Percent corporation-owned housing (%)		0.79 (0.70–0.88)[g]		
Missing father	1.66 (1.55–1.78)	1.64 (1.53–1.76)	1.37 (1.27–1.47)	1.18 (1.09–1.28)
Age mother (years)	1.03 (1.03–1.04)[e]	1.03 (1.02–1.03)[e]	1.01 (1.01–1.02)[e]	
Age mother < 20	1.48 (1.35–1.63)	1.46 (1.33–1.60)		
Age mother > 34	1.23 (1.18–1.29)	1.22 (1.17–1.27)	1.14 (1.09–1.19)	1.10 (1.05–1.15)
Age father > 39	1.17 (1.12–1.22)	1.14 (1.10–1.19)	1.15 (1.10–1.20)	1.16 (1.10–1.22)
Death of a parent		2.46 (1.49–4.06)		
Family composition (ref. = At least one married parent)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Two unmarried parents	1.01 (0.97–1.04)	1.05 (1.02–1.09)	1.04 (1.00–1.07)	0.97 (0.93–1.01)
One unmarried parent	1.36 (1.31–1.42)	1.27 (1.22–1.33)	1.21 (1.15–1.27)	1.12 (1.06–1.18)
Household members with income (n)	1.57 (1.33–1.85)[f]	1.60 (1.34–1.90)[f]		
Household income (percentile)	0.71 (0.66–0.77)[g]	0.75 (0.69–0.81)[g]	0.58 (0.53–0.64)[g]	0.57 (0.52–0.63)[g]
Percent benefits (%)	0.96 (0.96–0.97)[h]	1.11 (1.10–1.13)[m]	0.97 (0.96–0.97)[h]	0.97 (0.96–0.97)[h]
Homeowner	0.79 (0.76–0.82)	0.78 (0.75–0.81)	0.82 (0.79–0.86)	0.83 (0.79–0.87)
Received rental allowance	0.83 (0.80–0.86)	0.77 (0.74–0.80)		
Parental divorce	1.47 (1.30–1.65)	1.14 (1.10–1.19)	1.13 (1.08–1.18)	1.11 (1.06–1.16)
Highest parental educational level (ref. = Both high ISCED)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
High & medium ISCED	1.38 (1.31–1.46)	1.13 (1.00–1.29)	1.50 (1.41–1.60)	1.55 (1.46–1.66)
High & low ISCED	1.96 (1.83–2.10)	1.41 (1.23–1.63)	1.92 (1.77–2.07)	1.97 (1.81–2.16)
Both medium ISCED	1.72 (1.62–1.82)	1.42 (1.25–1.62)	1.67 (1.57–1.78)	1.85 (1.73–1.98)
Medium & low ISCED	2.38 (2.24–2.53)	1.56 (1.38–1.77)	2.30 (2.15–2.46)	2.23 (2.07–2.40)
Both low ISCED	2.43 (2.25–2.63)	1.53 (1.34–1.76)	2.02 (1.85–2.21)	2.12 (1.89–2.36)
Job status, mother (ref. = [Self-]employed)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
Unemployment benefits, mother	1.74 (1.66–1.82)	1.81 (1.71–1.92)	1.54 (1.46–1.62)	1.40 (1.32–1.48)
Sickness benefits, mother	1.43 (1.33–1.53)	1.06 (1.01–1.12)	1.38 (1.29–1.47)	1.27 (1.17–1.36)
Student, mother	1.20 (1.13–1.28)	1.43 (1.34–1.54)	1.21 (1.11–1.32)	1.25 (1.13–1.38)
No income or pensioned, mother	1.38 (1.32–1.45)	1.50 (1.42–1.57)	1.44 (1.37–1.51)	1.41 (1.33–1.50)
Job status, father (ref. = [Self-]employed)	1 (ref.)	1 (ref.)		
Unemployment benefits, father	1.39 (1.32–1.45)	1.23 (1.17–1.29)		
Sickness benefits, father	1.06 (0.97–1.17)	1.02 (0.93–1.12)		
Student, father	1.24 (1.14–1.35)	1.28 (1.16–1.41)		
No income or pensioned, father	1.14 (1.08–1.20)	1.10 (1.04–1.17)		
Insurance debt	1.39 (1.34–1.45)	1.32 (1.27–1.37)	1.21 (1.16–1.26)	1.14 (1.09–1.19)
CVD meds, mother	1.13 (1.06–1.20)			
Diabetes mellitus meds, mother	1.26 (1.13–1.39)	1.15 (1.07–1.23)	1.23 (1.14–1.33)	1.21 (1.12–1.32)
Epilepsy meds, mother	1.32 (1.18–1.48)	1.28 (1.17–1.40)		
Psychiatric meds, mother	2.54 (2.27–2.85)	3.03 (2.76–3.32)	2.08 (1.87–2.32)	1.38 (1.33–1.44)
Psychiatric meds, father	1.36 (1.30–1.43)	1.37 (1.31–1.43)	1.29 (1.24–1.35)	1.21 (1.16–1.27)
Mental health care, mother		1.40 (1.18–1.67)		
Crime victim	1.16 (1.11–1.21)	1.16 (1.12–1.20)	1.11 (1.07–1.15)	1.09 (1.05–1.13)
Violent crime victim	1.56 (1.47–1.67)	1.63 (1.54–1.71)	1.39 (1.32–1.47)	1.25 (1.18–1.32)
Crime suspect	1.53 (1.45–1.61)	1.44 (1.38–1.51)	1.24 (1.18–1.31)	1.14 (1.09–1.20)
Violent crime suspect	1.15 (1.07–1.25)	1.26 (1.19–1.34)	1.12 (1.05–1.19)	
Detainment	1.36 (1.26–1.47)	1.31 (1.23–1.40)		0.87 (0.81–0.94)
Parity (ref. = 0)	1 (ref.)	1 (ref.)	1 (ref.)	1 (ref.)
1	0.76 (0.73–0.78)	0.81 (0.78–0.84)	0.82 (0.79–0.85)	0.78 (0.75–0.81)
>1	0.78 (0.75–0.82)	0.82 (0.79–0.86)	0.78 (0.75–0.82)	0.72 (0.69–0.75)
Prior adverse birth outcome	1.27 (1.22–1.33)	1.10 (1.05–1.14)		
Male sex	NA	1.32 (1.29–1.35)	1.54 (1.49–1.59)	1.78 (1.71–1.85)
Gestational age (weeks)	NA	0.55 (0.51–0.58)[n]	0.65 (0.60–0.70)[n]	0.66 (0.61–0.71)[n]
Hoftiezer percentile (percentile)	NA	0.92 (0.91–0.93)[c]	0.94 (0.92–0.95)[c]	0.95 (0.94–0.97)[c]
Apgar score (range 0–10)	NA	0.77 (0.67–0.88)[n]		0.73 (0.62–0.86)[n]
Secondary c-section	NA	1.09 (1.04–1.14)		
NICU admission	NA	2.08 (1.80–2.40)	1.26 (1.15–1.38)	
Prior youth care interventions (n)	NA	NA	5.78 (5.16–6.48)[o]	7.57 (6.92–8.27)[o]

The following variables were not included in any of the parsimonious models: number of addresses, post-birth divorce, debt restructuring, migraine meds (mother), mental health care (father), non-vertex presentation, primary c-section, postpartum haemorrhage, and severe perineal tear. Blank cells indicate that the variable did not achieve statistical significance to be included in the parsimonious model.
The following transformations were applied corresponding to the letter in superscript (where X represents the input value): a = $\ln((X + 1)/10000)$; b = $((X + 1)/100)^{-0.5}$ c = $\ln(X/100)$; d = $(X/10)^{0.5}$; e = $(X/100)^{-2}$; f = $(X + 1)^{-1}$; g = $X/100$; h = $((X + 1)/10)^{-1}$; j = $((X + 1)/10000)^{-0.5}$; k = $(X/100)^{-1}$; m = $\ln((X + 1)/10)$; n = $X/10$; o = $\ln(X + 1)$.
The following interaction terms were included in the corresponding models: 1 = Household income × Both low ISCED, Parental divorce × Highest parental educational level, Psychiatric meds (mother) × Highest parental educational level; 2 = Household income × Both low ISCED, Percent inhabitant-owned housing × Highest parental

educational level, Psychiatric meds (mother) × Highest parental educational level, NICU admission × Highest parental educational level; 3 = Household income × Both low ISCED, Psychiatric meds (mother) × Highest parental educational level, Prior youth care interventions × Highest parental educational level; 4 = Household income × Both low ISCED, No income (mother) × Both low ISCED, Prior youth care interventions × Highest parental educational level. The coefficients for the interaction terms can be found in the supplementary calculator.

Abbreviations: CI = confidence interval; ISCED = International Standard Classification of Education; n = count; NA = not applicable; NICU, neonatal intensive care unit; ref. = reference.

care indicate that that male sex, lower gestational age at birth, and lower Hoftiezer percentile are robust independent risk factors. At one- and two-years after birth, the introduction of "prior youth care interventions" led to a notable reduction in the number of variables included in parsimonious models 3 and 4 compared to parsimonious models 1 and 2. This variable was able to replace the explained variance from approximately 15 other variables, while still improving model performance compared to model 2. We note that the study population changed depending on the risk assessment moment; this means that the performances of models 1 and 2 (no additional exclusion criteria), model 3 (exclusion of children born after 2018), and model 4 (exclusion of children born after 2017) are not directly comparable.

Across all models and reported probability thresholds, the NPVs were high (≥97.2 %) and PPVs were low (≤17.9 %). Applying the models into practice would hereby result in at least five "false positive children" for every "true positive child". It would hereby only be acceptable to implement the models if the benefits of the proposed intervention on one family would outweigh the harms done to the families who were unnecessarily inconvenienced. A cost-benefit analysis would help estimate whether such a screening program would be favourable in the long-term. An alternative possibility would be to avoid any form of targeted interventions and invest indiscriminately into ensuring, among other things, subsistence security, which has been demonstrated to improve family wellbeing along with a multitude of other benefits (Akee et al., 2010; Costello et al., 2016).

The results indicate that urban environments, two parent homes, maternal age between 20 and 34 years, higher economic status, higher educational level, no parental physical and mental health problems, no criminality (parent as victim or perpetrator), prior children, no adverse birth outcomes, and no prior youth care interventions are all protective factors against youth care between the ages of 0 to 4 years. These findings are consistent for a multitude of other adverse outcomes in childhood and later in life (Cantor et al., 2019; Osher et al., 2020; Schoon et al., 2015), and highlight structural inequalities in the conditions in which families live. These inequalities are reflected in the likelihood of receiving youth care, with children living in more deprived circumstances having a higher likelihood of being involved in youth care. Primary prevention – by addressing the social determinants of health and wellbeing of young families, such as the high poverty levels among single-parent families or the lack of subsidized childcare for children whose parents do not work – may help reduce the need of youth care, particularly among families living in vulnerable conditions (Maldonado & Nieuwenhuis, 2015).

Risk models have the potential to aid existing targeted interventions with proven effectiveness in the Netherlands. Incredible Years aims to improve parenting skills for parents of children aged 2 to 12 years with or at risk of behavioural problems (Gardner et al., 2019; Overbeek et al., 2021; Webster-Stratton, 2001). Video-feedback Intervention to Promote Positive Parenting and Sensitive Discipline (VIPP-SD) and Homestart are for parents with a child younger than age 7 years to improve parenting skills and social network (Asscher et al., 2008; Hermanns et al., 2013; Klein Velderman et al., 2006; Moss et al., 2011; Negrão et al., 2014; van Aar et al., 2015; Van Zeijl et al., 2006). Voorzorg targets young women in vulnerable conditions during pregnancy early motherhood to reduce the risk of child maltreatment (Mejdoubi et al., 2014, 2015; Olds et al., 2004). A final example is subsidized childcare to encourage parents to participate (more) in the workforce (Bettendorf et al., 2015).

5. Limitations

Measurement bias may be present given that not all Dutch children in need of youth care received youth care. Furthermore, it is unknown what occurs in each trajectory, as the progress, duration, and adhesion are not well documented in the national registry (Jeugdautoriteit, 2023). Some groups may be more likely to make use of youth care, independent of need. Especially ambulant youth care is increasingly used by higher income families, and public expenses for youth care are increasing faster in municipalities with a higher average household income. Conversely, some municipalities claim that most youth care is used by families receiving social benefits and living in areas with more poverty and single-parent homes (Batterink et al., 2017). Applying the models to practice hereby poses a risk of enhancing any potential biases in the system.

Other limitations of the registry data are the lack of important predictors such as smoking during pregnancy, social network strength, and sensitive/responsive parenting. This means that the models are missing crucial dimensions that likely play a major role in the probability of using youth care. Therefore, it is critically important that the models are used as basis to start a conversation with the parents, rather than for top-down decision making. This would avoid a potentially biased, algorithmic, top-down approach with no consideration for individual situations. Each family would instead receive targeted advice and support from a professional, where applicable.

Next, as individuals can encounter the outcome more than once and different individuals may have the same mother or live in the same neighbourhood, a conditional model would be more suitable for this study, i.e., estimation of random effects. However, this was computationally not feasible within the CBS remote access environment. The performed analysis took recurring events into consideration, thus hopefully providing equivalent results.

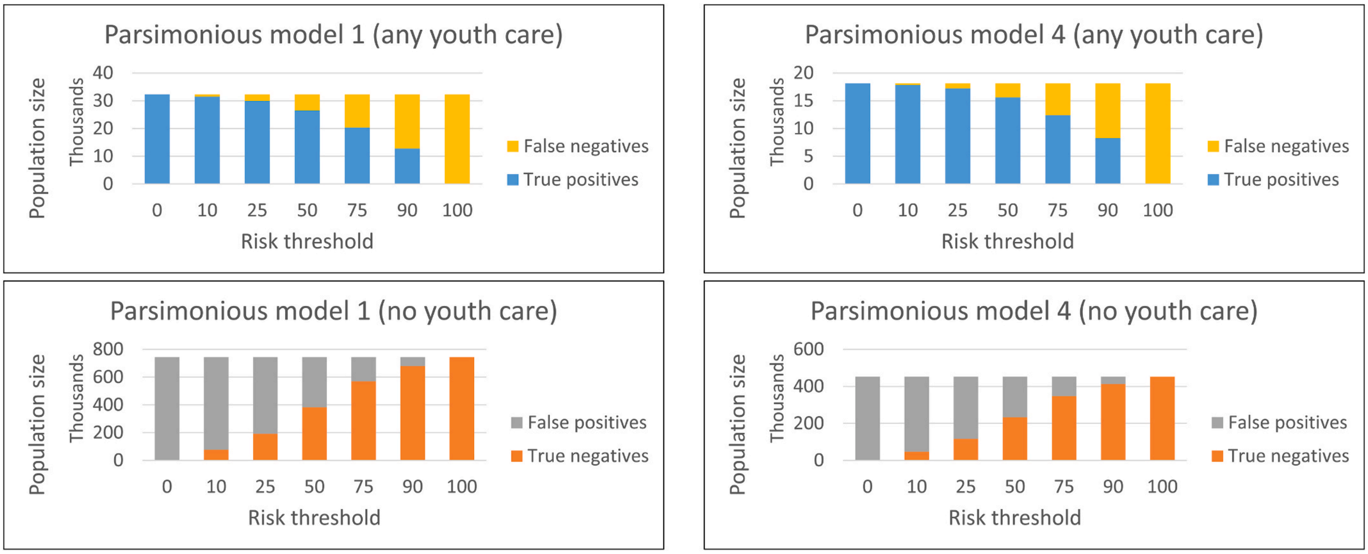
Finally, it should be noted that causal inference was not the purpose of our study. Hence, the coefficients reported in our study cannot be interpreted as causal estimates.

6. Conclusion

Youth care for children aged 0 to 4 years can be predicted with moderate discrimination using registry data routinely collected in the Netherlands. Risk assessment can already be performed one year before birth. Information on birth outcomes improves predictions. At one or two years after birth, the strongest predictor of youth care is having undergone prior youth care. Although performance was better at later follow-up moments, improvements remained small. Therefore, model usage for earlier prevention is recommended. Though the models can reliably identify true negative cases, the false positive rates are high due to the low prevalence of the outcome. The implementation of risk assessment into practice would likely lead to false positive classifications in most "high risk children". Preventive interventions would therefore need to be of minimal inconvenience to families who may would not benefit from it. Implementing such risk assessments can be considered an option to diminish the usage and costs of youth care services.

7. Contributors statement

Anton Schreuder conceptualized and designed the study, prepared the data, carried out the analyses, drafted the initial manuscript, and critically reviewed and revised the manuscript.



Threshold	0%	10%	25%	50%	75%	90%	100%
Cut-off probability	0.025	0.041	0.054	0.85	0.167	0.351	NA
Sensitivity	1	0.976	0.927	0.822	0.63	0.395	0
Specificity	0	0.103	0.258	0.514	0.766	0.913	1
PPV	0.042	0.045	0.051	0.068	0.105	0.164	NA
NPV	NA	0.99	0.988	0.985	0.979	0.972	0.958

Threshold	0%	10%	25%	50%	75%	90%	100%
Cut-off probability	0.014	0.029	0.042	0.068	0.121	0.222	NA
Sensitivity	1	0.984	0.949	0.861	0.681	0.463	0
Specificity	0	0.103	0.258	0.514	0.767	0.915	1
PPV	0.039	0.042	0.049	0.066	0.105	0.179	NA
NPV	NA	0.994	0.992	0.989	0.984	0.977	0.958

Fig. 2. Performance metrics at five probability thresholds for parsimonious models 1 and 4 for predicting any youth care.
Abbreviations: NA = not applicable; NPV = negative predictive value; PPV = positive predictive value.

David van Klaveren supervised data analyses and critically reviewed and revised the manuscript.

Maroesjka van Nieuwenhuijzen conceptualized the study and critically reviewed and revised the manuscript.

Wessel Kraaij conceptualized the study, supervised data preparation, and critically reviewed and revised the manuscript.

Tanja A.J. Houweling conceptualized the study, supervised data preparation and analyses, drafted the initial manuscript, and critically reviewed and revised the manuscript.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethical statement

The proposal for this study was reviewed by the Medical Ethics Committee (METC) of Erasmus MC, Rotterdam, The Netherlands. The METC concluded that the rules laid down in the Medical Research Involving Human Subjects Act, do not apply to our study (MEC-2021-0846, dd 10-01-2022).

Appendix A. Supplementary materials

Supplementary materials to this article can be found online at https://doi.org/10.1016/j.childyouth.2025.108600.

Data availability

The data that has been used is confidential.

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