Safety and risk assessment in child welfare

Moving forward

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CHAPTER 7
Exploring the Interrelatedness of Risk Factors for Child Maltreatment: A Network Approach

This chapter is adapted from:
Chapter 7

ABSTRACT

Background
Theories on the etiology of child maltreatment generally focus on the interaction between multiple risk and protective factors. Moreover, the quadratic model of cumulative risk describes a threshold at which the risk of child maltreatment increases exponentially, suggesting a synergistic effect between risk factors.

Objective
This study explored the interrelatedness of risk factors for child maltreatment.

Participants and Setting
The sample consisted of risk assessments performed for both high-risk families (n = 2,399; child protection services) and lower risk families (n = 1,904; community outreach services).

Methods
Network analyses were performed on parental risk factors. Three networks were constructed: a cross-sample network, a high-risk network, and a lower risk network. The relations between risk factors were examined, as well as the centrality of each risk factor in these networks. Additionally, the networks of the two samples were compared.

Results
The networks revealed that risk factors for child maltreatment were highly interrelated, which is consistent with Belsky’s multi-dimensional perspective on child maltreatment. As expected, risk factors were generally stronger related to each other in the high-risk sample than in the lower risk sample. Centrality analyses showed that the following risk factors play an important role in the development of child maltreatment: “Caregiver was maltreated as a child”, “History of domestic violence”, and “Caregiver is emotionally absent”.

Conclusions
We conclude that studying the interrelatedness of risk factors contributes to knowledge on the etiology of child maltreatment and the improvement of both risk assessment procedures and interventions for child maltreatment.

Keywords: Risk factor, child maltreatment, interrelatedness, network analysis, cumulative risk
7.1 INTRODUCTION

As child maltreatment is a major public health problem with serious and enduring consequences for victims (e.g., Stoltenborgh, Bakermans-Kranenburg, Alink, & Van IJzendoorn, 2015), much research has focused on the prediction and prevention of child maltreatment. Over the years, many risk factors for different child maltreatment forms have been identified in a large body of research (for instance, see the review studies of Assink et al., 2019; Mulder, Kuiper, Van der Put, Stams, & Assink, 2018; Stith et al., 2009 for an overview of risk factors for sexual abuse, physical abuse, and neglect). However, this research has primarily examined individual risk factors for child maltreatment and not the complex interplay of risk factors.

Multiple studies have shown that particularly the cumulation of risk factors rather than the presence of a single risk factor is predictive of future child maltreatment (Brown, Cohen, Johnson, & Salzinger, 1998; Lamela & Figueiredo, 2018; Li, Chu, Ng, & Leong, 2014; MacKenzie, Kotch, Lee, Augsberger & Hutto, 2011; Patwardhan, Hurley, Thompson, Mason, & Ringle, 2017; Thornberry et al., 2014; Yang & Maguire-Jack, 2018). Cumulative risk has been described as a linear additive model, in which each risk factor increases the risk of future child maltreatment (Appleyard, Egeland, Van Dulmen, & Alan Sroufe, 2005; Horan, & Widom, 2015). However, recent studies have shown evidence for a nonlinear model of cumulative risk (Lamela, & Figueiredo, 2018; Patwardhan, Hurley, Thompson, Mason, & Ringle, 2017). This nonlinear quadratic model describes a threshold at which the risk of child maltreatment increases exponentially. The exponential increase suggests that risk factors interact and strengthen each other inducing this synergistic effect.

Belsky’s (1993) multi-dimensional theory on the etiology of child maltreatment assumes that relations between multiple risk and protective factors, both within and between the immediate interactional (proximal) context of the child and the broader child context, cause child maltreatment. The immediate context comprises parental factors (such as characteristics of parents’ upbringing and personality), child factors (such as age, physical health, and behavioral characteristics), and factors related to parent-child interaction. The broader context comprises community factors (such as the degree to which social and family support is available), cultural factors (such as a society’s attitudes toward violence or corporal punishment), and evolutionary aspects in the sense that children and parents can be in a (biological) conflict of interest (see Belsky, 1993, pg. 424).

Belsky’s multi-dimensional perspective on child maltreatment is supported by a large number of studies that identified many different variables as risk factors (see the review studies of Assink et al., 2019; Mulder, Kuiper, Van der Put, Stams, & Assink, 2018; Stith et al., 2009 for an overview of risk factors). Additional support for Belsky’s perspective comes from studies showing that cumulative risk is most predictive (e.g., MacKenzie, Kotch, Lee, Augsberger & Hutto, 2011; Thornberry et al., 2014; Yang &
Maguire-Jack, 2018), and the identification of the quadratic model of cumulative risk 
(Lamela, & Figueiredo, 2018; Patwardhan, Hurley, Thompson, Mason, & Ringle, 2017).

Despite the strong theoretical basis and empirical support, research on the 
relations between risk factors is scarce. Most studies have only focused on identifying 
individual risk factors or examining the predictive power of cumulative risk. To improve 
our understanding of the role of risk factors in the etiology of child maltreatment, it 
is important to gain more insight into whether and how risk factors are interrelated. 
Therefore, we explored the interrelatedness of risk factors for child maltreatment.

Advances in methodology and statistics have made it possible to study the 
complexity of the relations between risk factors. An example of an advancement is 
network analysis. Borsboom and Cramer (2013) were the first to apply network theory 
to psychological attributes, and they describe that mental disorders result from a causal 
interplay between symptoms. In other words, the presence of a specific symptom 
causes another symptom to show up. In network analysis, the relations between these 
symptoms are presented in so-called networks (Borsboom & Cramer, 2013). These 
networks graphically depict relations between symptoms, in which the strength of the 
correlations between symptoms is determined after controlling for all other symptoms 
in the network (i.e., partial correlations; Epskamp et al. 2018; Epskamp, Waldorp, Mõttus, 
& Borsboom, 2016; Fisher, Reeves, Lawyer, Medaglia, & Rubel, 2017). The partial 
correlations between symptoms in these networks can even be indicative of a causal 
relation between these symptoms (For an elaborate explanation, see Epskamp et al., 
2018, pg. 419-420). Besides examining interrelatedness between symptoms, a centrality 
analysis can be performed to examine which symptom (or symptoms) is most "central" 
in the network of all symptoms, meaning that it can be determined which symptom is 
most likely to cause the development of other symptoms (Borsboom & Cramer, 2013). 
This centrality analysis provides important information on the treatment of disorders, 
as it can be expected that targeting the most central symptom in interventions helps 
reducing one or more other symptoms.

Network analysis has gained popularity in different research fields, such as clinical 
psychology, forensic psychology, psychiatry, personality research, social psychology, 
and quality of life research (Epskamp, Borsboom, & Fried, 2018). For instance, Fritz, 
Fried, Goodyer, Wilkinson, and Van Harmelen (2018) studied the interrelatedness of 
resilience factors for adolescents with and without exposure to childhood adversity. 
Rhemtulla et al. (2016) examined the interrelatedness of substance abuse symptoms, 
and Verschuere et al. (2018) studied how features of psychopathy are interrelated. 
Van den Berg et al. (2020) studied a sample of adult male sex offenders to determine 
how dynamic risk factors for sexual recidivism are interrelated in this specific group 
of offenders.

As shown by Van den Berg et al., network analysis is a new method that is particularly 
useful in exploring how risk factors for a negative outcome influence each other, and 
in making inferences about the magnitude of these influences. To our knowledge, 
risk factors for child maltreatment have not yet been examined in network models,
even though examining child maltreatment risk factors from a network perspective is highly promising for shedding light on the interrelatedness of child maltreatment risk factors. Consequently, this may lead to more insight into the processes underlying child maltreatment, and which specific risk factor interrelations lead to child maltreatment. In short, network analysis provides a unique opportunity to generate clinically and scientifically useful knowledge.

In the context of child maltreatment, risk factors may very well be interrelated just like symptoms of psychological disorders for which network analysis was originally developed (Borsboom & Cramer, 2013). For instance, a caregiver with substance abuse problems (risk factor 1) may experience financial problems (risk factor 2) due to substance abuse, which in turn may result in social isolation of the caregiver (risk factor 3). Modeling the interrelations between these and other child maltreatment risk factors in a network can provide information on the most central risk factors. Such central risk factors are most strongly associated with other risk factors, and thus, play an important role in the (re)occurrence of child maltreatment. Identifying central risk factors is very important for clinical practice, as it helps in determining what risk factors should be given priority in the prevention of child maltreatment and in assessing a family’s needs.

Research on relations between risk factors for child maltreatment is still too scarce to develop well-informed hypotheses on the centrality of particular risk factors. However, empirical research has shown that parental risk factors are the strongest predictors or most frequently significant predictors for child physical abuse or child neglect (Stith et al., 2009; Mulder et al., 2018). These studies suggest that such risk factors play an important role in the occurrence of child maltreatment and should be the primary focus when preventing child maltreatment. However, it is not known how these factors interrelate and which of these factors play a more central role in the development of child maltreatment. Therefore, in the current study we explored the interrelatedness of parental risk factors for child maltreatment. Additionally, we explore the interrelations of risk factors in two samples of families that differ in the risk for child maltreatment. Based on the nonlinear quadratic model of cumulative risk it was expected that the risk factors in the high-risk sample would relate stronger to each other, as it was expected that more risk factors are present in this sample.

To summarize, the purpose of the present study was to explore how risk factors for child maltreatment are interrelated by examining risk factors from a network perspective. This type of research has great potential to advance our understanding of child maltreatment (re)occurrence. To meet this purpose, we conducted network analyses on data that were collected from risk assessments performed in two different agencies. The first data are from the high-risk sample, which comprised children (and their families) who were referred to the Dutch child protection services. The second, lower risk, sample consisted of children (and their families) who were referred to Dutch community outreach services. In the analyses, three networks visualizing the interrelations between parental risk factors in the sampled children and their families
Chapter 7

were constructed: (1) a cross-sample network, (2) a high-risk (child protection) network, and (3) a lower risk (community outreach) network. Besides constructing these three networks, we examined which factors play a central role in the risk for child maltreatment by conducting centrality analyses. Finally, we compared differences in relations between - and centrality of - risk factors for child maltreatment across the two samples.

7.2 METHOD

7.2.1 Samples

The first sample of participants comprised children (and their family members) who were referred to child protection services (CPS) in the Netherlands. This is a sample at high-risk for child maltreatment, as most families are referred to child protection due to previous child maltreatment or other child safety problems. The families without child safety problems were referred to CPS for youth probation. We examined the risk assessments performed by child welfare workers for the youngest child in each family at the time of referral. Between July 2015 and March 2018, 2,399 assessments of the risk for future child maltreatment on individual children were completed and retrieved.

The second sample of participants consisted of children (and their family members) who were referred to community outreach services (COS) in the Netherlands. This sample is generally considered to have a lower risk of child maltreatment than the first sample, as most families are referred to community outreach services because of other problems than severe child safety issues, such as parental mental health problems or financial problems. For each family with children, the risk of child maltreatment was assessed at the time of referral for the youngest child. In total, 1,917 risk assessments on individual children were conducted between January 2016 and October 2018. Risk assessments that lacked information on the child’s age were excluded from the dataset \((n = 9)\). Risk assessments with improper assessment dates (i.e., before the year 2015) were also excluded, as the risk assessment instrument was implemented in 2015 \((n = 4)\). In total, less than 1% of the assessments were excluded, so 1,904 risk assessments were analyzed. To the authors’ knowledge there is no prior research that compared a sample of children and their family members who are at high-risk for child maltreatment to a lower-risk sample.

7.2.2 Measures

The Actuarial Risk assessment Instrument Youth Protection (ARIJ; Van der Put et al., 2016) was used to assess a set of risk factors in all families who were referred to
Interrelatedness of Risk Factors

either of the two agencies. The ARIJ is an actuarial risk assessment instrument for
determining the risk of future maltreatment in the Netherlands (Van der Put et al., 2016).
This risk assessment instrument comprises 23 items, which are grouped into items
assessing aspects of the current child safety situation (9 items) and items assessing
risk factors for child maltreatment (14 items). The predictive validity of the actuarial risk
estimate showed to be moderate, with a significant area under the curve (AUC) of .63, in
the CPS sample (Van der Put et al., 2016). For the COS sample, there was no information
available on the predictive validity of the instrument. Overall, the reliability of the risk
assessment items was moderate and the reliability of the actuarial risk was high (Vial,
Assink, Stams, & Van der Put, 2019 [Chapter 5]). The ARIJ mainly contains parental risk
factors, as these showed to be most predictive of child maltreatment (Van der Put et
al., 2016). Because parental risk factors play an important role in the (re)occurrence
of child maltreatment and should, therefore, be the primary focus when preventing child
maltreatment, we analyzed data on the 13 parental risk factors measured in the ARIJ.
All items can be responded to with one of three categories: “Yes” (when the risk factor is
present), “No” (when the risk factor is absent), and “Unknown” (when there is insufficient
information to determine the presence of a risk factor at time of the assessment). We
chose to include the response category “Unknown” in the data analysis, as previous
research showed that risk factors of which the presence cannot be assessed with
a certain degree of certainty can sometimes still be categorized as a risk for child
maltreatment (Van der Put et al., 2016). Table 7.1 lists all assessed parental risk factors
and the prevalence of each response category for each risk factor for the two samples.
Based on the responses to all items, the algorithm of the instrument produces a risk
estimate for future child maltreatment. This risk is expressed as low, medium, or high.
Professionals of both agencies were trained on how to perform a risk assessment using
the ARIJ, and both agencies implemented the ARIJ in a similar manner. Therefore, the
assessments were deemed to be comparable across samples.

7.2.3 Statistical Analyses

The statistical analyses were performed in a stepwise manner and were based on the
procedure and methods described by Fried et al. (2018), Rhemtulla et al. (2016), and
Verschuere et al. (2018). In short, we first constructed a network using all available
data from both samples. Next, we constructed a network for the CPS and COS samples
separately. In total, we constructed three networks of parental risk factors for child
maltreatment, so the steps described below were followed three times.

Each network is a graphical representation of partial correlations between risk
factors constructed with the statistical software R (version 3.5.1) and R-package
“qgraph” (version 1.6.1; Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom,
2012). Each node (circle) in a network represents a risk factor (i.e., an item of the risk
assessment instrument). The links between nodes are so-called “edges” that denote
the association between two risk factors. The thickness of these edges represents the strength of a correlation between two risk factors controlling for all other variables in the network. Because all risk factors were measured on a categorical scale, a mixed graphical network model was fitted to the data with R-package “mgm” (version 1.2-6; Haslbeck, & Waldorp, 2016). To produce a sparse and interpretable network, this package has a specification for penalization. Here, we used the Extended Bayesian Information Criterion for penalization, as this is the most conservative option and most suitable for categorical data (Haslbeck & Waldorp, 2016). To determine the centrality of risk factors, the R-package “qgraph” (version 1.6.1; Epskamp et al., 2012) was used for examining the “node strength centrality”, as this type of centrality showed to be the most stable of the three available centrality measures (Epskamp et al., 2018). Node strength centrality is the absolute sum of all relations each node has with other nodes, and simply put, shows how strong this node’s connections are with all other nodes (Fried, Epskamp, Nesse, Tuerlinckx, & Borsboom, 2016; Opsahl, Agneessens, & Skvoretz, 2010).

Before interpreting the obtained networks, we assessed their stability using R-package “bootnet” (version 1.2; Epskamp, Borsboom, & Fried, 2018). Correlation stability (CS) coefficients were calculated to make inferences about the stability of the node strength centrality and edge weight coefficients. CS-coefficients represent the maximum proportion of risk assessments that can be dropped in a bootstrap subset, without lowering the correlation between the bootstrap subset coefficients and the original coefficients below a default of .7 (with 95% probability). The centrality measures and the edge weights are considered stable when the corresponding CS-coefficient exceeds a value of .25, but values exceeding .5 are preferred (Epskamp et al., 2018). Edge-weight accuracy was also assessed by calculating confidence intervals using non-parametric bootstraps (using the R-package “bootnet”; Epskamp et al., 2018). These non-parametric bootstrap results were also used to perform edge weight difference tests and centrality difference tests, in which differences between edge weights and centrality coefficients can be tested within a network.

We compared the CPS and COS networks in different ways. First, all networks were standardized and the layout of the cross-sample network was used to fix the layout of the networks for the two samples. Second, we described standardized node strength centrality coefficients, so that these coefficients in the two different networks can be compared. Third, we correlated edge weights (Fried et al., 2018; Rhemtulla et al., 2016) and node strength centrality coefficients (Verschuere et al., 2018) across networks, to assess the similarity of these measures. Last, we visualized the variability of the edge weights in both networks by constructing a network in which the edges represent the standard deviation of the edge weight across both networks. It was not possible to test differences in edge weights between the networks, as a network comparison test is not available for nominal data (Van Borkulo et al., 2017).
7.3 RESULTS

7.3.1 Sample Characteristics

Table 7.1 shows the prevalence of the parental risk factors in both samples and Table 7.2 shows several characteristics of both samples. The samples differed in multiple aspects. In the child protection sample, the children were older (CP: $M_{age} = 9.56$, $SD = 5.93$; COS: $M_{age} = 7.11$, $SD = 5.19$; $t = 14.52$, $p < .001$), more risk factors were present (CP: $M = 5.67$, $SD = 3.30$; COS: $M = 4.65$, $SD = 3.24$; $t = 9.08$, $p < .001$), the risk of future child maltreatment was higher ($\chi^2 (2) = 74$, $p < .001$), and more children were in immediate danger ($\chi^2 (3) = 693$, $p < .001$). In the child protection sample, the most prevalent risk factors were A history of domestic violence (50%), Caregivers have a problematic relationship (48%) and Family conflict (47%). The risk factor Caregiver has a mental disability was the least prevalent (3%). Of the risk factors in the community outreach sample, the risk factors Parental stress about financial problems (61%), Caregivers have a problematic relationship (43%) and Caregiver has a psychiatric disorder (36%) were the most prevalent. The risk factor Caregiver is physically absent was the least prevalent (4%).

7.3.2 Cross-Sample Network

Figure 7.1 shows the network of parental risk factors for child maltreatment for both samples combined. Each node represents a risk factor, and each edge (the line between two nodes) represents a partial correlation between two risk factors controlling for all other risk factors in the network. The measures in the cross-sample network were sufficiently stable, as the CS-coefficients of the node strength centrality and edge weights were .59 and .75, respectively. In other words, a large portion of the risk assessments can be dropped, without lowering the correlation between the bootstrap coefficients and the original coefficients. All other bootstrap results on the cross-sample network can be found in the Appendices (Appendix 7.A - 7.D show the node strength centrality accuracy, confidence intervals of the edge weights, edge weight difference test results, and centrality difference test results).
Chapter 7

Table 7.1 Overview of the Assessed Parental Risk Factors for Child Maltreatment and their Prevalence in the two Samples

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Child Protection (N = 2,399)</th>
<th>Community Outreach (N = 1,904)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Caregiver has a history of abusing a child</td>
<td>%Yes 18 %No 57 %Unknown 26</td>
<td>%Yes 10 %No 72 %Unknown 18</td>
</tr>
<tr>
<td>2. Caregiver has a psychiatric disorder</td>
<td>%Yes 19 %No 41 %Unknown 40</td>
<td>%Yes 36 %No 45 %Unknown 18</td>
</tr>
<tr>
<td>3. Caregiver has an addiction</td>
<td>%Yes 10 %No 61 %Unknown 29</td>
<td>%Yes 8  %No 81 %Unknown 11</td>
</tr>
<tr>
<td>4. Caregiver has a mental disability</td>
<td>%Yes 3  %No 66 %Unknown 31</td>
<td>%Yes 9  %No 71 %Unknown 20</td>
</tr>
<tr>
<td>5. Caregiver is physically absent</td>
<td>%Yes 10 %No 85 %Unknown 5</td>
<td>%Yes 4  %No 94 %Unknown 2</td>
</tr>
<tr>
<td>6. Caregiver is emotionally absent</td>
<td>%Yes 25 %No 53 %Unknown 23</td>
<td>%Yes 19 %No 69 %Unknown 12</td>
</tr>
<tr>
<td>7. Caregiver was maltreated as a child</td>
<td>%Yes 14 %No 33 %Unknown 54</td>
<td>%Yes 11 %No 44 %Unknown 45</td>
</tr>
<tr>
<td>8. Caregiver has been violent before</td>
<td>%Yes 20 %No 45 %Unknown 35</td>
<td>%Yes 11 %No 65 %Unknown 25</td>
</tr>
<tr>
<td>9. Caregivers have a problematic relationship</td>
<td>%Yes 48 %No 38 %Unknown 15</td>
<td>%Yes 43 %No 48 %Unknown 9</td>
</tr>
<tr>
<td>10. There is family conflict</td>
<td>%Yes 47 %No 38 %Unknown 15</td>
<td>%Yes 31 %No 59 %Unknown 11</td>
</tr>
<tr>
<td>11. A history of domestic violence</td>
<td>%Yes 50 %No 30 %Unknown 21</td>
<td>%Yes 17 %No 73 %Unknown 9</td>
</tr>
<tr>
<td>12. Parental stress about financial problems</td>
<td>%Yes 32 %No 49 %Unknown 19</td>
<td>%Yes 61 %No 36 %Unknown 3</td>
</tr>
<tr>
<td>13. Social isolation of the family</td>
<td>%Yes 13 %No 68 %Unknown 19</td>
<td>%Yes 22 %No 72 %Unknown 6</td>
</tr>
</tbody>
</table>

Note. N = number of children and their families in the sample for which the risk for child maltreatment was assessed, Yes = Percentage prevalence of the response category “yes”, No = Percentage prevalence of the response category “no”, Unknown = Percentage prevalence of the response category “unknown”. 
Interrelatedness of Risk Factors

Table 7.2 Overview of the Sample Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Child Protection (N = 2,399)</th>
<th>Community Outreach (N = 1,904)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Child age (in years)</td>
<td>9.56</td>
<td>5.93</td>
</tr>
<tr>
<td>Number of risk factors assessed as present</td>
<td>5.67</td>
<td>3.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child safety assessment conclusion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate danger</td>
<td>598</td>
<td>24.9</td>
<td>125</td>
<td>6.6</td>
</tr>
<tr>
<td>Safe</td>
<td>1205</td>
<td>50.2</td>
<td>1662</td>
<td>87.3</td>
</tr>
<tr>
<td>More information needed</td>
<td>365</td>
<td>15.2</td>
<td>117</td>
<td>6.1</td>
</tr>
<tr>
<td>Safety assessment was missing</td>
<td>231</td>
<td>9.6</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk for future child maltreatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>771</td>
<td>32.1</td>
<td>784</td>
<td>41.2</td>
</tr>
<tr>
<td>Medium</td>
<td>420</td>
<td>17.5</td>
<td>410</td>
<td>21.5</td>
</tr>
<tr>
<td>High</td>
<td>1208</td>
<td>50.4</td>
<td>710</td>
<td>37.3</td>
</tr>
</tbody>
</table>

Note. N = number of children and their families in the sample for which the risk for child maltreatment was assessed, n = number of children in the sample in this category, % = percentage of the children in the particular category.

All risk factors in this network were positively correlated. The strength of the correlations between the risk factors can be found in Appendix 7.E. As can be seen in Figure 7.1, there were multiple strong correlations between risk factors. The thickness of the edges represents the strength of the correlation between the two risk factors controlling for all other risk factors in the network. The static risk factors clustered together, as Caregiver has a history of abusing a child (#1), Caregiver was maltreated as a child (#7), Caregiver has been violent before (#8), and A history of domestic violence (#11) all correlate strongly (r > .39), except risk factors #1 and #11 these were associated with a correlation just below .3 (r = .28), and risk factors #7 and #11 that were weakly associated (r = .12). Additionally, the risk factors concerning domestic violence clustered together. The factors Caregivers have a problematic relationship (#9), There is family conflict (#10), and A history of domestic violence (#11) were strongly associated with correlations above r = .31. Besides these two clusters, two associations between risk factors were strong: Caregiver is physically absent (#5) was correlated with Caregiver is emotionally absent (#6; r = .64), and Parental stress about financial problems (#12) was correlated with Social isolation of the family (#13; r = .5).

The centrality coefficient (i.e., the sum of all relations the risk factor has with other risk factors) of each risk factor in the cross-sample network can be found in Table 7.3.
Chapter 7

The risk factors a history of domestic violence (#11), Caregiver is emotionally absent (#6) and Caregiver was maltreated as a child (#7) were the most central, and thus, most strongly related to the other risk factors. The risk factor Caregiver has a mental disability (#4) was the least central factor, which can easily be seen in Figure 7.1, as it has weak connections to other risk factors.

Table 7.3 Standardized Node Strength Centrality Coefficients (z-scores) of all Three Networks

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Network</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cross-sample</td>
</tr>
<tr>
<td>1. Caregiver has a history of abusing a child</td>
<td>.31</td>
</tr>
<tr>
<td>2. Caregiver has a psychiatric disorder</td>
<td>.23</td>
</tr>
<tr>
<td>3. Caregiver has an addiction</td>
<td>-.96</td>
</tr>
<tr>
<td>4. Caregiver has a mental disability</td>
<td>-2.10</td>
</tr>
<tr>
<td>5. Caregiver is physically absent</td>
<td>-1.53</td>
</tr>
<tr>
<td>6. Caregiver is emotionally absent</td>
<td>1.11</td>
</tr>
<tr>
<td>7. Caregiver was maltreated as a child</td>
<td>.57</td>
</tr>
<tr>
<td>8. Caregiver has been violent before</td>
<td>.44</td>
</tr>
<tr>
<td>9. Caregivers have a problematic relationship</td>
<td>.27</td>
</tr>
<tr>
<td>10. There is family conflict</td>
<td>.38</td>
</tr>
<tr>
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<td>13. Social isolation of the family</td>
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Note. The node strength centrality coefficients in the community outreach network were insufficiently stable, as the CS-coefficient did not meet the threshold for stability with a value of .13.
Interrelatedness of Risk Factors

Figure 7.1. Cross-sample network (N = 4,303) showing the interrelations between the parental risk factors for child maltreatment. All the risk factors in the networks were positively correlated. The risk factor A history of domestic violence (#11) is the most central, whereas the risk factor Caregiver has a mental disability (#4) is the least central.

7.3.3 Individual Sample Network Comparison

Figure 7.2 shows the two individual sample networks. For comparison purposes, the networks were constructed with the same layout as the cross-sample network depicted in Figure 7.1 and a visualization of the variability of the edge weights in both networks can be found in Figure 7.3. The measures in the child protection network (the network at the left side of Figure 7.2) were sufficiently stable, as the CS-coefficients of the node strength centrality and edge weight were .75 and .36, respectively, which are both above the threshold of .25. However, the CS-coefficient of the edge weights was below the preferred value of .5 and should, therefore, be interpreted cautiously. The node strength centrality coefficients in the community outreach network (the network at the right side of Figure 7.2) were insufficiently stable, as the CS-coefficient did not meet the threshold for stability with a value of .13. Only a small portion of the risk assessments can be dropped without lowering the correlation between the bootstrap centrality coefficients and the original centrality coefficients. As this implies that no valid inferences can be drawn on centrality, we do not discuss the centrality of the risk factors in the community outreach network. For completeness, a comparison of the centrality coefficients of both networks is reported in Appendix 7.F. The stability of the edge weights in the community outreach network was sufficient, as the CS coefficient was above the threshold of .5 with a value of .67. All bootstrap results can be found...
in the Appendices (Appendix 7.G - 7.N show the node strength centrality accuracy, confidence intervals of the edge weights, results of the edge weight difference tests, and results of the centrality difference tests of the CP and COS network).

As expected, all risk factors in both networks were positively correlated. The strength of all correlations in both networks can be found in Appendix 7.E, which also shows the variability of the edge weights between both networks. The networks showed some clear similarities and the correlation between the edge weights of both networks was strong ($p = .61, p < .001$). However, the mean of the edge weights was higher for the CP sample than for the COS sample ($t(152) = 2.26, p < 0.05$), and thus the correlations are overall stronger in the CP network. In both networks, the risk factor *There is family conflict* (#10) correlated strongly with risk factors Caregivers have a problematic relationship (#9; $r \geq .56$) and *A history of domestic violence* (#11; $r \geq .44$). Another example of similarity between both networks is the correlation between Caregiver is physically absent (#5) and Caregiver is emotionally absent (#6), which was strong in both samples ($r \geq .48$). In contrast, risk factor Caregiver has been violent before (#8) had a strong correlation with risk factor Caregiver was maltreated as a child (#7) ($r \geq .38$) in both networks, but in the CP network, the former (Caregiver has been violent before; #8) was also strongly associated with risk factors Caregiver has a history of abusing a child (#1; $r = .40$) and *A history of domestic violence* (#11; $r = .56$). In contrast, the COS network had a stronger correlation between risk factor Caregiver was maltreated as a child (#7) and Caregiver has a history of abusing a child (#1; $r = .56$). Another difference between both networks is that the CP network revealed a stronger correlation between risk factor Parental stress about financial problems (#12) and risk factors Caregiver was maltreated as a child (#7; $r = .34$), Caregivers have a problematic relationship (#9; $r = .22$), and Social isolation of the family (#13; $r = .47$) than the COS network.

Next, centrality coefficients of the CP network were studied. All centrality coefficients can be found in Table 7.3. The risk factors Caregiver is emotionally absent (#6) and Caregiver was maltreated as a child (#7) play the most central role in the child protection network and are therefore most strongly related to all other risk factors. The risk factor Caregiver has a mental disability (#4) plays the least central role.
**Interrelatedness of Risk Factors**

**Figure 7.2.** Individual sample networks showing the interrelations between the parental risk factors for child maltreatment. All risk factors in both networks were positively correlated.

**Figure 7.3.** Visualization of the variability of the edge weights in both networks. An edge represents the standard deviation of the edge weight across both networks. The correlations between risk factors #8 - #11, #7 - #12, and #12 - #13 vary most between the two networks.
7.4 DISCUSSION

Theories on child maltreatment generally focus on interactions between multiple risk and protective factors, and state that the way in which these factors interact is determinative in whether child maltreatment occurs (e.g., Belsky, 1993). Empirical studies support this perspective of multiple interacting risk factors, as several studies have identified cumulative risk to be most predictive of child maltreatment (Brown, Cohen, Johnson, & Salzinger, 1998; Lamela & Figueiredo, 2018; Li, Chu, Ng, & Leong, 2014; MacKenzie, Kotch, Lee, Augsberger & Hutto, 2011; Patwardhan, Hurley, Thompson, Mason, & Ringle, 2017; Thornberry et al., 2014; Yang & Maguire-Jack, 2018) and other more recent studies have shown evidence for a nonlinear quadratic model of cumulative risk (Lamela, & Figueiredo, 2018; Patwardhan, Hurley, Thompson, Mason, & Ringle, 2017). However, research on the interrelatedness of risk factors is scarce. To our knowledge, the present study was first to explore the interrelatedness of risk factors for child maltreatment, and thus to partially test Belsky’s multi-dimensional perspective on child maltreatment. As theory and empirical research suggest that in particular parental risk factors play an important role in the occurrence of child maltreatment (e.g., Belsky, 1993; Stith et al., 2009; Mulder et al., 2018), we examined the interrelatedness of parental risk factors for child maltreatment. The most important results are discussed below.

First, a cross-sample network was constructed to examine interrelations between risk factors for child maltreatment in both samples. This strongly interrelated network revealed positive relations between all factors that were part of the network. Two separate clusters of factors could be identified in this network: (1) a cluster of particularly static risk factors (except the risk factor Caregiver has a mental disability, #4) and (2) a cluster of risk factors concerning domestic violence (including problematic partner and family relations). The risk factors A history of domestic violence (#11), Caregiver is emotionally absent (#6), and Caregiver was maltreated as a child (#7) were the most central risk factor. The risk factor Caregiver has a mental disability (#4) was the least central risk factor, as this factor has the least connections to other risk factors.

Next, we looked in more detail at the differences in risk factor interrelatedness between the high-risk sample and the lower risk sample. In general, risk factors are very similarly related to each other in both samples. However, the risk factors in the high-risk sample are generally stronger related to each other than the risk factors in the lower risk sample. Further, the global strength of the relations in the high risk sample is stronger than in the lower risk sample. Both observations may offer an explanation for the different values of the CS-coefficients across the two samples. In the high risk sample, the centrality coefficients are the most stable measures (CS-coefficient is the highest), whereas the edge weights are the most stable in the lower risk sample. However, further research using simulation methods may shed more light on the origins of this difference between low and high risk samples.

When comparing the specific relations between risk factors in both networks, two associations between risk factors stand out most: (1) Caregiver has been violent before...
(2) Caregiver was maltreated as a child (11) and Parental stress about financial problems (12). Both relations were much stronger in the high-risk sample. The centrality measures of both networks could not be compared, as the centrality measures of the lower risk (community outreach) sample were unstable. Instability in networks might be due to different reasons, such as heterogeneity within the sample, a rather small sample size, a high number of estimated parameters, a high density of the true network structure, model misfit, or violations of distributional assumptions (Borsboom et al., 2017; Epskamp, & Fried, 2018; Fried, 2018). As community outreach services serve a heterogeneous population, it would be interesting to study subpopulations in this sample. In the high-risk sample, the risk factors Caregiver is emotionally absent (6) and Caregiver was maltreated as a child (7) were the most central.

The parental risk factors for child maltreatment showed to be highly interrelated, which is consistent with the idea that risk factors interact with each other as described in Belsky’s multi-dimensional perspective on child maltreatment. Belsky (1993) conceptualized child maltreatment as a consequence of the interactions in and between the immediate interactional context and the broader context. In the current study, we only studied parental risk factors. It would be interesting to study how non-parental factors are interrelated to each other and parental risk factors, and how factors in the immediate context are related to the factors in the broader context. It may also be possible that so-called bridge factors (Borsboom & Cramer, 2013) exist, these factors would connect risk factors in different contexts to each other.

The unique contribution of the current results to the understanding of the child maltreatment etiology is that the risk factors in the high-risk sample showed to be generally stronger related to each other than the risk factors in the lower risk sample. These results help us understand the nonlinear quadratic model of cumulative risk better. When the number of present risk factors increase, these extra risk factors also strengthen other risk factors, which can result in an exponential increase in risk of child maltreatment. Future research should look into the relations between risk factors in more detail and how these can explain the nonlinear quadratic model of cumulative risk. As a starting point, regression analysis could be performed on case decisions using the interrelated factors.

Another interesting result is that maltreatment during a caregiver’s childhood plays a central role (risk factor 7) in the risk factor network for both the high and lower risk families. Moreover, this risk factor has strong relations to the other static risk factors Caregiver has a history of abusing a child (1), Caregiver has been violent before (8), and A history of domestic violence (11). These results support our knowledge on the intergenerational transmission of violence and child maltreatment (Assink et al., 2018; Pears & Capaldi, 2001; Stith, 2000), in which caregivers who have experienced maltreatment as child are more likely to abuse their children, to be violent and to be in a household with domestic violence. Parental history of child abuse victimization seems to be an important factor in explaining child maltreatment. Therefore, it is necessary to
always measure this risk factor when assessing the risk of future child maltreatment. Additionally, this possible unresolved trauma needs attention in the treatment of these caregivers, which may help reduce the risk of future child maltreatment.

### 7.4.1 Limitations

As this study is the first exploration of the interrelatedness of child maltreatment risk factors, it is important to acknowledge some limitations and highlight some difficulties we encountered. First, some of the examined risk factors overlap conceptually. The most central risk factors *A history of domestic violence* (#11) and *Caregiver is emotionally absent* showed strong connections with risk factors that overlap at least to some extent. For example, *A history of domestic violence* (#11) overlaps with *Caregiver has been violent before* (#8), *There is family conflict* (#10), and *Caregivers have a problematic relationship* (#9). For example, when a caregiver has been violent towards the other caregiver, the risk factors *A history of domestic violence* (#11) and *Caregiver has been violent before* (#8) both need to be assessed as present according to the ARIJ risk assessment instrument’s guidelines. Due to this overlap, the centrality of these factors may have been overestimated, as the relations of this factor with other factors may have been overestimated. However, it is important to keep in mind that the relation between two factors is determined after controlling for all other factors in the network. So it is still informative that two factors relate to each other, given that all other (possibly) related factors were controlled for. Nonetheless, future research should carefully assess how central these risk factors are when overlap between risk factors is minimalized. To do this, risk factors should be reformulated, and their predictive validity should be reassessed, as reformulating the risk factors may influence their validity.

Second, the instrument that was used in performing the risk assessments (ARIJ) measured only a limited number of parental risk factors. The items of the ARIJ only measure risk factors that showed to be predictive in a Dutch child protection services population (Van der Put et al., 2016). However, much more (parental) risk factors have been identified in multiple meta-analyses (see, for instance, Assink et al., 2019; Mulder et al., 2018; Stith et al., 2009). Ideally, all these parental and non-parental risk factors should be assessed in a large sample, so their interrelatedness can be explored. Because the networks that were constructed in the present study did not comprise all factors relevant in the processes underlying child maltreatment, the obtained connections between the risk factors can be the result of an unmodeled factor or variable that is not part of the network (Epskamp et al. 2018). It is, of course, questionable whether it is at all possible to model all relevant factors in a single network, but in the current study, we should acknowledge that several important risk factors for child maltreatment were not included.

Third, another limitation is that risks for child maltreatment are often assessed with only a single item, even though risks often refer to very complex problems. An example
Interrelatedness of Risk Factors

is the risk factor Caregiver has an addiction (#3). This factor could by itself be described in a network of all the different symptoms of addiction. Additionally, the degree to which a risk factor is present may not be straightforward. However, the instrument that was used to assess the child maltreatment risk factors asks professionals to assess a risk factor as either present or absent. It is up to the child welfare professional to determine whether or not a risk factor exceeds a certain threshold so that it is assessed as being present. This rather strict procedure for measuring the presence of risk factors is quite efficient for risk assessment and allow for an actuarial risk outcome. However, when examining risk factors in network analysis, it may be more informative to measure the presence of each factor on a scale, which may better reflect reality. Future research should therefore consider measuring risk factors more comprehensively.

Fourth, the samples consisted of a specific group of families. For example, very little caregivers had a mental disability in both samples. At least one of the caregivers had a mental disability for 3% of the families registered at the child protection agency and for 9% of the families registered at the community outreach agency. In the Netherlands, most families in which one of the family members has a mental disability go to a specific agency that is specialized in care for children and caregivers with mental disabilities. For this reason, the agencies that participated in this study did not serve many families with this type of problem. Therefore, the samples of risk assessments that were analyzed in this study are not representative of all risk assessments that are performed in families with child safety problems. The two samples that we studied also differed in other aspects, such as the child’s age, the risk for child maltreatment, and the degree to which immediate child safety problems were present. The connections between risk factors showed some differences as well, even though they were very similar overall. These results show that it is important to examine subpopulations.

Lastly, it should be noted that professionals often decided that insufficient information was available to assess the presence of some risk factors. For example, the risk factor Caregiver was maltreated as a child (#7) was assessed as “unknown” for 54% of the child protection families and 45% of the community outreach families. Professionals may have chosen this response category that often, because they did not have this information at the time of the assessment, as only the first risk assessment conducted for a child was used in this study. For the follow-up risk assessments, the prevalence of the response category “unknown” is usually lower. However, these follow-up assessments are not always performed after the same amount of time, since the agencies differ in their assessment procedures. Therefore, to be as consistent as possible, we used assessments performed at the time of referral, even though this meant that some information would be missing. Ideally, future research should contain less missing information.
Chapter 7

7.4.2 The Value of Network Analysis for Clinical Practice

Most central risk factors are clinically most relevant. Reducing the impact of central risk factors also reduces the impact of other risk factors, and therefore, targeting central risk factors seems very promising to reduce overall risk. For child protection services, the risk factor Caregiver was maltreated as a child (#7) was the most central risk factor that did not have conceptual overlap with other factors. It can therefore be hypothesized that interventions should address this risk factor first, when it is assessed to be present, for example with trauma treatment. Another central risk factor in the child protection sample was Caregiver is emotionally absent (#6) and may therefore also be an important risk factor to address in interventions.

Further research should study these hypotheses on the centrality of risk factors in different ways, so we can see the possible clinical value of the central risk factors. Targeting the most central risk factors should help to reduce risk, and therefore, improve the effectiveness of interventions and prevention of child maltreatment. This may be especially effective in high-risk samples, as our results showed that relations between risk factors are overall stronger in a high-risk population. Fried et al. (2017) describe future directions for research on the hypotheses generated by network analysis and describe in more detail how this type of research could help improve clinical practice. It should be noted that some of the most central risk factors could be static in nature, which makes intervening on these factors particularly complex.

Besides information on the clinical importance of specific risk factors, applying network analysis to risk factors for child maltreatment has more potential for clinically useful information on intervention and prevention. We would like to raise the following research possibilities. First, it would be interesting to compare networks of families in which child maltreatment reoccurred, to families were child maltreatment did not reoccur (Are networks for families with child maltreatment reoccurrence more densely connected? Is the centrality of risk factors different?). Second, studying the interrelatedness of risk factors and protective factors would be interesting (Are protective factors negatively related to risk factors? Are protective factors less densely connected in families with child maltreatment reoccurrence?). Third, the interrelatedness of risk factors might vary in different (sub)populations (Are risk factor networks different for primary, secondary, or tertiary prevention of child maltreatment? Are risk factor networks different for families with different ethnic backgrounds?). Fourth, risk factor networks might differ for types of child maltreatment (child neglect, child sexual abuse, or physical abuse; Are different risk factors central in a risk factor network for sexual abuse?). At last, it would be interesting to go into more detail on how static and dynamic risk factors are interrelated.

Network analysis provides even more possibilities when using more complex and extensive research methods. For instance, in longitudinal (experimental) research it becomes possible to develop so-called directed networks, in which causal relations between risk factors can be studied (Epskamp et al., 2018; Fried et al., 2017). In this
Interrelatedness of Risk Factors

way, network analyses can meet the critique of Pearl (2009), who stressed that we need to move from traditional statistical analysis to causal analysis. Longitudinal research also provides the possibility to develop personalized networks (Epskamp et al., 2018). For this method, the presence and severity of risk factors should be measured over time. Currently available instruments for assessing the presence of risk factors are probably not appropriate for this type of research, because these are not developed to measure (small) changes in risk factors. It should therefore be assessed first how these longitudinal research methods can be applied to risk factors, but these methods show great promise for providing clinically useful information and improving our knowledge on child maltreatment.
APPENDIX 7.A - Accuracy of the node strength centrality in the cross-sample network according to the bootstrap results

CS-coefficient = .59
APPENDIX 7.B - Bootstrap confidence intervals of the edge weights in the cross sample network

The x-axis specifies the weight of the edge and the y-axis specifies the edge.
1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
Chapter 7

APPENDIX 7.C - Results of the edge weight difference test for the cross sample network

A black square indicates a significant difference between two compared edge weights (specified on the x- and y-axis) and a grey square indicates that the difference between two edge weights is not significant.
1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
APPENDIX 7.D - Results of the node strength centrality difference test for the cross sample network

A black square indicates a significant difference between two compared strength coefficients (the risk factors are specified on the x- and y-axis) and a grey square indicates that the difference between two strength coefficients is not significant. The strength coefficient of each risk factor is plotted on the diagonal.

1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
### APPENDIX 7.E - Strength of the correlations between the risk factors in the three networks

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Interrelatedness of Risk Factors

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<th>Community outreach</th>
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Note. If an edge between two nodes is not included in this table the edge has a weight of zero in all networks. 1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
APPENDIX 7.F - Visualization of the differences between the standardized node strength centrality coefficients (z-scores) of the risk factors in the community outreach network and the child protection network

The x-axis specifies the z-score and y-axis specifies the risk factor. The red line indicates the community outreach services network and the blue line the child protection services network. Overall, the centrality coefficients differed moderately, as the correlation across centrality indices of both networks is relatively low and non-significant (\( \rho = .42, p = .15 \)). The centrality of risk factor Caregiver has a psychiatric disorder (#2) and risk factor Parental stress about financial problems (#3) differ most between both networks. Caregiver has a psychiatric disorder (#2) played a far more central role in the community outreach network, whereas, Parental stress about financial problems (#3) had a far more central role in the child protection network.

1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
APPENDIX 7.G - Accuracy of the node strength centrality in the child protection network according to the bootstrap results

CS-coefficient = .36
APPENDIX 7.H - Bootstrap confidence intervals of the edge weights in the child protection network

The x-axis specifies the weight of the edge and the y-axis specifies the edge.
1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
APPENDIX 7.I - Results of the edge weight difference test for the child protection network

A black square indicates a significant difference between two compared edge weights (specified on the x- and y-axis) and a grey square indicates that the difference between two edge weights is not significant.

1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
APPENDIX 7.J - Results of the node strength centrality difference test for the child protection network

A black square indicates a significant difference between two compared strength coefficients (the risk factors are specified on the x- and y-axis) and a grey square indicates that the difference between two strength coefficients is not significant. The strength coefficient of each risk factor is plotted on the diagonal.

1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
APPENDIX 7.K - Accuracy of the node strength centrality in the community outreach network according to the bootstrap results

CS-coefficient = .13
APPENDIX 7.L - Bootstrap confidence intervals of the edge weights in the community outreach network

The x-axis specifies the weight of the edge and the y-axis specifies the edge.
1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
APPENDIX 7.M - Results of the edge weight difference test for the community outreach network

A black square indicates a significant difference between two compared edge weights (specified on the x- and y-axis) and a grey square indicates that the difference between two edge weights is not significant.

1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
APPENDIX 7.N - Results of the node strength centrality difference test for the community outreach network

A black square indicates a significant difference between two compared strength coefficients (the risk factors are specified on the x- and y-axis) and a grey square indicates that the difference between two strength coefficients is not significant. The strength coefficient of each risk factor is plotted on the diagonal.

1 = Caregiver has a history of abusing a child; 2 = Caregiver has a psychiatric disorder; 3 = Caregiver has an addiction; 4 = Caregiver has a mental disability; 5 = Caregiver is physically absent; 6 = Caregiver is emotionally absent; 7 = Caregiver was maltreated as a child; 8 = Caregiver has been violent before; 9 = Caregivers have a problematic relationship; 10 = There is family conflict; 11 = A history of domestic violence; 12 = Parental stress about financial problems; 13 = Social isolation of the family.
Acknowledgments
We would like to thank the community outreach services and child protection services for making this study possible.

Authors' contributions
Annemiek Vial designed the study, collected the data, conducted all statistical analyses, and drafted the manuscript. Claudia van der Put and Mark Assink participated in the design of the study and critically reviewed the manuscript. Jolanda Kossakowski advised on the statistical analyses and critically reviewed the manuscript. Geert Jan Stams critically reviewed the manuscript.