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## Early detection of risk for maltreatment within Dutch preventive child health care: A proxy-based evaluation of the long-term predictive validity of the SPARK method

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### ABSTRACT

**Background:** For effective prevention of child maltreatment, it is crucial that risk factors for child maltreatment are identified as early as possible. In the Dutch preventive child healthcare, the SPARK-method is used for this purpose.

**Objective:** The current study investigated the predictive validity of the SPARK-method for predicting child protection activities, as a proxy for child maltreatment, and whether the estimation can be improved with an actuarial module.

**Participants and setting:** Participants included a community sample of 1582 children of approximately 18-months-old for whom the SPARK was administered during well-child visits at home (51 %) or at the well-baby clinic (49 %).

**Methods:** SPARK measurements were linked to data on child protection orders and residential youth care over a 10-year follow-up period. The predictive validity was evaluated using Area Under the receiver operating characteristic Curve (AUC) values.

**Results:** Results showed good predictive validity for the SPARK clinical risk assessment (AUC = 0.723; large effect). The actuarial module led to a significant improvement in predictive validity (AUC = 0.802; large effect),  $z = 2.05$ ,  $p = .04$ .

**Conclusion:** These results show that the SPARK is suitable for estimating the risk of child protection activities and that the actuarial module is a valuable addition. The SPARK can be used to support professionals in preventive child healthcare with their decision on appropriate follow-up actions.

### 1. Introduction

Child maltreatment is a large problem with severe consequences for both individual victims and society as a whole. Maltreatment at an early age has serious short- and long-term consequences for the children themselves and even for the next generation (Eigsti & Cicchetti, 2004; English et al., 2005; Norman et al., 2012). To prevent child maltreatment, early detection of risk factors for child maltreatment is crucial. In the Dutch preventive child health care (CHC) services lies a unique opportunity for early detection, because it is the only sector that follows all children in the Netherlands from birth to the age of 18 years (Inspectie Gezondheidszorg en Jeugd,

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2017). The Dutch CHC uses the SPARK-method (Structured Problem Analysis of Raising Kids; Staal, 2016; Staal et al., 2011; Vink et al., 2016) for this purpose. The SPARK is a structured interview used by the CHC professional in dialogue with prospective parents and parents of young children (18, 36 and 60 months) with the aim of identifying parenting and developmental problems at an early stage (Staal, 2016). In that phase, problems are still relatively small and may therefore be tackled more easily in preventive interventions to prevent problems from getting bigger and thus requiring child protection activities. The aim of the current study was therefore to examine the predictive validity of the SPARK method for predicting future child protection activities, as a proxy for child maltreatment.

For effective early detection of child maltreatment, it is important that the most important risk factors for child maltreatment are identified at an early stage. Research shows that family and parental factors are important predictors of child maltreatment, such as high levels of conflict in the family, addiction and psychopathology of the parent(s), and social isolation (Assink et al., 2019; Mulder et al., 2018; Stith et al., 2009; Van IJzendoorn et al., 2020). In addition, child factors can lead to an increased risk of child maltreatment, including the child's externalizing and/or internalizing behavioral problems, and the child's social competencies (Assink et al., 2019; Austin et al., 2020; Stith et al., 2009).

Moreover, research shows that an increased risk of child maltreatment results primarily from a cumulation of risk factors (Begle et al., 2010; MacKenzie et al., 2011; Masten & Wright, 1998; McGoron et al., 2020; Patwardhan et al., 2017). That is, the more risk factors present, the greater the risk of child maltreatment. Studies show that the risk of child maltreatment increases exponentially from three or more risk factors (Patwardhan et al., 2017), four or more risk factors (Brown et al., 1998), five or more risk factors (Nair et al., 2003; Yang & Maguire-Jack, 2018), and six or more risk factors (Lamela & Figueiredo, 2018). So a cumulation of risk factors is a strong predictor of child maltreatment, regardless of the presence of specific individual risk factors, which is also referred to as the cumulative risk model (e.g., Lamela & Figueiredo, 2018). Risk assessment instruments therefore primarily map out various risk factors for child maltreatment.

Two types of risk assessment instruments can be distinguished: 1) instruments screening for maltreatment in the general population (onset of maltreatment); and 2) instruments assessing the risk of recurrence of maltreatment in populations already investigated by child protection services. The latter types of instruments are currently most commonly used in child protection practice. However, screening for potential child maltreatment before the maltreatment actually occurs may contribute to the early detection of child maltreatment risk, on the basis of which children and their families can be referred to preventive intervention programs in a timely manner. Given the relatively good performance of screening tools (Van der Put et al., 2017), it may be useful to invest time, money, and resources in developing and strengthening preventive strategies for child maltreatment.

In recent years there has been a shift from the traditional risk-based approach to a strength-based approach in which more attention is paid to the strengths and well-being of youth and families in risk assessment strategies (e.g., Conrad-Hiebner et al., 2019). Arguments are that (a) it is more motivating to focus on promoting strengths (i.e., protective factors) than to focus solely on risk factors and (b) this reduces the likelihood of overestimating risk (Cording & Beggs Christofferson, 2017; De Vries Robbé & Willis, 2017; Miller, 2006). In line with this shift, there are an increasing number of instruments that (also) consider protective factors (e.g. García-Mollá et al., 2023; Navarro-Pérez et al., 2023), including the SPARK.

Research on the mechanisms and incremental value of protective factors in the context of early detection and risk assessment of child maltreatment is scarce. The literature describes multiple ways in which protective factors can prevent child maltreatment (e.g., Cording & Beggs Christofferson, 2017; Masten & Wright, 1998). Among others, protective factors can lower the risk of a negative outcome (child maltreatment) by having a direct effect on the outcome regardless of the presence of risk (main effect), or by buffering the effect of the presence of risk factors (interaction effect; e.g., Zimmerman et al., 2013). For example, research on protective factors for neglect among families living in poverty (the present risk factor) has shown that the likelihood of physical neglect decreases as the family experiences more social support (Sattler, 2022). However, the question is whether risk factors and protective factors really are two different groups of factors or the same factors, with a risk effect at one extreme and a protective effect at the other, that is, (Deković, 1999). In the case of social support, a greater degree of social support would be considered protective, and a lack of a social support as a risk of child maltreatment. With the SPARK, protective factors are assessed as opposing risk factors.

Previous research showed good predictive validity of the SPARK's risk assessment for confirmed reports of child maltreatment over a 1.5-year follow-up period (Staal et al., 2013). However, additional research is needed because (confirmed) reports of child maltreatment are a strong underrepresentation of the actual prevalence of child maltreatment (Stoltenborgh et al., 2015; Van der Put & Assink, 2017). In addition, the study by Staal et al. (2013) involved a relatively short follow-up period (1.5 years). Thus, the goal of the current study was to further investigate the predictive validity of the SPARK method for predicting child protection activities, as a proxy for child maltreatment.

In addition, we investigated whether the predictive validity of the SPARK could be improved by the development of an actuarial risk module. The SPARK is a structured clinical instrument, while research shows that such instruments predict child maltreatment with less accuracy than actuarial instruments (Baird & Wagner, 2000; Lätsch et al., 2021; Shlonsky & Wagner, 2005; Van der Put et al., 2017). With clinical instruments, the professional determines whether there is an increased risk of child maltreatment, whereas with actuarial instruments this is determined by the instrument, based on the statistical association of factors with child maltreatment (Dawes et al., 1989). As a result, in general, actuarial instruments have a higher reliability than structured clinical instruments, because the same (objective) scoring rules are applied each time (Van der Put, Assink & van Solinge, 2017). Moreover, actuarial instruments only measure risk factors that are statistically related to child maltreatment and the weighting of these factors is scientifically determined, thus providing an optimal scoring system (Dawes et al., 1989). We therefore hypothesized that the actuarial risk assessment has a higher predictive validity than the structured clinical assessment.

In summary, the purpose of this study was to investigate the predictive validity of the SPARK for the risk of child protection

activities and whether the predictive validity can be improved with an actuarial module.

## 2. Methods

### 2.1. Sample

In the current study, secondary analyses were conducted on data collected with the SPARK which was used with (parents of) children aged 18 months. The data consisted of 1876 measurements collected in the period 2007–2008 from 1866 unique children. If multiple measurements were available for a child, one measurement was randomly selected so that each child appeared only once in the sample. In addition, only measurements for which the risk assessment was completed were included. After this selection, measurements from 1582 children were available for analysis. The sample consisted of 46 % girls. The majority of the children came from a two-parent family (92.1 %), followed by a one-parent family (2.8 %), a blended family (2.8 %) or another type of family composition (1.6 %). About half of the SPARK measurements were administered during a well-child visit at home (50.9 %), and the other half at the well-baby clinic (48.8 %). A detailed description of the data collection procedure and sample can be found in [Staal et al. \(2013\)](#).

### 2.2. Instrument

The SPARK is a structured interview used to identify parenting and developmental problems in prospective parents and parents of young children at an early stage and to discuss care needs with parents. The SPARK can be administered at different ages, namely prenatally, and at 18, 36 and 60 months of age. In the current study, only SPARK measurements administered to 18-month-old children were included. The SPARK method consists of three steps, namely: (1) identifying questions, concerns and problems of the parents; (2) discussing the nature and urgency of the questions, concerns and problems with the parents; and (3) analyzing the gathered information and deciding on appropriate follow-up actions. During the interview with the parents, domains focused on the child, the family and the environment are discussed from a broad scope. Per domain the parents receive an explanation of the domain, after which the domain is further discussed with a solution-focused approach.

Next, the CHC professional assesses the overall risk of (severe) parenting and developmental problems, divided into low, increased and high risk. Low risk is defined as a balanced situation in which there is a favorable living environment for the child's development in physical, cognitive and social-emotional terms; increased risk is defined as a situation which requires more parental capabilities in order to achieve a healthy development of the child on a physical, cognitive and social-emotional level, and high risk is defined as a situation in which parenting burden and capabilities are out of balance, which may result in a threat to the child's development on a physical, cognitive and social-emotional level.

For the risk assessment, the CHC professional uses information from the child's file and the conversation with the SPARK, the observed interaction between parent and child, and the observation of the environment in which the interview takes place. The risk assessment consists of the following 24 factors regarding developmental tasks of the child, observable factors, and risk and protective factors known from the literature: (1) motor development; (2) the behavior of the child; (3) interaction/exemplary behavior between parent and child; (4) speech and cognitive development of the child; (5) eating and drinking habits; (6) attachment; (7) child's development and physical health in infant period; (8) other child factors (e.g., few toys, explanation of family situation); (9) atmosphere at home; (10) safety; (11) hygiene of family members; (12) hygiene of the home; (13) furnishing; (14) parent's experience in infant period; (15) competence of parents; (16) agreement between parents; (17) amount of social support; (18) financial topics; (19) chronic health problems parent or sibling; (20) addiction parents; (21) psychiatric problems parents; (22) adverse childhood experiences parents; (23) openness parents during the well-child visit; (24) other.

For each of these factors, the CHC professional assesses whether it positively or negatively influences the overall risk of parenting and developmental problems. If the factor does not influence the risk of child maltreatment or has not been taken into account by the CHC professional in the overall risk estimation, the factor is not filled in. So if the professional believes that a factor has a positive influence on the overall risk of parenting and developmental problems, it is considered a protective factor, such as sufficient social support or healthy cognitive development. On the other hand, if the professional believes that a factor has a negative influence on the overall risk, it is considered a risk factor, such as little social support or delayed cognitive development. Some factors can only be scored as a risk factor (and not as a protective factor), namely: (19) chronic health problems parent or sibling; (20) addiction parents; (21) psychiatric problems parents; and (22) adverse childhood experiences parents.

Moreover, previous research showed that the SPARK was valid and discriminated between groups of children at a high, increased and low risk for parenting and developmental problems in a reliable way. The inter-rater reliability among trained CHC professionals for the overall risk assessment is excellent, with an intraclass correlation (ICC) of 0.93 ([van Stel et al., 2012](#)). [Van Stel et al. \(2012\)](#) showed that the SPARK was practicable and provided useful information that helped in the choice, together with the parents, of the type of care needed in a family. The overall risk assessment of SPARK proved to be a strong predictor for confirmed reports of child abuse and neglect made to the Advice and Reporting Centers for Child Abuse and Neglect (ARCAN) and Youth Care Agency (YCA) in the 1.5 years after completing the SPARK (odds ratio of high versus low risk: 16.3 (95 % confidence interval: 5.2–50.8)). The specificity and negative predictive value of risk for a confirmed report to ARCAN or YCA were high (high risk: 0.97 and 0.99, increased risk: 0.80 and 0.99; [Staal et al., 2013](#)). The average duration of taking the SPARK is 30 min ([Staal et al., 2015, 2016](#)). A detailed description of the (development of the) SPARK can be found in [Staal's \(2016\)](#) dissertation.

### 2.3. Outcome measures

Future child protection activities were measured by two outcome measures, namely the presence of: (1) a (new) child protection order in a 10-year follow-up period; and (2) residential youth care (including foster care) in a 10-year follow-up period. Child protection orders are issued by the juvenile court and can consist of the following measures: (a) a (provisional) guardianship order, whereby the local authority is given the legal authority to supervise the needs and development of the child while the child lives at home or elsewhere; (b) an order to take away custody (temporary or provisional), whereby the person's rights and duties as a parent are taken away (Driessen & Verschuren, 2021). Residential youth care includes foster care and other forms of family-centered care, and residential treatment. Both foster care and residential treatment can involve part-time or full-time care (Driessen & Verschuren, 2021).

The follow-up period was 10-years after the SPARK was administered. However, the data on child protection orders and residential youth care were only available from 2011 onwards, while the SPARK was administered in 2007 and 2008. As a result, data on child protection orders and residential youth care were not available in the first three years after the SPARK measurement. The children were 18 months when the SPARK was administered (in 2007 or 2008). For each child, we looked at whether a child protection order or residential youth care was issued during 2011 to 2018, that is, when the children were between 5.5 years to 11.5 years old. The data were provided by Statistics Netherlands (In Dutch: *Centraal Bureau voor de Statistiek*). Because all youth care institutions are required to report to Statistics Netherlands, this data is considered the most complete information on child protection orders and residential youth care. The following outcome measures were analyzed: (1) one or more child protection orders in the follow-up period (1 = yes; 0 = no); (2) residential youth care in the follow-up period (1 = yes; 0 = no); and (3) a combination measure (1 = one or more child protection orders and/or residential youth care in the follow-up period; 0 = no child protection orders and/or residential youth care in the follow-up period).

Note that results are based on calculations by the first author using non-public microdata from Statistics Netherlands. These microdata are accessible for statistical and scientific research under certain conditions (for further information [microdata@cbs.nl](mailto:microdata@cbs.nl)).

### 2.4. Statistical analysis

The predictive validity of the SPARK was assessed using Area Under the receiver operating characteristic Curve (AUC) values. AUC values are an effective way to calculate the predictive validity of a test (Fawcett, 2006; Rice & Harris, 2005). Roughly speaking, a value of 1 indicates perfect prediction, and a value of 0.5 indicates probability equal to chance (for a positive association). Criteria used to evaluate the size of the effects were based on the guidelines provided by Rice and Harris (2005), where  $AUC \geq 0.556$  is considered low predictive accuracy (i.e., small effect);  $AUC \geq 0.639$  is considered medium predictive accuracy (i.e., medium effect); and  $AUC \geq 0.714$  is considered excellent predictive accuracy (i.e., large effect; Rice & Harris, 2005). The 95 % confidence intervals (CIs) of the AUC values were calculated using 2000 stratified bootstrap replications (Carpenter & Bithell, 2000). The outcome measure used for the analyses was the combination measure (child protection order and/or residential youth care) unless otherwise indicated. For assessment of the predictive validity of the factors of the SPARK risk assessment, the responses were recoded to 0 = protective, 1 = neutral, and 2 = risk. If the factor was rated as having no influence it was left blank (further referred to as neutral), in case of positive influence it was scored as protective, and in case of negative influence it was scored as a risk factor.

Next, we examined whether an actuarial risk module contributes to a more accurate prediction of (risk of) future child protection activities. For the development of the actuarial module, we opted for equal weighting of items (sum score) for a number of reasons. Firstly, various studies show that an increased risk of child maltreatment arises from an accumulation of risk factors (rather than the presence of one or a few specific factors), whereby it is of secondary importance which specific factors are involved (also referred to as the cumulative risk model). Secondly, when using individual weightings based on, for example, a logistic regression analysis, the following risk is present: if two individual risk factors (factor A and B) are strongly interrelated, the model only heavily weights one of these factors, for example factor A. Because the unique contribution of factor B is low, this factor is given a low weighting. However, if only factor B is present in a specific family (and not factor A), this family may wrongly receive a low risk estimate. Finally, a risk assessment based on a sum score is easy to use for professionals and easy to explain to the families concerned.

Using equal weighting of the items, a sum score was calculated based on the factors with a significant association with the combination measure (child protection orders and/or residential youth care) with the above mentioned three-point scoring (protective, neutral, risk), where a higher sum score indicates a higher risk of future child maltreatment. Based on the sum score, a risk classification was developed that is useful in practice. Additionally, separate sum scores were calculated for the factors that were rated by the CHC professional as risk (sum score of risk factors; 1 = risk, 0 = no risk) and protective (sum score of protective factors; 1 = protective, 0 = not protective). Split-sample validation was used, in which the risk classification was developed based on one half of the sample (the construction sample) and validated on the other half of the sample (the validation sample).

The AUC values of the clinical versus the actuarial risk assessment, and the sum score of the risk factors versus the sum score of the protective factors were compared using DeLong's method (DeLong et al., 1988; Sun & Xu, 2014). A significance level of  $\alpha = 0.05$  was used for all analyses.

### 2.5. Software

Data were processed and analyzed using R (version 3.6.2; R Core Team, 2021). AUC values (incl. 95 % CIs) were calculated using the `pROC` package (Robin et al., 2011).

### 3. Results

#### 3.1. Descriptive statistics

In the 10-year follow-up period, 1 % of the sample had a child protection order, and 0.6 % had residential youth care. The prevalence of the combination measure (child protection order and/or residential youth care) was 1.5 %. Table 1 summarizes the prevalence of the factors of the SPARK's risk assessment. The clinical overall risk assessment of parenting and developmental problems performed with the SPARK was rated as low in 76.5 % of the children, as increased in 20.2 %, and as high in 3.2 % of the children.

#### 3.2. Predictive validity of the factors of the SPARK and the clinical risk assessment

The predictive validity of the risk and protective factors and the clinical overall risk assessment with the SPARK was evaluated. Table 1 provides an overview of the AUC values (including 95 % BIs). The predictive validity of family and parental factors was highest, with medium effects for financial topics (AUC = 0.705), agreement between parents (AUC = 0.675), parental competence (AUC = 0.665), atmosphere at home (AUC = 0.664), the amount of social support (AUC = 0.657), and other relevant factors (AUC = 0.649). Factors that showed significant but low predictive validity were the child's speech and cognitive development (AUC = 0.638), child's development and physical health in infant period (AUC = 0.601), parents' adverse childhood experiences (AUC = 0.597),

**Table 1**

Prevalence and predictive validity of the SPARK's risk and protective factors, and clinical overall risk assessment.

		Risk	Protective	Neutral	AUC	95 % CI
		%	%	%		
<b>Child</b>						
1.	Motor development	6.6	53.9	39.6	0.542	[0.436, 0.648]
2.	Behavior	7.1	57.8	35.0	0.588*	[0.481, 0.695]
3.	Interaction/exemplary behavior between parent and child	3.9	56.6	39.6	0.562	[0.454, 0.670]
4.	Speech and cognitive development	10.3	46.6	43.1	0.638**	[0.532, 0.744]
5.	Eating and drinking habits	12.2	26.6	61.2	0.567	[0.498, 0.636]
6.	Attachment	1.9	49.2	48.9	0.512	[0.411, 0.613]
7.	Child's development and physical health in infant period	12.5	19.2	68.4	0.601**	[0.521, 0.681]
8.	Other child factors (e.g., few toys, explanation of family situation)	5.5	2.2	92.3	0.545*	[0.479, 0.612]
<b>Living environment</b>						
9.	Atmosphere at home	2.2	46.3	51.5	<b>0.664***</b>	[0.579, 0.749]
10.	Safety	2.2	13.7	84.1	0.533	[0.446, 0.620]
11.	Hygiene family members	— <sup>a</sup>	21.3	78.4	0.560 <sup>+</sup>	[0.482, 0.637]
12.	Hygiene home	0.9	18.1	81.0	0.521	[0.435, 0.607]
13.	Furnishing	1.7	16.5	81.8	0.534	[0.477, 0.590]
<b>Parent(s)</b>						
14.	Parent's experience in infant period	14.2	16.5	69.3	0.582*	[0.500, 0.664]
15.	Competence of parents	4.7	48.5	46.8	<b>0.665***</b>	[0.568, 0.762]
16.	Agreement between parents	5.3	20.5	74.1	<b>0.675***</b>	[0.587, 0.763]
17.	Amount of social support	5.9	34.6	59.5	<b>0.657***</b>	[0.539, 0.774]
18.	Financial topics (e.g., low income, debt)	4.0	11.1	84.9	<b>0.705***</b>	[0.617, 0.793]
19.	Chronic health problems	3.3	—	88.4	0.544 <sup>+</sup>	[0.477, 0.611]
20.	Addiction	— <sup>a</sup>	—	92.2	0.575**	[0.523, 0.628]
21.	Psychiatric problems	3.1	—	90.5	0.596**	[0.525, 0.668]
22.	Adverse childhood experiences	3.2	—	90.2	0.597**	[0.525, 0.668]
23.	Openness during the well-child visit	2.1	44.6	53.2	0.533	[0.432, 0.633]
24.	Other relevant factors	10.2	3.2	86.5	<b>0.649***</b>	[0.553, 0.745]
<b>Clinical overall risk assessment</b>						
		%			AUC	95 % CI
	Low	76.5			<b>0.723***</b>	[0.614, 0.831]
	Increased	20.2				
	High	3.2				

Note.  $N = 1582$ ; AUC = Area Under the receiver operating characteristic Curve; CI = confidence interval. The three-point scale was used to calculate AUC values, with 0 = protective, 1 = neutral; 2 = risk. AUC values greater than the cutoff value for a medium effect (AUC > 0.639) are boldfaced.

<sup>a</sup> Not reported due to low prevalence (Statistics Netherlands does not give permission to report on groups with size  $n < 10$ ).

<sup>+</sup>  $p < .10$ .

\*  $p < .05$ .

\*\*  $p < .01$ .

\*\*\*  $p < .001$ .



parents' psychiatric problems (AUC = 0.596), parent-child interaction (AUC = 0.588), degree of difficulties experienced in infant period (AUC = 0.582), parents' addiction (AUC = 0.575), and other child factors (e.g., few toys, explanation of family situation; AUC = 0.545). The clinical overall risk assessment showed good predictive validity (AUC = 0.723; large effect). Table A1 (Appendix A) provides an overview of the AUC values (including 95 % CIs) of the factors by outcome measure.

### 3.3. Predictive validity of the SPARK with actuarial risk assessment

Additionally, we investigated whether the predictive validity of the SPARK could be improved with an actuarial module. For the actuarial module, a sum score was calculated based on the factors with a significant association with child protection activities, namely: behavior of the child, speech and cognitive development of the child, atmosphere at home, other child factors, child's development and physical health in infant period, parent's experience in infant period, competence of the parents, agreement between parents, amount of social support, financial topics, parental addiction, parental psychiatric problems, adverse childhood experiences of the parents, and finally, other relevant factors. To calculate the sum score, the three-point scale was used, with 0 = protective, 1 = neutral; 2 = risk.

The predictive validity of the sum score based on the significant factors was good (AUC = 0.808; large effect), and significantly larger than the predictive validity of the clinical risk assessment (AUC = 0.723),  $z = 3.40$ ,  $p < .001$ . Based on the sum score of the significant factors, a risk classification was developed based on the construction sample ( $n = 791$ ), and validated using the validation sample ( $n = 791$ ). The risk classification showed good predictive validity, with large effects for both the construction sample (AUC = 0.802) and the validation sample (AUC = 0.805), thus, the risk classification was applied to the full sample. Again, the predictive validity of the risk classification was good (AUC = 0.802; large effect), and significantly higher than the predictive validity of the clinical overall risk estimate (AUC = 0.723),  $z = 2.05$ ,  $p = .04$ .

The original risk classification used a low-increased-high risk classification. The risk classification based on the sum score was adjusted so that the risk groups better reflect the risk of child protection activities. The following risk categories were used: low risk (sum score between 0 and 11), average risk (sum score between 12 and 16) and high risk (sum score of 17 or higher). The risk classification is shown in Fig. 1. Due of the low prevalence ( $n < 10$ ), it was not possible to report the prevalence of child protection activities for the low risk group. The prevalence of child protection activities was 1.2 % in the average risk group (sum score between 12 and 16) and 19.4 % in the high risk group (sum score higher than 16).

By separately summing the risk and protective scores we investigated whether the predictive validity of the SPARK could be improved. As expected, the risk of child maltreatment increased as the number of risk factors increased, with an exponential increase in the risk of child protection activities starting at three risk factors. At 0–2 risk factors, the prevalence of child protection activities was 0.7 %, at 3–4 risk factors 4.5 %, and at five or more risk factors 21.2 %. In addition, the risk of child protection activities decreased as the number of protective factors increased. The risk of child protection activities decreased exponentially from four protective factors. Because of the low prevalence, it was not possible to report the prevalence of child protection activities for the sum score of the protective factors. As earlier mentioned, Statistics Netherlands does not give permission to report on groups with size ( $n < 10$ ).

The predictive validity of the sum score of risk factors was higher (AUC = 0.771; large effect), than that of the sum score of protective factors (AUC = 0.685; medium effect), but the difference was not significant. Neither differed significantly from the predictive validity of the clinical risk estimate with the SPARK (AUC = 0.723). Table A2 (Appendix A) gives an overview of the AUC values (including 95 % CIs) of the clinical risk estimate and the actuarial risk estimates by outcome measure.

Further analyses were based on the sum score that included both the risk and protective aspects, because the predictive validity of that sum score was highest. Next, the extent to which there was overlap between the risk groups identified based on the clinical risk assessment versus the actuarial risk assessment was examined. The results are shown in Table 2. The overlap between the risk groups was greatest for the increased-average risk group at 62.7 %. The degree of overlap was lower for the low-risk (48.6 %) and high risk

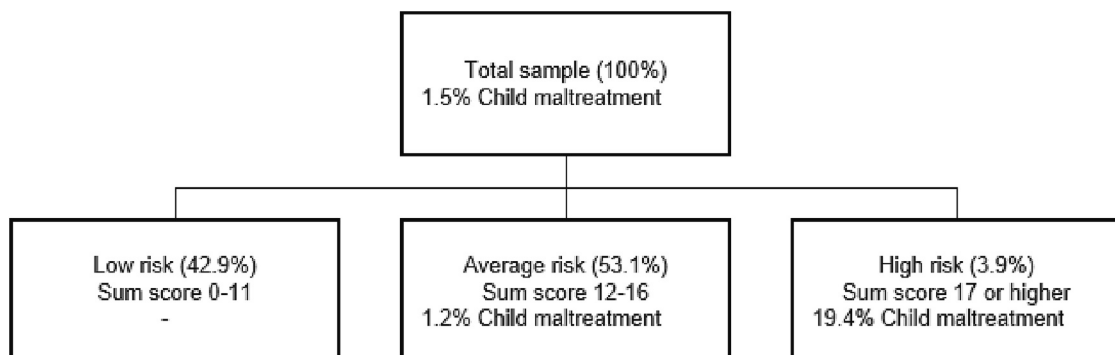


Fig. 1. Actuarial risk classification based on the sum score of the significant factors.

Note.  $N = 1582$ . To calculate the sum score, the three-point scale was used, where 0 = protective, 1 = neutral; 2 = risk. The prevalence of child maltreatment among the low-risk group was not reported because of the low prevalence (Statistics Netherlands does not give permission to report on groups with size  $n < 10$ ).

**Table 2**

Overlap between the risk classification with the clinical risk assessment versus actuarial risk assessment.

		Actuarial risk classification			Total
		Low	Average	High	
Clinical risk classification					
Low	%	48.6			100
Increased	%		62.7		100
High	%			45.1	100

Note.  $N = 1582$ .

(45.1 %) groups. This means that of the total number that classified as high risk by the actuarial module ( $n = 62$ ), 54.9 % were not classified as high risk by the clinical assessment. Thus, additional cases were identified as high risk with the actuarial module, that were not classified as high risk by the clinical risk assessment.

#### 4. Discussion

This study examined the predictive validity of the SPARK method for predicting child protection activities. Results show good predictive validity for the SPARK risk assessment ( $AUC = 0.723$ ; large effect) for predicting child protection orders and residential youth care (follow-up period of 10 years). The predictive validity of the SPARK is higher than the average predictive validity of child maltreatment risk assessment instruments ( $AUC = 0.681$ ; Van der Put et al., 2017). Furthermore, the predictive validity of the SPARK as found in the current study is similar to the findings from the study by Staal et al. (2013), with an  $AUC$  value of 0.745 for predicting confirmed reports of child maltreatment (follow-up period of 1.5 years). Consistent with previous research (Assink et al., 2019; Mulder et al., 2018; Patwardhan et al., 2017; Stith et al., 2009; Van IJzendoorn et al., 2020), the results of the current study showed that parental and family factors were the strongest predictors of child protection activities, as a proxy for child maltreatment. In the current study, financial topics ( $AUC = 0.705$ ; medium effect) and the degree of agreement between parents ( $AUC = 0.675$ ; medium effect) were the strongest predictors of child protection activities.

Notably, a large proportion of the factors (10 out of 24) were not significantly related to future child protection activities, including: attachment, motor development, and parental openness during the well-child visit. For accurate risk assessment, it is generally not necessary to include a long list of risk factors. A meta-analysis showed that the predictive value of risk assessment instruments for child maltreatment does not depend on the length of the instrument (Van der Put et al., 2017). This is partly because factors are often strongly related (e.g., hygiene of the home and hygiene of family members) and therefore do not uniquely contribute to the prediction of child maltreatment. Thus, the length of the SPARK risk assessment could be shortened. Such an adjustment will need to be validated over time to see if there is no (large) decrease in the predictive validity and usefulness for the broader task of the preventive CHC. Such a decrease is not expected because only risk factors that are not significantly associated with future child maltreatment would be omitted in the actuarial risk assessment. However, even though early risk assessment of child maltreatment is an important task of the CHC, the CHC also operates from a broader scope of monitoring and signaling healthy development of children and parenting. Thus, the non-significant factors of the SPARK can still be used for this purpose.

The additional part of our research was to investigate the extent to which an actuarial module improves the assessment of the risk of child protection activities. To this end, a sum score was calculated based on the factors significantly associated with child protection activities. As expected, the predictive validity of the SPARK increased with actuarial risk estimation ( $AUC = 0.808$ ), compared to clinical risk estimation ( $AUC = 0.723$ ). The predictive validity of the risk classification (low-average-high) based on the sum score was also significantly higher ( $AUC = 0.802$ ), relative to the clinical risk estimate. Furthermore, results showed that the cumulative risk (i.e., the sum score) has a higher predictive validity than individual risk factors, which is in line with findings from previous studies (e.g., Begle et al., 2010; Masten & Wright, 1998; McGoron et al., 2020). In the current study, there was an exponential increase in child protection activities from three risk factors on, and an exponential decrease in child protection activities from four protective factors on. The predictive validity of the sum score risk factors ( $AUC = 0.771$ ; large effect) was higher than that of the sum score protective factors ( $AUC = 0.685$ ; medium effect), but this difference was not significant. It is possible that in preventing child maltreatment, it is more important to eliminate risk than to promote protective factors. Other studies also show that children from high-risk families benefit less from the presence of protective factors (e.g., Luthar & Goldstein, 2004; Miller et al., 1999; Vanderbilt-Adriance & Shaw, 2008). However, for both sum scores, the predictive validity was lower than the predictive validity of the sum score that included both risk and protective factors ( $AUC = 0.808$ ; large effect). With this, a balanced risk estimate that includes both risk and protective factors as applied with the SPARK seems to be the preferred method.

These findings should be interpreted in light of several limitations. First, child protection orders and residential youth care are not direct measures of child maltreatment. However, due to financial and ethical reasons, it was not possible to verify for all children for whom the SPARK was administered whether child maltreatment actually occurred. This is because it requires very intensive research conducted by a multidisciplinary team consisting of pediatricians and child psychologists. We think that the combination of child protection orders and residential youth care provides the most complete estimation of the prevalence of child maltreatment, but also here, it probably is still the tip of the iceberg.

Second, due to the outcome measures that were used, it was not possible to examine the predictive validity of the SPARK for different types of child maltreatment. Still, research shows that there is a large overlap between risk factors for different types of child



maltreatment (e.g., [Assink et al., 2019](#); [Mulder et al., 2018](#)). Also, many cases involve a combination of different types of child maltreatment (e.g., [Alink et al., 2010](#); [Arata et al., 2005](#); [Finkelhor et al., 2007, 2011](#)). Thus, it is expected that the predictive validity of the SPARK is similar for different types of child maltreatment.

Third, the factors of the SPARK's risk assessment are currently only filled in to provide insight into how the risk assessment was made by the CHC professional. The CHC professionals are not obligated to fill in responses for all factors. It is possible that this provides a limited picture of the predictive value of the factors. However, previous research has shown good to excellent inter-rater reliability among CHC professionals, so the effects are expected to be limited. Also, despite this limitation, the SPARK method provides CHC professionals with insight into which factors they should incorporate in their (risk) assessment. Still, it may be useful to oblige CHC professionals to (at least) fill out the responses for the factors significantly associated with child protection activities.

Finally, we used the following risk categories: low risk, average risk and high risk in the present study. The risk in the low risk group was <1 %, the risk in the average group was similar to the average risk in the total population and the risk in the high risk group was 10 times higher than the average risk. These risk categories are difficult to compare with the categories of other risk assessment instruments. The reason for this is that instruments often make the classifications relative to the average risk and this differs per population for which the instrument has been developed. For example, the current classification has been made for use in the population of children aged 18 months and the average risk in this group differs from, for example, older children or children in certain risk groups. This makes it difficult to compare the results of risk assessment instruments with each other and this complicates standardization of risk communication.

Based on the findings of the current study, there are some recommendations for practice and future research. First, it is recommended that the risk assessment for the purpose of child maltreatment be adapted and that the actuarial risk classification is applied. It is important to incorporate these findings in the SPARK-training and the user-manual. This can contribute to increasing the knowledge and awareness of the importance of risk assessment and thus to motivating the CHC professionals to fill in the risk assessment as precise and unambiguously as possible. Moreover, the value of the SPARK's risk assessment with actuarial module depends on whether it is accepted by CHC professionals and whether they view it as having added value in their daily practice. Thus, it is important to evaluate whether CHC professionals accept the actuarial module and whether it helps them in their broad preventive task.

Lastly, to actually contribute to the prevention of child maltreatment, it is important that appropriate follow-up steps are taken after the early detection of risk. Previous research on the SPARK showed that follow-up actions better match the care needs of the parent as well as the level of risk for the child (compared to care-as-usual; [Staal et al., 2016](#)). Depending on the risk level, follow-up actions could entail, for example, scheduling an additional well-child visit, a referral to a (preventive) intervention, and/or to carry out an extensive safety and risk assessment with an instrument specifically developed for child maltreatment, such as the Actuarial Risk Assessment Instrument for Child Protection (ARIJ; in Dutch: *Actuarieel Risicotaxatie Instrument voor Jeugdbescherming*; [Van der Put et al., 2016](#); [Vial et al., 2021](#)).

## 5. Conclusion

Based on the findings from current research, the SPARK method seems to be suitable for estimating the risk of child protection activities. The combination of a good inter-rater reliability (based on earlier research by [Van Stel et al., 2012](#)) and predictive validity of the SPARK method offers possibilities for a broad(er) implementation of the SPARK within the CHC. In order to actually contribute to the early prevention of child maltreatment, it is crucial to link the risk assessment to appropriate follow-up actions. The SPARK with actuarial module can be used to support CHC professionals in the decision to offer additional support to families at increased or high risk of child protection activities.

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## CRedit authorship contribution statement

**Claudia van der Put:** Conceptualization, Validation, Funding acquisition, Supervision, Writing – Reviewing and Editing. **Isidora Stolwijk:** Formal analysis, Investigation, Visualization, Writing – original draft. **Ingrid Staal:** Validation, Resources, Writing – Reviewing and Editing.

## Declaration of competing interest

The authors declare that they have no conflict of interest.

## Data availability

The authors do not have permission to share data.

## Appendix A

**Table A1**  
Predictive validity of the SPARK factors by outcome measure.

	Child protection orders		Residential youth care		Combination measure	
	AUC	95 % CI	AUC	95 % CI	AUC	95 % CI
Child						
1. Motor development	0.547	[0.420, 0.674]	0.479	[0.306, 0.653]	0.542	[0.436, 0.648]
2. Behavior	<b>0.649**</b>	[0.520, 0.779]	0.428	[0.288, 0.568]	0.588*	[0.481, 0.695]
3. Interaction/exemplary behavior between parent and child	0.537	[0.406, 0.669]	0.545	[0.369, 0.722]	0.562	[0.454, 0.670]
4. Speech and cognitive development	<b>0.683**</b>	[0.558, 0.807]	0.529	[0.363, 0.695]	<b>0.638**</b>	[0.532, 0.744]
5. Eating and drinking habits	0.568	[0.495, 0.642]	0.565	[0.446, 0.684]	0.567	[0.498, 0.636]
6. Attachment	0.509	[0.384, 0.633]	0.509	[0.348, 0.669]	0.512	[0.411, 0.613]
7. Child's development and physical health in infant period	0.557	[0.466, 0.648]	<b>0.656*</b>	[0.534, 0.777]	0.601**	[0.521, 0.681]
8. Other child factors (e.g., few toys, explanation of family situation)	0.545 <sup>+</sup>	[0.463, 0.627]	0.533	[0.437, 0.629]	0.545*	[0.479, 0.612]
Living environment						
9. Atmosphere at home	<b>0.647**</b>	[0.540, 0.753]	<b>0.650*</b>	[0.504, 0.797]	<b>0.664***</b>	[0.579, 0.749]
10. Safety	0.524	[0.422, 0.626]	0.552	[0.417, 0.687]	0.533	[0.446, 0.620]
11. Hygiene family members	0.568 <sup>+</sup>	[0.467, 0.669]	0.505	[0.375, 0.636]	0.560 <sup>+</sup>	[0.482, 0.637]
12. Hygiene home	0.525	[0.441, 0.608]	0.478	[0.295, 0.662]	0.521	[0.435, 0.607]
13. Furnishing	0.544	[0.483, 0.605]	0.525	[0.428, 0.622]	0.534	[0.477, 0.590]
Parent(s)						
14. Parent's experience in infant period	0.537	[0.445, 0.630]	<b>0.638*</b>	[0.512, 0.763]	0.582*	[0.500, 0.664]
15. Competence of parents	<b>0.693***</b>	[0.597, 0.790]	0.580	[0.390, 0.771]	<b>0.665***</b>	[0.568, 0.762]
16. Agreement between parents	<b>0.677***</b>	[0.590, 0.765]	<b>0.649*</b>	[0.483, 0.815]	<b>0.675***</b>	[0.587, 0.763]
17. Amount of social support	<b>0.718***</b>	[0.614, 0.822]	0.554	[0.334, 0.773]	<b>0.657***</b>	[0.539, 0.774]
18. Financial topics (e.g., low income, debt)	<b>0.732***</b>	[0.621, 0.844]	0.625*	[0.509, 0.742]	<b>0.705***</b>	[0.617, 0.793]
19. Chronic health problems	0.495	[0.435, 0.555]	0.618**	[0.498, 0.738]	0.544 <sup>+</sup>	[0.477, 0.611]
20. Addiction	0.565*	[0.508, 0.622]	0.582*	[0.491, 0.673]	0.575**	[0.523, 0.628]
21. Psychiatric problems	0.546	[0.489, 0.604]	<b>0.658***</b>	[0.518, 0.798]	0.596**	[0.525, 0.668]
22. Adverse childhood experiences	0.635***	[0.533, 0.738]	0.517	[0.510, 0.525]	0.597***	[0.525, 0.668]
23. Openness during the well-child visit	0.533	[0.408, 0.657]	0.517	[0.360, 0.674]	0.533	[0.432, 0.633]
24. Other relevant factors	<b>0.678***</b>	[0.557, 0.800]	0.562	[0.435, 0.689]	<b>0.649***</b>	[0.553, 0.745]

Note.  $N = 1582$ ; AUC = Area Under the receiver operating characteristic Curve; CI = confidence interval; Combination measure = child protection order and/or residential youth care. AUC values greater than the cutoff value for a medium effect ( $AUC > 0.639$ ) are boldfaced.

<sup>+</sup>  $p < .10$

\*  $p < .05$

\*\*  $p < .01$

\*\*\*  $p < .001$

**Table A2**

Predictive validity of the clinical and actuarial risk estimates of the SPARK by outcome measure.

	Child protection orders		Residential youth care		Combination measure	
	AUC	95 % CI	AUC	95 % CI	AUC	95 % CI
Clinical overall risk assessment	<b>0.717***</b>	[0.585, 0.849]	<b>0.661**</b>	[0.478, 0.844]	<b>0.723***</b>	[0.614, 0.831]
Sum score significant factors	<b>0.816***</b>	[0.696, 0.937]	<b>0.713**</b>	[0.567, 0.859]	<b>0.808***</b>	[0.716, 0.899]
Risk classification	<b>0.799***</b>	[0.670, 0.927]	<b>0.734**</b>	[0.594, 0.875]	<b>0.802***</b>	[0.711, 0.893]
Sum score risk factors	<b>0.731***</b>	[0.571, 0.892]	<b>0.730**</b>	[0.558, 0.902]	<b>0.771***</b>	[0.657, 0.884]
Sum score protective factors	<b>0.744*</b>	[0.647, 0.841]	0.554	[0.481, 0.628]	<b>0.685<sup>+</sup></b>	[0.607, 0.763]

Note.  $N = 1582$ ; AUC = Area Under the receiver operating characteristic Curve; CI = confidence interval; Combination measure = child protection order and/or residential youth care. AUC values greater than the cutoff value for a medium effect (AUC > 0.639) are boldfaced.

<sup>+</sup>  $p < .10$ .

\*  $p < .05$ .

\*\*  $p < .01$ .

\*\*\*  $p < .001$ .

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