Identification of child mental health problems in primary care: an interdisciplinary approach

Koning, N.R.

IDENTIFICATION OF CHILD MENTAL HEALTH PROBLEMS IN PRIMARY CARE

AN INTERDISCIPLINARY APPROACH

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Chapter 1

General introduction

General introduction

Mental health problems (MHPs) have a substantial impact on the global burden of disease. In 2010, MHPs accounted for 7.4% of all disability-adjusted life years(1). On average one in five adults experienced an MHP within the previous 12 months worldwide and 29.2% of adults experience one or more mental health disorders across their lifetime(2). Roughly half of all lifetime MHPs occur by the age of 14 years and three-quarters of MHPs are present at the age of 24 years(3, 4). Adult mental illness may be prevented through early intervention in childhood and adolescence(4). Early identification of MHPs in children is thus important in order to provide adequate treatment strategies and enable prevention of adverse outcomes in later life(5). Or, as Kieling et al. stated: 'Action is imperative to reduce the burden of MHPs in future generations and to allow for the full development of vulnerable children and adolescents worldwide'(6).

General practitioners (GPs) are the gatekeepers of the Dutch healthcare system and are, together with preventive youth healthcare professionals, in a well-placed position to identify child MHPs(7). Approximately 80% of Dutch children and adolescents with MHPs visited their GP within the preceding year(8). However, these children were often visiting for physical rather than psychological reasons and were often not recognised by their GP as having MHPs(8). In this introduction, the case of Tess is presented to illustrate the difficulties GPs can face when identifying child MHPs.

The story of Tess, 14 years old

Julia is a GP in a group practice of three. This morning she saw Tess (14 years old), together with her mother. Tess and her mother have been patients in the practice for six years, since they moved from a neighbouring village. The reason for the visit is that her mother is worried because Tess has not been herself for a long time, is constantly tired and is not eating well.

After some hesitation, Tess tells Julia that she is somehow not happy anymore. A lot appears to have happened in the past few years. Tess's parents divorced 3 years ago, her father had lost his job and had some mental issues. Tess still finds this difficult and has had some difficulties with making friends at her new school. Lately, she hasn't been able to concentrate that well and her grades are declining. Julia decides to refer Tess to secondary mental healthcare because of Tess's depressive feelings.

After the consultation, Julia asks herself if she could have seen this coming? The medical history of Tess shows visits for a viral upper tract infection, a broken wrist due to a roller skating accident and several visits with different colleagues for constipation in the past couple of years, which was treated with dietary advice and temporary laxatives.

Child mental health problems

To help Julia, this thesis aims to improve the early identification of child MHPs in general practice. First, a general background with regard to child MHPs and the Dutch healthcare system for children will be provided. The current state of research regarding the identification of child MHPs in primary care will be described, before concluding with the objective and outline of this thesis, and the used patient cohort.

Definition

Psychosocial problems can be described as any behavioural/externalizing problems (e.g. hyperactivity or aggressive behaviour), emotional/internalizing problems (e.g. depressive feelings or anxiety) or social problems (difficulties to make contact with or keep contact with others)(9-11). In general, different terminology and definitions are used to refer to a similar concept. The World Health Organization (WHO) describes mental and behavioural disorders as a set of disorders which are generally characterized by some combination of abnormal thoughts, emotions, behaviour and relationships with others; however, symptoms may vary substantially(12).

This thesis aims to improve the early identification of child MHPs in primary care, including general practice and preventive youth healthcare (PYH). In light of early identification, we include any problems in psychosocial functioning, ranging from problems with mild to severe impairment.

Prevalence and risk factors

MHPs are common in children and adolescents. Depending on age, setting and definition, reported prevalence rates vary from 10 to 20 and sometimes 25%(6, 10, 13, 14). A meta-analytic review found that worldwide almost one in seven children under 18 years meet diagnostic criteria for a mental health disorder(15). The occurrence of MHPs differs per problem type, but also across age and gender (figure 1)(13). In primary school for instance, externalizing problems become more apparent in boys. Internalizing problems such as depressive feelings and anxiety occur more frequently among girls in adolescence(13, 14, 16).

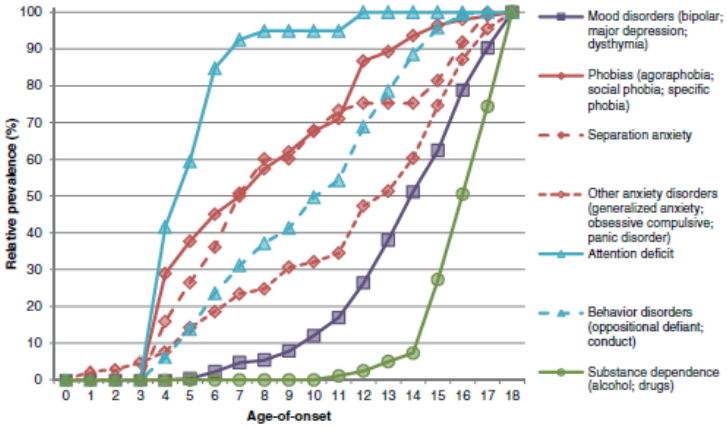

Figure 1. Standardized cumulative prevalence curves for Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IC) disorders, Ormel et al(13). The figure shows the relative percentage of children with a specific MHP according to age. For example, from the children aged 18 years with substance dependency, 50% already had this dependency at age 16 years.

Multiple risk factors play a role in the origin of MHPs(10). Individual attributes (e.g. genetic background, a child's temperament), social circumstances (e.g. family composition) and the environment in which people live (e.g. neighbourhood, socioeconomic status, culture) all have an impact on one's mental health and well-being(10, 17).

The different risk factors associated with a child's mental health can occur at any stage in life. The life-cycle approach provides a model that maps relevant risk factors of child MHPs and shows how risk exposures in the formative stages of life, including substance use in pregnancy, insecure attachment in infancy or family violence in childhood, can affect mental well-being or predispose towards MHPs many years later (figure 2)(6, 17).

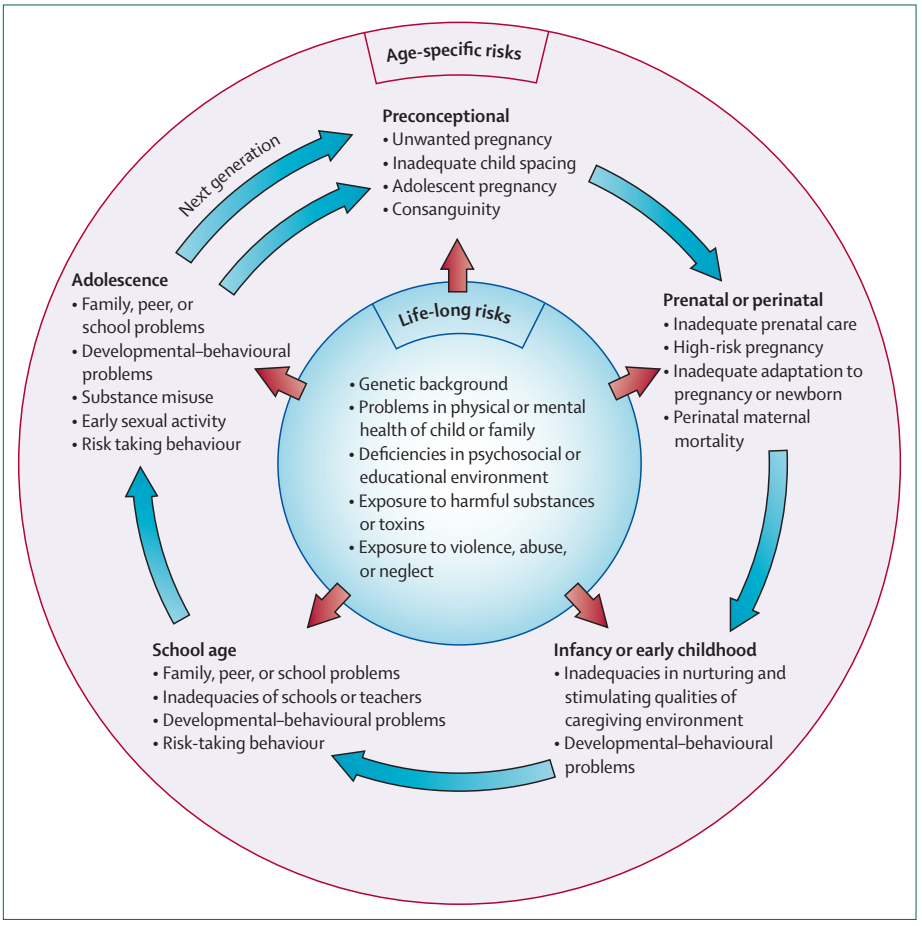

Figure 2. The lifecycle approach to risk factors for MHPs, Kieling et al(6)

Impact of child mental health problems

Child MHPs often have a negative effect on a child's everyday functioning and wellbeing(10). In children and young adults aged 10 to 29 years old, MHPs accounted for the highest proportion of total disability-adjusted life years(1). It is known that child MHPs influence a child's healthy development and frequently have long lasting effects, resulting in, for instance, a higher risk of impediment due to a DSM-diagnosis later in life and a poorer performance at school and/or on the job market(3, 4, 10, 18, 19). Disturbances to an individual's mental well-being can also lead to broader welfare losses at the family/household and societal level(12, 20). The burden on

families ranges from economic difficulties to emotional reactions to MHPs, the stress of coping with disturbed behaviour, the disruption of household routine and the restriction of social activities(12, 20, 21). The economic costs of MHPs are large. A study performed in the United States estimated the lost family income due to childhood MHPs to be approximately $10,000 yearly(20).

Primary healthcare for children in the Netherlands

General practitioners (GPs) and preventive youth healthcare professionals (PYHPs) are the key professional groups involved in the Dutch primary healthcare for children. Almost every Dutch citizen is enlisted with a general practice and general practice is the formal point of entry into secondary healthcare, including mental healthcare(22). In addition, PYHPs provide regular check-ups to children and adolescents with the aim to prevent disease, promote health and allow early detection of health risks, disease, and developmental problems in the physical, psychological, social and cognitive domains(7). Due to structured call schedules linked to the municipal basic administration, approximately 80-90% of all children aged 0 to 19 years are regularly seen in preventive youth healthcare (PYH)(23). Around 15 preventive check-ups are provided during the first four years of a child's life. During primary and secondary school, PYH offers four contact moments(7). PYHPs use several validated screening tools to aid MHP recognition. Examples of these screening tools are the Strengths and Difficulties Questionnaire (SDQ) and the short indicative questionnaire for psychosocial problems among adolescents (KIVPA), two questionnaires which are filled out by parents or children themselves depending on age(10).

All in all, GPs and PYHPs each have their own specific knowledge and tasks within the Dutch healthcare system. They each have different information on the (mental) health and illnesses of children and their families, and gather this information at different times and for different reasons. This means that their roles can potentially be complementary(24). Sharing relevant information between general practice and PYH could facilitate early identification of child MHPs and such collaboration is promoted by several professional associations including the Dutch College of GPs (Nederlands Huisartsen Genootschap), the National Family Practice Association (Landelijke Huisartsen Vereniging) and Dutch Preventive Youth Healthcare Physicians (Artsen Jeugdgezondheidszorg Nederland)(25). However, collaboration and interdisciplinary communication between both domains still is not part of usual practice on either side. It is unknown how current collaboration between general practice and PYH is and how often they share information.

Identification of child mental health problems

With the current knowledge about risk factors for adverse child mental health outcomes and with both the GPs and the PYHPs regularly seeing a child during childhood and adolescence, one would expect that MHPs are adequately identified. However, a substantial number of children with MHPs will not be recognised as having MHPs by their GPs and PYHPs(8, 26). Children usually do not present with a recent-onset and well-defined single disorder. More commonly, children have a long history of several problems, distress and impairments below or above diagnostic thresholds(27, 28). In addition to the under-recognition of child MHPs, a between-professional variance in the identification of child MHPs has been reported(29). This between-professional variance in identification could not be explained by child characteristics and could only partly be explained by investigated professional or practice characteristics(29). Factors such as gender, past treatment for MHPs, type of visit, professional acquaintance with the child and professional training were found to be associated with the identification of child MHPs by primary care professionals in two systematic reviews published over a decade ago(30, 31).

Risk prediction models based on routine healthcare data

A possible solution to improve the identification of child MHPs in an efficient way might be the use of a risk prediction model based on readily available routine healthcare data. Risk predictions facilitate the identification of groups of patients at high risk for e.g. developing a specific disease or responding to a provided treatment. Prediction models for anxiety and depression in (young) adults in primary care have been developed and have shown good discriminative properties, with only the study on depression in young adults solely based on readily available routine healthcare data(32-34). To our knowledge, models based on readily available routine healthcare data that help identifying MHPs in children and adolescents in primary care are not available yet. Such a model estimating the probability of a child developing an MHP in, for instance, the next year might help professionals to better recognise problems in daily practice, thereby improving timely recognition. In the case of Tess, a risk prediction model would have automatically calculated Tess's risk of developing an MHP based on the available data in Tess's electronic medical record. At the time Tess had visited Julia or one of her colleagues for constipation, there would have been a possibility for them to see Tess's risk of developing an MHP, and they might have taken the opportunity to approach the constipation differently, with more

attention to the context. As mentioned before, both GPs and PYHPs potentially have complementary information(24). This leads to the question of whether Julia could have better evaluated Tess's situation when relevant information was exchanged between PYH and GP.

Objective and outline of this thesis

In order to improve the early identification of child MHPs, the main objective of this thesis was to develop a prediction model for child MHPs based on readily available information from electronic health records from general practice. In addition, we investigated whether combining electronic health record information from general practice and PYH resulted in better performing prediction models. Next to model development, we explored several contextual aspects of improving MHP identification in primary care such as the current collaboration between GPs and PYHPs and factors associated with identified MHPs by primary care professionals.

Chapter 2 provides an overview of the literature regarding factors associated with child MHP identification in primary care. The factors we found serve as a starting point for the development of a prediction model for child MHPs. In Chapter 3, we explore the development of a prediction model for a first recorded child MHP based on routine healthcare data from Dutch general practice. Different prediction models were developed for different age categories. Chapter 4 presents the results of the study investigating the usefulness of routine healthcare data from Dutch PYH for research purposes and specifically for the development of a prediction model regarding concerns for MHPs according to PYH.
Using the findings of chapter 3 and 4, we combine the routine healthcare data from general practice and PYH in Chapter 5. We examined the overlap between concerns for MHPs in PYH and MHPs according to GPs. In addition we investigated whether combining information from PYH and general practice is useful in the identification of child MHPs.
As not all children with MHPs need to be referred to mental healthcare, we link the general practice and PYH data to data regarding mental healthcare use from Statistics Netherlands in Chapter 6. We examined how MHP diagnosis occurs in primary care and in mental healthcare, the timeline of diagnosis and whether combining data from both general practice and PYH aids identification of children who use mental healthcare.

In chapter 7, we investigate the current collaboration between GPs and PYHPs in a qualitative study. In addition, we make an inventory of physicians' needs regarding collaboration and where they see room for improvement. Finally, in chapter 8 the findings of this thesis are summarised and discussed. Clinical implications, using the case of Tess as an example, are outlined, and methodological reflections and recommendations for future research are presented.

Cohort study used in this thesis

This thesis presents the results of the Pippi-study, which stands for 'primary care integrated for the identification of psychosocial problems in children'. In the Pippi-study, patient data from both general practice and PYH was analysed. The population-based cohort consisted of all children aged 19 years or younger on 31st December 2016 who were registered with a general practice that was affiliated with the ELAN primary care network (Extramural LUMC Academic Network) of the Leiden University Medical Centre (LUMC), in the Netherlands. The participating general practices were located in the greater Leiden area. The routine healthcare data of all included children were anonymously extracted from the electronic medical records by an external trusted third party (TTP). The TTP de-identified the general practice routine healthcare data of every child. In order to link the patient data from general practice with the data from PYH, the TTP provided both the Dutch citizen service number and the pseudo patient number from the children included in the Pippi-study to the PYH organisation from the Leiden region (Gemeentelijke Gezondheidsdienst Hollands Midden). The PYH organisation extracted all available data for these children and also deidentified their routine healthcare data with the same pseudo patient numbers. In this way, we received anonymous patient data from PYH and general practice for approximately 50,000 children, which we could combine on the individual patient level with the pseudo patient number.

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Chapter 2

Factors associated with the identification of child mental health problems in primary care - a systematic review

Nynke R. Koning, Frederike L. Büchner, Marjolein E.A. Verbiest, Robert R.J.M. Vermeiren, Mattijs E. Numans, Mathilde R. Crone

Eur J Gen Pract. 2019 Jul;25(3):116-127

Abstract

Background: Although common and often with long-lasting effects, child mental health problems (MHPs) are still under-recognized and under-treated. A better understanding of the factors associated with the identification of MHPs in primary care may improve the recognition of MHPs.

Objectives: To review studies on factors associated with the identification of child MHPs in primary care.

Methods: Six leading databases were systematically searched until 1 October 2018. Two independent researchers selected articles and extracted data on study characteristics and factors associated with MHP identification. Inclusion criteria were the investigation of factors associated with MHP identification by primary care professionals (PCPs) in children aged 0-18 years.

Results: Of the 6,215 articles identified, 26 were included. Prevalence rates of PCP-identified MHPs varied between 7 and 30%. PCPs identified 26 and 60% of children with an increased risk of MHPs as indicated by MHP assessment tools, but associated factors were investigated in relatively few studies. MHPs were more often identified in children with a family composition other than married parents, with worse mental health symptoms, prior MHPs, among boys in elementary school, when contact with PCPs was related to parental psychosocial concerns or routine health check-ups, when PCPs were recently trained in MHPs or when PCPs felt less burdened treating MHPs.

Conclusion: MHP identification varied substantially between studies and PCPs and was related to several child, family and practice factors. Future studies should systematically investigate factors associated with MHP identification by PCPs and specifically in children with an increased risk of MHPs according to mental health assessment tools.

Introduction

Mental health problems (MHPs), defined as any emotional, behavioural or developmental problems, are common in children and adolescents(1, 2). The severity of MHPs varies widely, from children with mild problems without impairment, to children with severe impairment(3). MHPs often have a negative influence on a child's everyday functioning and well-being and may lead to various adverse outcomes later in life such as a poorer performance at school and/or on the job market and a higher risk of impediment due to a Diagnostic and Statistical Manual of Mental Disorder (DSM) diagnosis later in life(4-10). Early identification of MHPs in children is thus important in order to provide adequate treatment strategies and prevent adverse outcomes.

Primary care has a central role in the identification and treatment of children with MHPs(10). Most countries distinguish primary care professionals (PCPs) who provide preventive care (i.e. preventive youth healthcare focusing on the healthy development of a child) from those PCPs providing curative care (i.e. general practice or paediatric consultation focused on resolving health problems). The majority of children and adolescents in Western societies visit any PCP at least once a year(11-13). Seeing children regularly throughout childhood, PCPs are in a unique position to manage child MHPs(14). Governments in developed countries now have a greater awareness of PCPs as the 'gatekeepers' of child mental health services(14-17).

Although children regularly visit a PCP, several children will not be recognized as having MHPs(18-21). For example, in two cohort studies conducted among children visiting a PCP for a routine health assessment in the US and the Netherlands, PCPs did not recognize MHPs in 50% and 43% respectively of the children with elevated scores on mental health screening tools(22, 23). A potential explanation might be that relevant information is not (explicitly) shared by parents. MHPs in children consequently remain undertreated and a large proportion of children with MHPs do not receive adequate care (24, 25).

Over a decade ago, two reviews identified several sometimes contrasting factors associated with identified child MHPs. Both reviews prioritized further research in primary care settings that explored child, parental and service factors influencing primary care identification(25, 26). Since then, new studies regarding the identification of child MHPs in primary care have been conducted. The present study aimed to review systematically the current literature regarding factors associated with PCP identification of child MHPs. In addition, we investigated factors associated with PCP identification of children with an increased risk of MHPs as assessed by MHP screening tools.

Methods

Search strategy

We conducted a systematic search for original articles published before 1 October 2018. A search strategy including MeSH terms and broad concepts such as 'psychosocial problems' and narrow diagnoses such as 'anxiety disorder', was developed for PubMed and adapted for equivalent searches in Embase, CINAHL, Web of Science, Cochrane and PsycINFO (Supplement table 1). In addition, we performed a grey literature search in seven databases (WHO database, OpenGrey, GreyLit, GLIN (Grey Literature in the Netherlands), Academic Search Premier, Clinical Trials and Current Controlled Trials) in order to avoid missing relevant titles published outside the conventional databases.

Inclusion and exclusion criteria

The title and abstract and after that the full text of the articles were independently screened by two authors (NK and FB) using predefined inclusion and exclusion criteria. We included studies that: (1) focused on children aged 0-18 years who visited a PCP (directly or indirectly through parents or caretakers), (2) examined PCP-identified MHPs, and (3) explored factors associated with identified MHPs. We defined MHPs as any emotional, behavioural or developmental problem causing mild to severe impairment. Exclusion criteria were: (1) articles that contained non-original data, (2) reviews, dissertations, book chapters, case reports, editorials, oral presentations and poster presentations, and (3) articles published in a language other than English or Dutch.

Quality appraisal

Quality assessment of the included studies was performed by a critical appraisal based on standardized criteria using the Crowe Critical Appraisal Tool (CCAT). The CCAT has been tested for validity and reliability(27-30). Two researchers (NK and MV) appraised the articles independently. Discrepancies in scores were mostly attributable to different interpretations of a sub-item and were discussed in a group meeting with NK, MV and MC until consensus was reached. We did not have a pre-specified CCAT score under which we would exclude a study.

Data extraction

We extracted general descriptive characteristics from the included studies, as well as factors associated with MHP identification and their effect measures e.g., relative risks or odds ratios. In cases where no effect measure was present, a description of the association between the factor and the outcome was obtained from the text; if this was not reported the study was excluded from further analyses. Unless otherwise specified, only factor associations adjusted for other background variables are presented.

Results

Our initial search resulted in 6,215 original titles (Figure 1). Screening of titles, abstracts and full texts resulted in the inclusion of a final set of 26 studies. Reasons for excluding studies were related to a lack of focus on factors associated with PCP identification of MHPs or a study outcome other than PCP-identified MHPs. Quality appraisal scores for the 26 studies ranged from 24 to 33 points (maximum 40), with an average of 27.8 points (Supplement Table 2). Since we did not assign extremely low or high quality scores, no studies were excluded from further analysis based on the CCAT.

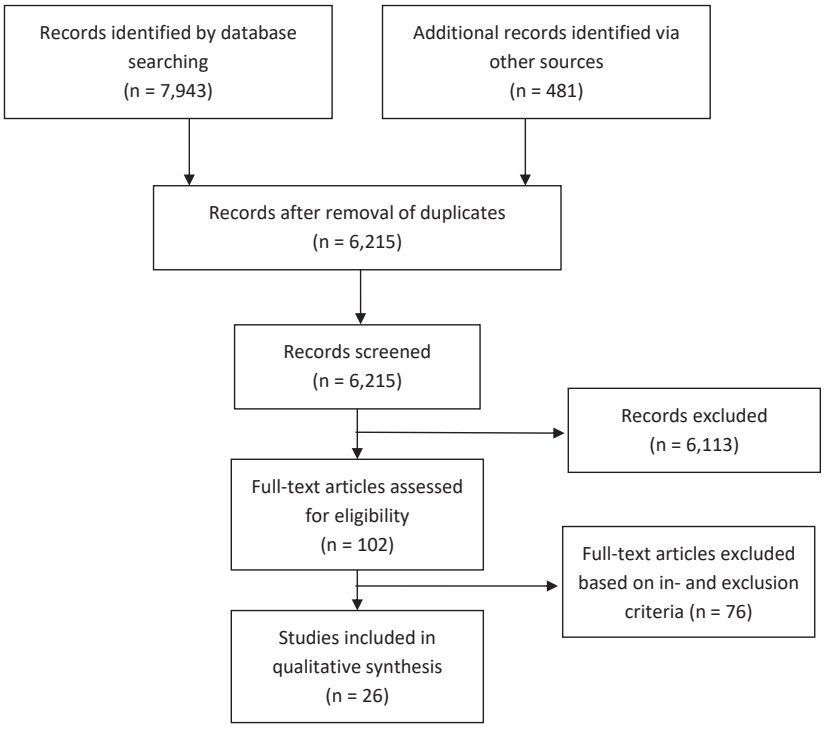

Figure 1. Flow diagram of the article inclusion process

General description

The 26 included studies were published between 1992 and 2018 (Supplement Table 3a). Twelve studies were performed in the US (22,31-41), 11 in the Netherlands(19, 20, 23, 42-49) and three in the UK(21, 50, 51). The study setting was general practice in seven studies(19, 21, 22, 36, 39, 50, 51), preventive youth healthcare in 15(20, 23, 31, 34, 37, 40-49) and combined preventive youth healthcare and general practice in

four studies(32, 33, 35, 38). All included studies involved cross-sectional analyses of children visiting a PCP. No study included all children in the age range 0-18 years, and most often studies focused on children aged 5-12 years. The studies used different inclusion and exclusion criteria, e.g. regarding age groups, exclusion of children with prior MHPs and acute care visits. Owing to differences between included studies, we present the direction of the associations between investigated factors and the identification of MHPs by PCPs.

MHPs in general (i.e. the broad concept of MHPs) were investigated in 24 studies, mostly by asking the PCP whether MHPs were currently present without defining MHPs specifically(20-23, 31-35, 37-40, 42-50). One study investigated only depression and anxiety(36), another only depression(51). Twenty-four studies included information on factors associated with MHPs identified by child, parent and professional questionnaires(19-23, 31-40, 42-50), sometimes (additionally) by chart review(36, 41, 51), by interviews with the child/parent(19, 23, 36, 44, 45), or by videotape analysis(39). Thirteen studies compared PCP identification with scores on mental health assessment tools; the results of these studies will be discussed separately(21-23, 32, 36, 38, 42, 44-46, 48-50).

PCPs identified an MHP in 7%-30% of children (Supplement Table 3b). Overall, we found that PCP identification rates were higher in studies that included only preventive care compared to studies that also included curative care.

Factors associated with PCP identification of MHPs: child characteristics

In children of junior school age (4-12 years), boys were more often identified with MHPs. However, this was not the case in younger or older children (Table 1)(19, 23, 33, 34, 36, 40, 42, 44, 46, 47, 49, 50). More MHPs were identified in children with parent-reported problems related to school, and MHPs were also more frequently identified in school-aged children experiencing life events (e.g. divorce) in the past year(23, 42, 49, 51).

Somatic complaints (e.g. headache) and a past (treatment for a) MHP were also related to increased MHP identification, whereas more visits to a PCP in the past year was only related to MHP identification in the case of adolescents(23, 31, 35, 36, 42, 44, 47, 49, 51). Neonatal/developmental problems, comorbid conditions, a child's age or ethnicity were not (consistently) related to MHP identification(19, 20, 23, 31, 33-37, 40, 42-45, 47, 49-51).

Characteristics of parent/family

Children with a family structure other than married parents were more often recognized with MHPs in five studies, whereas two studies found no association(23, 31, 33, 34, 37, 42, 47). MHPs were also more often identified in children living in a deprived area(43, 51).

Associations between parental education, socio-economic status, employment status, a family history of MHPs and identified MHPs were inconclusive(19, 23, 32, 33, 40, 42, 44, 46, 47, 49, 50). Other characteristics of the parent/family did not impact MHP identification.

Professional, practice and visit characteristics

PCP characteristics (e.g. age, gender and work experience) and practice characteristics (e.g. practice type and accessibility of mental healthcare) did not influence PCP identification of MHPs(31, 33-35, 41, 46). PCPs with less focus on psychosocial well-being identified fewer children with MHPs(33), while PCPs experiencing a lower burden in treating MHPs identified more children(35). The training of PCPs in MHP identification resulted in increased identification when such training had recently taken place(33, 35, 48).

Children visiting a PCP for a well-child visit(34, 40) or for psychosocial concerns(33, 35), and children well-known to a PCP (i.e. the PCP was the child's usual medical provider), were more often identified with an MHP(33, 40). However, MHPs were more often identified only when PCPs or observers reported discussion of MHPs during consultations. When parents reported discussion or when parents used a checklist to prompt parental disclosure of child MHPs, MHP identification did not increase(21, 22, 35, 39, 40, 50).

Three studies examined between-professional variance in the identification of child MHPs(37, 46, 47). Between-professional variance could not be explained by parent-reported problems(37) or any child-related characteristic(37, 46), and could only be partly explained by PCP or practice characteristics(37, 46, 47).

Identification of children with an increased risk of MHPs

Thirteen studies compared PCP identification with scores on mental health assessment tools. PCPs recognized MHPs in 26-60% of the children with elevated scores on assessment tools (for purposes of simplification further indicated as 'correct' identification)(21-23, 32, 36, 38, 42, 44-46, 48-50). Seven studies investigated factors associated with 'correct' identification, though most studies only investigated one factor. PCPs more often identified children with an increased risk of MHPs when children were older, were boys, well-known to their clinician, were visiting for a psychosocial problem, when PCPs used an assessment questionnaire such as the Child Behavior Checklist (CBCL) or when PCPs were trained in MHP recognition(34, 38, 46, 48). Practice type, ethnicity, family composition, PCP work experience and parent-reported concerns showed no consistent association with 'correct' identification(32, 34, 38, 45, 46, 48). One study found that physicians experiencing a higher MHP burden identified fewer children with problems as evaluated by mental health assessment tools, but identified more children in whom assessment tools did not indicate MHPs(35).

Table 1. Associations between the investigated factors and PCP identification of mental health problems

	Factor associated with mental health problem identification[a]	Number of studies
Child	Higher age	9
	Male gender	12
	Ethnicity	9
	Smoker	1
	Alcohol/drugs misuse	1
	Life events in past year	4
	Parent report of school problems	2
	Child-perceived difficulties	2
	More visits in past year	4
Medical history	Neonatal/developmental problems	1
	Comorbid conditions	7
	Somatic complaints	1
	Past MHP	1
	Past treatment for MHP	5
	Child health limitation – parent impression	1
Mental health problems based on tool	Child's MHP - clinical total score	11
	Child's MHP - clinical internalizing/ emotional symptom score	6
	Child's MHP – clinical externalizing/ behavioural symptom score	5
	SDQ burden to family	1
	Parent-perceived difficulties (on SDQ)	2
	Teacher reported MHP on TRF	1

	Positive association with identified mental health problems number of studies	**Negative association with identified mental health problems number of studies**	**No association with identified mental health problems number of studies**
	5	2, of which 1 study for only age 12-16	2
	7, of which 1 study only for age 4-11[a]		6, of which 1 only for age 12-17
	Economic immigrant: 1	Black: 1 Hispanic: 1	8, of which 1 specifically for ethnicity former colonies/ other (non-) industrialized countries
	1		
	Alcohol misuse in boys: 1		Drugs misuse: 1
	2		2
	2		
			2
	2		2
			1
		1	6
	1, for e.g. headache, back pain, tiredness		
	1		
	General treatment: 3 Psychological treatment: 2 Medical treatment:2; Other treatment: 1		Other treatment: 1
	1, only for age 12-17		1, only for age 4-11
	10		1
	4, of which 1 specifically anxiety/depression symptoms		2
	3		2
	1		
	1		1
	1, only for age 4-11		

Table 1. Continued

	Factor associated with mental health problem identification[a]	Number of studies
Parent/family	Older maternal age	1
	Family structure other than married parents	7
	Absence of siblings	3
	Higher parental education	7
	Parent unemployed/working <16 h/week	2
	Lower socioeconomic status	2
	Higher area deprivation[b]	2
	Highly urbanized area of home address	2
	Parental distress	2
	Better family functioning	1
	Day care	1
	Parenting practice	1
	Parent sense of competence being parent	2
	Parent positive affect or negative affect	1
	Parent poor MH status/MHP history	2
Perinatal characteristics	Duration of pregnancy, type of delivery, post-delivery hospitalization of child, birth weight, parity	1
Professional	Higher age	3
	Male gender	2
	More work experience	3
	Professional training MHP	
	Child well-known	2
	Lower psychosocial orientation	1
	More perceived efficiency treating MHP	1
	Lower physician burden	2
	Physician training in MHP	3
	Job satisfaction	1
	Job control	1
	Use of screening tool	3

	Positive association with identified mental health problems number of studies	Negative association with identified mental health problems number of studies	No association with identified mental health problems number of studies
	1		
	5		2
			3
		4, of which 1 study only for high level	4, of which 1 study only average level
			2
		1	1
	2		
	1		1
			2
		1	
		1	
		Over reactive style: 1	Lax style: 1
	1		1
			1
	1		1
			All separately investigated: 1 All together investigated but hospitalization and parity: 1
			3
			2
		>21 years: 1	3, of which 1 only for <21 years
	2		
		1	
			1
	1		1
	Training 3 months ago: 1		3, of which1 for training 6 months ago
			1
			1
	On indication: 1	Always/on indication use of CBCL: 1	Always/on indication use of LSPPK/TRF: 1 Always: 1

Table 1. Continued

	Factor associated with mental health problem identification[a]	**Number of studies**
Practice	Practice type (solo/group neighbourhood health centre, prepaid group, multi-specialty)	2
	Low accessibility MH specialist	3
	Composition of practice	1
Visit	Type of visit	5
	Season of visit	1
	Parent reported discussion MHP	2
	Physician reported MHP exploration/parental disclosure	3
	Parent initiated disclosure negative psychosocial information (researcher determined)	1
	Parent checklist prompting parental disclosure	1
	Longer duration of visit	1

[a] Not included in this table are the associations with identified mental health problems in children with increased scores on mental health problem assessment tools, [b] Composite, based on postcodes, degree of urbanization, proportion of ethnic minorities, mean income per earner.

	Positive association with identified mental health problems number of studies	Negative association with identified mental health problems number of studies	No association with identified mental health problems number of studies
			2
	1		2
			1
	Well-child: 2 Psychosocial: 2		Visit not for MHP: 1
			1
	1		1
	3		
	1		
			1
	1		

[c] This study presented associations separately for the two age groups 4-11 and 12-17 years (19); different findings for the different age groups are therefore specified. LSPPK = National checklist indicating psychosocial problems in 5-year-olds. MH = Mental health, MHP = mental health problem, SDQ = Strengths and difficulties questionnaire, TRF = Teacher report form

Discussion

Main findings

This study presents the results of a systematic review of literature regarding factors associated with the identification of child MHPs by primary care professionals (PCPs). Most of the included studies were performed in the US and the Netherlands. Prevalence rates of identified MHPs varied between studies and PCPs recognized 26-60% of children with an elevated score on MHP screening tools. Overall, we found that MHPs were more often identified among children with mental health symptoms, with a family composition other than married parents and with a history of MHPs. Boys in junior school and children who visited a PCP regarding psychosocial concerns or a well-child visit were also more often identified with an MHP. PCPs who felt less burdened treating MHPs and PCPs recently trained in child MHPs were more likely to identify MHPs and also more likely to recognize MHPs in children showing an increased score on MHP assessment tools. Interestingly, discussion of MHPs during a consultation only resulted in more PCP-identified MHPs when the exploration was reported by PCPs, but not when parents reported the exploration. No clear association was found between other background characteristics of child, family, and professionals and PCP identification of child MHPs.

Comparison with previous reviews

In line with reviews by Zwaanswijk et al.(26) and Sayal et al.(25), published over a decade ago and based on fewer studies, our study confirms the association of the factors family composition, past treatment for MHPs, severity of child psychopathology, mental health symptoms, type of visit, professional acquaintance with the child, professional training, parental expression of concerns with the identification of child MHPs by PCPs. In addition, we found that prior life events led to more MHPs identified only during school age(19, 23, 31-38, 42, 44, 47, 49-51). Zwaanswijk et al. and Sayal et al.(25, 26) included fewer studies reporting on this association and did not mention a difference in the association between prior life events and MHP identification across ages.

Sayal et al.(25) also reported that other factors preventing GPs from recognizing or dealing with mental health issues are likely to reflect lack of confidence, skills or knowledge. This is in line with our findings that PCP identification was influenced by the PCP's psychosocial orientation and the PCP's experienced burden treating MHP.

In contrast to Zwaanswijk et al. and Sayal et al.(25, 26), our study did not confirm the association between male gender and increased MHP identification across all ages. Our study showed that male gender was only associated with increased identification at junior school age, a finding that may be related to the fact that boys have higher rates

of problems and that MHPs become more apparent at the age when a child enters the school setting(3, 49). In addition, we did not find a clear association between a child's age and MHP identification. Zwaanswijk et al.(26) reported a clear association between older age and MHP identification, while Sayal et al.(25) only reported a similar result in studies performed in both preventive and curative care or in curative care only. However, Sayal et al.(25) found that a younger age was associated with MHP identification in one study performed in preventive care only(25). In our study, the study setting did not impact the association between age and MHP identification. Also, we did not find an association between limited service availability to refer patients to and a decreased MHP identification.

The number of MHPs identified by PCPs varied between studies, with lower rates found in studies involving younger children. More importantly, however, we found that identification rates varied between similar professionals within studies(37, 46, 47). This variance could not be explained by child characteristics(37, 46) and could only be partly explained by the included PCP or practice characteristics(37, 46, 47). Nevertheless, a large part of the variation in identification rates remained unexplained, suggesting that other factors in the recognition process play a role. To improve the identification of child MHPs, and decrease the inter-professional variation in identification, we suggest that the knowledge gap explaining the inter-professional variation should be targeted in future studies. For instance, good professional training and the use of protocols have shown to reduce inter-professional variation and improve the identification of problems in children showing elevated scores on MHPs assessment tools(20, 48). Proper professional training is also likely to influence positively the PCP's focus on psychosocial well-being and PCP experienced burden treating MHPs, factors that were reported to impact PCP identification of child MHPs in our study. The importance of training and skills was also confirmed by PCP-reported barriers to the identification of MHPs(14, 52-55). However, it should be taken into account that training activities may be time-consuming and that training activities may only improve MHP identification in the short term(20, 48).

The identification of MHPs was related to the number of mental health symptoms and a history of problems, both signifying more severe problems(19, 34, 35, 37, 42, 44, 46, 47, 49, 50). Parental disclosure of mental health concerns only resulted in higher identification rates when professionals recognized that parents had raised concerns(21, 22, 50). Parents might fail to disclose their concerns effectively(39), and professionals often do not agree with parent-reported concerns or that psychosocial information was discussed during consultation(22). Other explanations might relate to professionals not adequately responding to parental disclosure or to other as yet unknown factors in the recognition process.

Strengths and limitations

We used a wide-ranging search strategy in leading medical and psychological databases and in the grey literature to avoid overlooking relevant articles. This approach expands on two prior reviews which used relatively short search strategies limited to either two or three databases(25, 26).

An important feature of this review was the inclusion of studies performed in both preventive care and curative care. Although healthcare systems worldwide vary considerably, a preventive healthcare programme for children can be found in most countries, and primary care attendance rates are consistent among different healthcare systems(10, 56, 57). The inclusion of studies from both settings also provided broader information on factors associated with the identification of child MHPs by professionals in primary care. While not all factors were investigated in studies of both preventive and curative care, factors that were investigated in studies that included both settings generally showed similar associations when compared to studies performed in only one setting.

Unfortunately, most studies did not include an independent assessment of the child's mental health, e.g. by a questionnaire such as the CBCL. PCP recognition differed between professionals, so some PCPs appear more inclined to identify MHPs than others. It is also possible that some PCPs were more focussed on reporting MHPs in specific children, e.g. in children with divorced parents. Therefore, the associations found in our study do not necessarily predict actual MHPs. Future studies should compare factors associated with PCP-identified MHPs and factors associated with objectively proven MHPs.

In addition, most studies did not define the term child MHPs. This may have impeded the comparison of study results and might (partly) explain the wide variation in identification rates. The included studies, however, reflect the identification process as found in daily practice and most studies measured identification by asking the professional whether they thought an MHP was present, indicating the investigation of a broad concept of MHPs, which corresponded with the aim of our study(20-23, 31-35, 37-40, 42-50).

Additionally, in this review we only presented results after adjustment for several background variables. As the included studies adjusted for different sets of background variables, this probably hampered comparability of the studies. In studies that also reported univariable analyses, the univariable results did not alter conclusions based on multivariable results.

Implications

Some characteristics were investigated in only one study, while the identification of MHPs indicated by mental health assessment tools was investigated in relatively few studies. An increased risk flagged by MHP assessment tools only indicates that a child might experience problems and that further attention is warranted, it does not imply an MHP diagnosis. To obtain more robust evidence regarding factors associated with PCP-identified MHPs, and especially the identification of children with an increased risk of MHPs, we recommend better exploration of factors determining identification of child MHPs by PCPs.

In addition, further insight into the factors explaining variations in MHP identification is needed. This could be facilitated by a study design in which the actual identification process is monitored. The next challenge is to decrease variation in identification and to ensure that the right children are identified. Training and screening tools might increase the sensitivity of professionals (and decrease variation) but might also lead to an increase in the number of children identified and thus to more 'false positives' needing additional assessment(58). An understanding of the factors associated with missed MHP identification in children flagged by independent mental health assessment is important to the framing of strategies and policies to improve identification. In this review, we identified relatively few studies investigating this problem. As mentioned above, we recommend that this issue should be targeted in future studies. Combining data from different sources, including data from routine healthcare, might have great potential for improving MHP recognition(59). For example, in the Netherlands each child participates in regular preventive health assessments performed in community paediatric centres, thus providing a long-term overview of the child's health status. Additionally, a general practitioner is usually consulted when children or parents have health problems and can, therefore, monitor family developments and possible effects on a child's health(19, 56). Combining complementary information from different sources might aid better problem identification.

Conclusion

MHPs were more often identified in children with more mental health symptoms, with prior MHPs, among boys in junior school or as a result of visits to PCPs related to psychosocial concerns or well-child visits. In addition, PCPs who felt less burdened treating MHPs and PCPs who were recently trained in child MHPs were more likely to identify MHPs, and more likely to recognize MHPs in children with an increased score on MHP assessment tools. Factors associated with PCP-identification of children with an increased risk of MHPs were largely comparable with factors associated with MHP identification in general, but were investigated in relatively few studies.

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Supplementary files

Supplement Table 1. Search strategy

("child" OR "children" OR "childhood" OR "infant" OR "infants" OR "infancy" OR "kid" OR "kids" OR "youth" OR "youngster" OR "youngsters" OR "toddler" OR "toddlers" OR "childhood" OR "adolescent" OR "adolescents" OR "baby" OR "juvenile" OR "offspring" OR "teenager" OR "teenagers" OR "newborn" OR "newborns") **AND** ("psychosocial problem" OR "psychosocial problems" OR "psychosocial issue" OR "psychosocial issues" OR "psychosocial disorder" OR "psychosocial disorders" OR "psychological problem" OR "psychological problems" OR "psychological issue" OR "psychological issues" OR "psychological disorder" OR "psychological disorders" OR "mental health" OR "mental health problem" OR "mental health problems" OR "mental health issue" OR "mental health issues" OR "mental health disorder" OR "mental health disorders" OR "mental disorders" OR "behaviour problem" OR "behaviour problems" OR "behaviour issue" OR "behaviour issues" OR "behaviour disorder" OR "behaviour disorders" OR "behavior problem" OR "behavior problems" OR "behavior issue" OR "behavior issues" OR "behavior disorder" OR "behavior disorders" OR "emotional problem" OR "emotional problems" OR "emotional issue" OR "emotional issues" OR "emotional disorder" OR "emotional disorders" OR "psychiatry" OR "psychopathology" OR "internalizing" OR "externalizing" OR "internalising" OR "externalising" OR "internalized" OR "externalized" OR "internalised" OR "externalised" OR "internalize" OR "externalize" OR "internalise" OR "externalise" OR depress* OR "attention deficit" OR "attention deficits" OR "oppositional defiant disorder" OR "autism spectrum disorder" OR "Conduct Disorder" OR "Conduct Disorders" OR "disruptive behavior" OR "disruptive behaviors" OR "disruptive behaviour" OR "disruptive behaviours" OR "ADHD" OR "ODD" OR "ADD" OR "Autism" OR "Aspergers syndrome" OR "Asperger's syndrome" OR asperger* OR autis* OR "Conduct Disorder" OR "Conduct Disorders" OR "anxiety problem" OR "anxiety problems" OR "anxiety issue" OR "anxiety issues" OR "anxiety disorder" OR "anxiety disorders") **AND** ("primary health care" OR "primary healthcare" OR "primary care" OR "general practitioner" OR "general practitioners" OR "general practice" OR "family physician" OR "family physicians" OR "family practice" OR "GP" OR "G.P." OR "Child Health Service" OR "Child Health Services" OR "Infant Health Service" OR "Infant Health Services" OR "pediatrician" OR "pediatricians" OR "paediatrician" OR "paediatricians" OR "CHP" OR "CHPs" OR "CHP's" OR "child health care" OR "child healthcare" OR "child health professional" OR "child health professionals" OR "youth healthcare" OR "youth health care") **AND** ("identification" OR "recognition" OR "detection" OR "signaling" OR "signalling" OR "signal" OR "signals" OR "discovering" OR "finding" OR "exploration" OR "detect" OR "recognise" OR "identificate" OR "early diagnosis")

Supplement Table 2. Quality appraisal of included studies assessed with the Crowe Critical Appraisal Tool

Year, 1st author, Country	Total score (max = 40)	Preamble	Introduction
1992 Horwitz(31) US	26	4	4
1997 Kelleher(32) US, PR, Canada	32	5	5
1997 Lynch(39) US	27	4	5
1998 Horwitz(40) US	26	4	4
1999 Kelleher(38) US	29	4	4
1999 Wildman(22) US	25	4	4
2001 Brugman(23) NL	24	4	4
2001 Scholle(33) US, PR, Canada	27	4	5
2004 Leaf(34) US	28	4	4
2004 Reijneveld(41) NL	25	4	4
2004 Sayal(21) UK	25	3	4
2005 Reijneveld(42) NL	25	5	4
2005 Reijneveld(20) NL	29	4	4
2005 Zwaanswijk(19) NL	28	4	4
2006 Martinez(48) UK	27	4	4
2006 Wiefferink(47) NL	29	5	4
2007 Brown(35) US	25	3	4
2008 Vogels(46) NL	31	4	4
2009 Klein Velderman(43) NL	30	4	5
2010 Crone(44) NL	30	4	4
2010 Richardson(36) US	27	4	3
2012 Dempster(37) US	28	4	4
2012 Theunissen(45) NL	27	4	4
2016 Crone (49)NL	32	5	5
2016 Mayne (41)NL	28	4	4
2018 Nichols (51)UK	33	5	5

NL = the Netherlands, PR = Puerto Rico, UK = United Kingdom, US = United States

Design	Sample	Data	Ethics	Results	Discussion
3	3	3	2	3	3
4	3	4	4	3	4
3	3	3	3	3	3
3	3	3	2	3	3
4	3	4	3	4	3
2	3	4	2	3	3
3	3	3	2	3	2
2	3	3	3	4	3
3	3	3	3	4	4
3	3	3	2	3	3
2	3	4	3	3	3
2	3	3	2	4	2
3	3	4	3	4	4
3	4	3	4	4	2
2	4	3	4	2	4
4	3	3	4	3	3
3	3	3	2	3	4
4	4	4	3	4	4
4	3	4	4	4	4
3	4	4	3	4	4
3	3	3	3	4	4
4	3	3	3	4	5
2	4	3	2	4	4
3	3	4	4	4	4
3	3	4	4	3	3
4	4	4	4	3	4

Supplement Table 3a. Characteristics of included studies – study characteristics[a]

Year 1st author Country	Design	Primary Care Setting	Population	Inclusion criteria
1992 Horwitz (31) US*	Cross-sectional analysis within community based cohort study	Youth healthcare including acute care visits	1886 children age 4-8 years	First visit of all children visiting a clinician within 2 designated time periods
1997 Kelleher(32) US, PR, Canada**	Cross-sectional analysis within cohort study	Youth healthcare and general practice	1100 children age 4-15 years with + PSC-score	Children consecutively presenting physicians for non-emergent services with parent/caretaker; excluding visits for procedures only and missing data
1997 Lynch(39) US	Not randomized experimental study to evaluate a method of prompting parental PsP disclosure	General practice	60 parents and professionals of children age 3-10 years	Parents of 60 children visiting for well-care or acute-care examination not specifically for psychosocial reasons
1998 Horwitz(40) US*	Cross-sectional analysis within community based cohort study	Youth healthcare including acute care visits	1841 children age 4-8 years	First visit of all children visiting a clinician within 2 designated time periods

	Factors investigated	Outcome + measure	Analysis*	Analysis additionally adjusted for
	Child: CBCL, characteristics Family: characteristics Professional: (visit) characteristics	Mental disorders, psychological symptoms and social problems rated by professional on a developed checklist of psychosocial and developmental problems	Univariable frequencies	NA
	Child: PSC, characteristics Family: characteristics, family functioning, insurance status Professional: (visit + practice) characteristics	Professional answered: 'Is there a new, ongoing, or recurrent PsP present?' I.e. any mental disorders, psychological symptoms or social situations warranting clinical attention or intervention	Multilevel multivariable regression	Ethnicity, age, gender, family composition, PSC-score, parent education, family functioning, clinician type, age, sex beliefs, number of children enrolled in study, well-known child, well-child visit, practice structure, % managed care patients, children within practices.
	Child: CBCL, characteristics Family: characteristics, psychosocial disclosures Professional: characteristics	Professional answered whether the child displayed evidence of PsP requiring further treatment.	Univariable regression	NA
	Child: CBCL, characteristics Family: characteristics Professional: (visit) characteristics	Professional rated specific problems on a developed checklist of psychosocial and developmental problems	Multivariable regression	NA

Supplement Table 3a. Continued

Year 1st author Country	Design	Primary Care Setting	Population	Inclusion criteria
1999 Kelleher(38) US, PR, Canada¨	Cross-sectional analysis within cohort study	Youth healthcare and general practice	1913 children age 4-15 years with + PSC-score	Children consecutively presenting physicians for non-emergent services with a parent/caretaker speaking English/Spanish; excluding visits for procedures only and missing data
1999 Wildman (22) US	Cross-sectional	Community based general practice centre	75 parents of children age 2-16 years	English-speaking patients visiting a physician. Excluded: patients who had completed similar questionnaires previously or failed to complete all questionnaires
2001 Brugman (23) NL	Cross-sectional	Youth healthcare without acute care visits	3990 children age 5-15years	Per centre: all children in 3 school classes for 2nd, 4th, 7th (primary school) and 2nd grade (secondary school). Excluding children with incomplete data or currently treated for PsP
2001 Scholle(33) US, PR, Canada	Cross-sectional analysis within cohort study	Youth healthcare and general practice without acute care visits	19 963 children age 4-15 years	Children consecutively presenting physicians for non-emergent services with a parent/caretaker speaking English/Spanish; excluding visits for procedures only or missing data
2004 Leaf(34) US	Cross-sectional analysis within community based cohort study	Youth healthcare including acute care visits	1629 children age 4-8 years	The first visit of all children visiting a clinician within 2 designated time periods

	Factors investigated	Outcome + measure	Analysis*	Analysis additionally adjusted for
	Child: PSC, characteristics Family: characteristics, family functioning, Insurance status Professional: (visit + practice) characteristics	Professional answered: 'Is there a new, on-going, or recurrent PsP present?' I.e. any mental disorders, psychological symptoms, or social situations warranting clinical attention or intervention	Multilevel multivariable regression	Parent education, family functioning, clinician age, sex beliefs and number of children enrolled in the study, practice structure, % managed care patients, children within practices.
	Child: ECBI, characteristics Family: characteristics, parental distress Professional: recognition of parent-raised concerns/child behaviour problems	Professional reported: 'Are you concerned the child might have any type of psychosocial or developmental problem?'	Multivariable regression	Not reported
	Child: CBCL, characteristics Parent: characteristics, child medical history Professional: -	Professional answered question: 'Does the child have a PsP at this moment?' Mild, moderate and severe problems	Univariable and multilevel multivariable logistic regression	Clustering by physician
	Child: PSC, characteristics Family: characteristics, family functioning Professional: (visit, practice) characteristics	Professional answered question: 'Is there a new, on-going, or recurrent PsP present?'	Multilevel multivariable regression	Clustering by physicians
	Child: CBCL, characteristics Family: characteristics, Professional: (visit, practice) characteristics	Professional rated specific problems on a developed checklist of psychosocial and developmental problems	Multilevel multivariable regression	Clustering by physicians; child's age, race, parents' education

Supplement Table 3a. Continued

Year 1st author Country	Design	Primary Care Setting	Population	Inclusion criteria
2004 Reijneveld (42) NL	Cross-sectional	Youth healthcare without acute care visits	2229 children age 21 months to 4 years	Participating child health care services provided random sample of 150 children excluding children currently being treated for PsP or with missing data
2004 Sayal(21) UK	Nested case-control	General practice	186 children age 5-11 years: matched high and low scorers on hyperactivity items of SDQ	186 matched high and low scorers who visited a participating GP
2005 Reijneveld (43) NL Area deprivation	Cross-sectional	Youth healthcare without acute care visits	4080 children age 4-16 years	Per centre: all children in 3 school classes for 2nd, 4th, 7th (primary school) and 2nd grade (secondary school). Excluding children with incomplete data
2005 Reijneveld (20) NL Ethnicity	Cross-sectional	Youth healthcare without acute care visits	4098 children age 5-15 years	Per centre: all children in 3 school classes for 2nd, 4th, 7th (primary school) and 2nd grade (secondary school). Excluding children with incomplete data or currently being treated for PsP
2005 Zwaanswijk(19) NL	Cross-sectional	General practice	2449 children 4-18 years	Random sample from participating practices

	Factors investigated	Outcome + measure	Analysis*	Analysis additionally adjusted for
	Child: CBCL, characteristics, mental health history Family: characteristics Professional: -	Professional answered question: 'Does the child have a PsP at this moment?'	Multilevel univariable and multilevel multivariable logistic regression	Clustering by physician
	Child: SDQ, characteristics, mental health history Family: characteristics, Professional: parent expressed concern, competency	Professional reported presence of mental health disorders	Multivariable logistic regression	Age, sex, under-privileged area
	Child: CBCL, characteristics, Family: characteristics, area deprivation Professional: -	Professional answered question: 'Does the child have a PsP at this moment?' Only moderate and severe problems	Univariable and multilevel multivariable logistic regression	Levels: child, area, physician; Child age, sex, family structure, parental educational level, employment, ethnic background, CBCL problem scores
	Child: CBCL, characteristics, mental health history Family: characteristics, area deprivation Professional: -	Professional filled out question: 'Does the child have a PsP at this moment?'	Univariable and Multilevel multivariable logistic regression	Clustering by physician; age, parent educational level, family composition, urbanization
	Child: YSR, CBCL, TRF, characteristics Parent: characteristics, Professional: (visit) characteristics	Medical record-based PsP with ICPC-codes P-codes for psychological problems and Z-codes for social problems	Univariable and multivariable logistic regression as no significant cluster effect	Parental MHP, parent education level, type of insurance

Supplement Table 3a. Continued

Year 1st author Country	Design	Primary Care Setting	Population	Inclusion criteria
2006 Martinez (50) UK	Cross-sectional	General practice	98 GP attenders age 13-16 years	Children consecutively visiting 13 GPs excluding patients with incomplete data
2006 Wiefferink (48) NL	RCT on the effect of a structured method training to identify PsP	Youth healthcare without acute care visits	7852 children age 5-6 years	Physicians invited all children from 2 or 3 2nd grade primary school classes. Excluding non-Dutch children, children treated for PsP in past year, missing data on CBCL
2007 Brown(35) US	Cross-sectional analysis of RCT to assess physician training in PsP discussion skills	Youth healthcare and general practice	774 children age 5-16 years	All children visiting participating clinics without considerable pain, excluding children with missing outcome data.
2008 Vogels(47) NL	Cross-sectional	Youth healthcare without acute care visits	3140 children age 8-12 years	Per centre: random sample of children visiting clinic. Excluding children of non-Dutch origin, or currently not under treatment for PsP or with missing data
2009 Klein Velderman (44) NL	Cross-sectional	Youth healthcare without acute care visits	701 children aged 14 months	Participating centres provided a random sample of 100 children excluding without missing data

	Factors investigated	Outcome + measure	Analysis*	Analysis additionally adjusted for
	Child: SDQ, characteristics Parent: characteristics Professional: exploration of psychological issues during visit	GP's reported degree of psychological disturbance on that day on a 5-point scale	Multivariable regression	
	Child: CBCL, characteristics Parent: characteristics, Professional: (visit) characteristics	Professional filled out question: 'Does the child have a PsP at this moment?'	Multilevel multivariable logistic regression	Clustering by physician; other factors in analysis not reported
	Child: SDQ Family: characteristics Professional: (visit) characteristics	Professional answered question: 'Is there a new on-going or recurrent PsP present?'	Multilevel multivariable logistic regression	Clustering by physician, intervention effect
	Child: CBCL, characteristics Family: characteristics Professional: (practice) characteristics	Professional answered question: 'Does the child have a PsP at this moment?'	Univariable and multilevel multivariable logistic regression	Clustering by physician; age, gender, number of parents, educational level, treatment status
	Child: ITSEA, characteristics Family: -characteristics Professional: characteristics	Professionals filled out question: 'Does the child have a PsP at this moment?'	Univariable and multivariable logistic regression as no significant cluster effect	

Supplement Table 3a. Continued

Year 1st author Country	Design	Primary Care Setting	Population	Inclusion criteria
2010 Crone(45) NL	Cross-sectional	Youth healthcare without acute care visits	2392 children age 5-12 years	Participating centres provided a random sample of 100 children visiting clinic. Excluding children with missing data
2010 Richardson (36) US	Cross-sectional	General practice	581 children age 11-17 years	English-speaking children randomly sampled from participating practices without asthma
2012 Dempster (37) US	Cross-sectional	Youth healthcare including acute care visits	831 children age 2-16 years	Patients visiting physician for well-child or acute care visits, excluding patients with missing data
2012 Theunissen (46) NL	Baseline data of RCT on the effect of a structured method training to identify PsP	Youth healthcare without acute care visits	3070 children age 5-6 years	Physicians invited all children from 2 or 3 second grade primary school classes, excluding non-Dutch children, children treated for PsP in past year, missing data on CBCL

	Factors investigated	Outcome + measure	Analysis*	Analysis additionally adjusted for
	Child: CBCL, characteristics Family: -characteristics Professional: characteristics	Professionals filled out question: 'Does the child have a PsP at this moment?'	Multilevel multivariable logistic regression	Clustering by physician; child age, sex, child country of birth, geographic region, family income, parent employment status, education, family situation, parental language, treatment history
	Child: characteristics, mental health history, C-DISC depression and anxiety, moods and feelings questionnaire, Anxiety Sensitivity Index, CBCL Family: -characteristics Professional:-	Medical record-based depression and anxiety diagnoses, related medication, referrals	Univariable and Multivariable logistic regression	
	Child: characteristics, ECBI Family: characteristics, parenting characteristics Professional: (practice) characteristics, professional belief scale	Professional reported concerns about child behavioural or emotional functioning, behavioural or emotional problem treatment, or referral to mental health service.	Multivariable logistic regression	Parental affect, parental self-efficacy, parenting style, older child's age, single parent family
	Child: CBCL, characteristics, ECBI Family: -characteristics, Professional: (practice) characteristics	Professional filled out question: 'Does the child have a PsP at this moment?'	Univariable and multilevel multivariable logistic regression	Preventive paediatrician level

Supplement Table 3a. Continued

Year 1st author Country	Design	Primary Care Setting	Population	Inclusion criteria
2016 Crone (49) NL	Cross-sectional	Youth healthcare without acute care visits	3870 children age 14 months to 12 years	Per centre: random sample of ≥100 children age 14 months – 12 years excluding previously being treated for PsP or with missing data
2016 Mayne(41) US	Cross-sectional analysis of cohort study	Youth healthcare	294 748 children visiting primary care practices age 4-18 years	Child EMR extracted from practices participating in research network, excluding children with epilepsy
2018 Nichols (51) UK	Matched case-control	General practice	98 562 cases and 281 248 controls age 15-24 years	Child EMR extracted from practices participating in research network Cases: children age 15-24 years with incident first depression, excluding prior depression. Cases: no depression until index date of matched case

[a] Mental health problems (MHP) and psychosocial problems (PsP) refer to the same concept, terms used refer to the wording used in the specific studies

*Only results additional to the results of Horwitz et al 1998 (40) are presented, as similar studies,

** Only results additional to the results of Kelleher et al 1999 (38) are presented, as similar studies

CBCL = Child behaviour checklist, C-disc = computerized diagnostic interview schedule for children, ECBI = Eyberg child behaviour inventory,

	Factors investigated	Outcome + measure	Analysis*	Analysis additionally adjusted for
	Child: CBCL, characteristics Family: -characteristics Professional: (visit) characteristics	Professionals filled out question: 'Does the child have a PsP at this moment?'	Univariable and multilevel multivariable logistic regression	Other parent, child, environmental stressors and child, family and PCP characteristics
	Child: characteristics Family: characteristics, Professional: (practice) characteristics	Medical record-based mental health problem diagnosis or related medication	Multilevel multivariable logistic regression	Gender, age, child within practice
	Child: characteristics Family: -characteristics	Medical record-based first recorded depression diagnosis	Multivariable logistic regression	

EMR = electronic medical record, ITSEA = Infant toddler social and emotional assessment, MHP = mental health problem, NA = not applicable, NL = the Netherlands, PCP = primary care professional, PsP = psychosocial problems, PR = Puerto Rico, PSC = Paediatric symptom checklist, RCT = randomized controlled trial, SDQ = Strengths and difficulties questionnaire, TRF = Teacher's report form, UK = United Kingdom, US = United States, YSR = Youth self-report

Supplement Table 3b. Characteristics of included studies – Mental health problem (MHP) prevalences and study results[a, b]

Year 1st author Country	Prevalence MHP based on tool	Prevalence MHP physician reported	% children of 'correctly' identified by physician[c]
1992 **Horwitz(31)** **US[*, $]**		27.3%	
1997 Kelleher(32) US, PR, Canada[¨]	12%		54%
1997 **Lynch(39)** **US[$]**	20%		
1998 Horwitz(40) US		27.5%	
1999 Kelleher(38) **US, PR, Canada**			57%
1999 Wildman (22) **US**	13%		50%

	Positive association with identified mental health problems OR/RR (when reported with 95% CI)	**Negative association with identified mental health problems OR/RR (when reported with 95% CI)**	**No association with identified mental health problems**
	Unmarried parents RR 1.73		Frequent healthcare user in past year, Child ethnicity, Practice type
			Rural practice *Season of visit*
	Parent initiated disclosure of PsP (observer reported) RR 3.64 (1.48-8.90)		Parent checklist to prompt parent PsP disclosure during visit
	Older maternal age OR 1.41 Poor parent mental health status OR 1.55 Male child OR 1.7 Well-child visit OR 3.03 Child well-known to clinician OR 1.82	Poverty OR 0.61 Child severe medical problem OR 0.79	Caregivers reported discussion of PsP with physician
	Ethnicity Hispanic American OR 0.55 *Age 8-11 OR 1.75* *Age 12-15 OR 1.77* *Male child OR 1.72* *PSC-score OR 1.09* *Child well-known to clinician OR 5.25* *Well child visit OR 1.32* *Psychosocial problem visit OR 19.7*	*Commercial insurance OR 0.72*	*Ethnicity African American* *One-parent household*
	Physician reported parental disclosure of PsP OR 3.22		Parental distress ECBI scores

Supplement Table 3b. Continued

Year 1st author Country	Prevalence MHP based on tool	Prevalence MHP physician reported	% children of 'correctly' identified by physician[c]
2001 Brugman (23) NL	8.8%	25%	57%
2001 Scholle (33) US, PR, Canada		19.0%	

	Positive association with identified mental health problems OR/RR (when reported with 95% CI)	**Negative association with identified mental health problems OR/RR (when reported with 95% CI)**	**No association with identified mental health problems**
	Clinical CBCL Internalizing score OR 2.49 (1.90-3.28) Clinical CBCL Externalizing score OR 1.93 (1.48-2.53) Very highly urbanized area OR 1.34 (1.01-1.77) Past psychological treatment PsP OR 2.21 (1.56-3.12) Past medical treatment PsP OR 4.67 (3.43-6.35) Past other treatment PsP OR 2.65 (1.81-3.90) Life event past year OR 1.55 (1.30-1.85) Parent reported academic problems OR 2.28 (1.84-2.83)	Age 12-16 OR 0.58 (0.42-0.81)	Child gender, Ethnicity One-parent family No siblings Parental educational level Parent employment status, Parent reported physical illness/handicap)
	Higher child age OR 1.02 Male child OR 1.46 Not living with married parents OR 1.52 PSC Internalizing symptoms OR 1.13 PSC Externalizing symptoms OR 1.04 Psychosocial visit OR 22.2 Child well-known to clinician OR 1.69 Longer duration of visit OR1.45	Ethnicity Black OR 0.61 Ethnicity Hispanic OR 0.66 Commercial insurance OR 0.77 Physician belief (not specified) OR 0.96 Better family functioning OR 0.70	Parent education, Physician age, Physician gender Year completed training, Special fellowship/ rotation High % managed care patients Availability on-site mental health service Season of the year

Supplement Table 3b. Continued

Year 1st author Country	Prevalence MHP based on tool	Prevalence MHP physician reported	% children of 'correctly' identified by physician[c]
2004 Leaf(34) US	13.9%	27.9%	
2004 Reijneveld (42) NL	6.1%	9.4%	29.4%
2004 Sayal(21) UK	23%	11%	26%

	Positive association with identified mental health problems OR/RR (when reported with 95% CI)	**Negative association with identified mental health problems OR/RR (when reported with 95% CI)**	**No association with identified mental health problems**
	Male child OR 1.65 (1.31-2.07) Unmarried parents OR 1.76 (1.23-2.52) Clinical CBCL total score OR 3.70 (2.83-4.85) Preventive care visit OR 2.54 (1.96-3.29) Interaction effect between paediatricians' training and paediatricians' familiarity: No training/know moderate-well OR 2.78 (1.93-3.99) Some training/not know well OR 2.96 (1.45-6.03) Some training/Know moderate-well OR 3.33 (1.78-6.21) Advanced training/Not know well OR 3.55 (1.49-8.45) Advanced training/Know moderate-well OR 5.39 (2.69-10.78) *Advanced training X2 10.78*		Having a medical condition Paediatrician's age, gender, years in practice; size, composition and type of practice
	Higher age OR 1.68 (1.09-2.60) One-parent family OR 3.20 (1.63-6.27) Past psychological treatment PsP OR 8.78 (3.72-20.76) Past medical treatment PsP OR 8.58 (3.72-20.76) Clinical CBCL total problems score OR 3.43 (2.04-5.75) Clinical CBCL externalizing problems score OR 4.88 (2.93-8.14)	Medium/high parental educational level OR 0.54 (0.37-0.80) Day care OR 0.54 (0.34-0.85)	Child gender, Ethnicity, No. siblings, Parental employment, Very highly urbanized, Pregnancy duration <37 wks, Artificial delivery, Birth weight <2500g, Hospitalization after birth, Second and older child, Clinical CBCL internalizing problem score, Past other treatment PsP, Life event in past year, Parent report of physical illness/handicap
	Parental perception of difficulties on SDQ OR 11.6 (2.4-56.2) GP reported parental expression of concern OR 247.1 (26.1-2340.8)		

Supplement Table 3b. Continued

Year 1st author Country	Prevalence MHP based on tool	Prevalence MHP physician reported	% children of 'correctly' identified by physician[c]
2005 Reijneveld (43) NL	8.5%	10.1%	
2005 Reijneveld (20) NL Ethnicity	8.5%	22.2%	
2005 Zwaanswijk (19) NL	4-11 years 20.4%, 12-17 years 14.3%	4-11 years 7.1%, 12-17 years old: 6.7%	
2006 Martinez (50) UK	32%	30%	61.2%
2006 Wiefferink (48) NL	7%	27.1 %	54.9%

	Positive association with identified mental health problems OR/RR (when reported with 95% CI)		Negative association with identified mental health problems OR/RR (when reported with 95% CI)	No association with identified mental health problems
	Moderately deprived area OR 1.39 (1.03-1.87) Most deprived area OR 1.76 (1.30-2.38)			
	Ethnicity economic immigrants (vs. Dutch) OR 1.62 (1.01-2.60)			Ethnicity former colonies/ other non-industrialized/ other industrialized
	<u>Age 4-11 years:</u> Male child OR 2.2 (1.1-4.6) Clinical CBCL total problem score OR 2.5 (1.3-5.1) Teacher report PsP OR 3.0 (1.5-6.1)	<u>Age 12-17 years:</u> General impression of health OR 6.9 (3.2-15.1) Clinical CBCL total problem score OR 5.0 (2.1-12.2)		Child chronic physical disorders <u>Age 4-11 years:</u> General impression of child health, <u>Age 12-17 years:</u> Child gender
	Physician reported exploration of PsP OR 11.13 (2.78-44.53) Child reported SDQ score (some need vs. low need) OR 4.37 (1.02-18.74) Child reported SDQ score (high need vs. low need) OR 11.22 (2.92-43.12)			Child gender, age, history of family MHP, parent/ adolescent perceived difficulties
	Physician training 3 months ago vs. no training OR 3.7 (1.2-11.8) *Physician training 3 months ago vs. no training OR 3.7 (1.2-11.8) for moderate and severe PsP*			Physician training 6 months ago vs. training 3 months ago *Physician training 3 months ago vs. no training for mild, moderate and severe PsP*

Supplement Table 3b. Continued

Year 1st author Country	Prevalence MHP based on tool	Prevalence MHP physician reported	% children of 'correctly' identified by physician[c]
2007 **Brown(35) US**	42.3%	48.4%	
2008 **Vogels(47)** **NL**		20.7%	
2009 **Klein Velderman (44) NL**	11.1%	7.6%	27%

	Positive association with identified mental health problems OR/RR (when reported with 95% CI)	**Negative association with identified mental health problems OR/RR (when reported with 95% CI)**	**No association with identified mental health problems**
	Parent reported PsP discussion OR 3.67 (2.29-6.11) Visit PsP OR 2.16 (1.08-4.3) SDQ burden to family OR 2.03 (1.26-3.25) Positive SDQ OR 2.47 (1.57-3.90) Higher age OR 1.11 (1.05-1.25) Mental health service use OR 3.22 (1.99-5.26) Lower physician believed burden OR 1.66 (1.23-2.20) *Higher physician believed burden: wrongly identified children*	Private insurance OR 0.65 (0.42-0.97) Easily consulted PsP related specialists OR 0.54 (0.39-0.76) *Higher physician believed burden: correctly identified children*	Child's ethnicity, parent distress, number of previous visits, visit not for PsP, physician specialty (GP vs. paediatrician), job satisfaction, job control, confidence in PsP treatment and referral skills, intervention of physician training
	Clinical CBCL total problem score OR 1.05 (1.04-1.05) One-parent family OR 2.39 (1.76-3.25) Past treatment PsP OR 2.18 (1.70-2.83)	Higher age OR 0.83 (0.74-0.92) Female child OR 0.70 (0.58-0.85) Medium education OR 0.53 (0.32-0.88) High education OR 0.43 (0.25-0.72)	
	Clinical ITSEA total problem score OR 5.78 (2.89-11.55) Clinical Internalizing ITSEA score OR 3.16 (1.50-6.66) Past/current professional care PsP OR 3.93 (1.59-9.70)		Child gender, Ethnicity, No siblings, Deprived households, Parental educational level Negative pregnancy outcome (pregnancy duration <37 weeks/ birth weight <2500g), Instrumental delivery, Life events past year, Parent report chronic illness/handicap, Clinical Externalizing ITSEA score

Supplement Table 3b. Continued

Year 1st author Country	Prevalence MHP based on tool	Prevalence MHP physician reported	% children of 'correctly' identified by physician[c]
2010 Crone(45) NL	~4.9%	~21.16%	60% of children with industrialized background and 30% with Turkish/ Moroccan background
2010 Richardson (36) US	8.5%		22%
2012 Dempster (37) US		13.8%	
2012 Theunissen (46) NL	9.3%	26.2%	57.7%

	Positive association with identified mental health problems OR/RR (when reported with 95% CI)	Negative association with identified mental health problems OR/RR (when reported with 95% CI)	No association with identified mental health problems
	Vs. normal CBCL total problem score and ethnicity industrialized: -Elevated CBCL total problem score and ethnicity industrialized OR 5.22 (3.01-9.06) -Elevated CBCL total problem score and ethnicity Surinamese/Antillean OR 6.68 (1.56-28.67) -Elevated CBCL total problem score and ethnicity other non-industrialized country OR 6.39 (1.34-30.54)		Child Ethnicity *Parental concerns*
	Higher depressive and anxiety symptom score tools OR 1.19 (1.03-1.38) More primary care visits OR 2.36 (1.16-4.81)		Child age, Child gender, Mean income, Anxiety disorder based on C-DISC, Child-perceived psychosocial impairment Internalizing CBCL score Externalizing CBCL score
	Higher age child OR 1.27 (1.19-1.36) Higher ECBI OR 1.03 (1.02-1.04)	Parent over reactive parenting style OR 0.93 (0.88-0.98)	One-parent status, Insurance, Parent affect, Parent lax parenting style, Parenting sense of competence
	Elevated CBCL score OR 5.09 (3.90-6.65) *More use of CBCL OR 3.04 (1.13-8.20)*	Physician work experience >21 years OR 0.37 (0.17-0.84) Always/on indication use of CBCL OR 0.25 (0.11-0.54) Female child OR 0.56 (0.47-0.67) Medium parental educational level OR 0.64 (0.53-0.79) High parental educational level OR 0.54 (0.42-0.68)	Physician age Work experience < 21 years Always/on indication use of LSPPK Always/on indication use of TRF *Less us of the TRF* *Physician work experience*

Supplement Table 3b. Continued

Year 1st author Country	Prevalence MHP based on tool	Prevalence MHP physician reported	% children of 'correctly' identified by physician[c]
2016 Crone (49) NL	4.7%	17.5%	47.2%
2016 Mayne(41) US		15%	

	Positive association with identified mental health problems OR/RR (when reported with 95% CI)	Negative association with identified mental health problems OR/RR (when reported with 95% CI)	No association with identified mental health problems
	Clinical CBCL/ITSEA score OR 3.43 (2.41-4.89) Child history of problems OR 5.85 (4.75-7.21 Lower parenting efficacy OR 1.28 (1.05-1.56) Male child OR 1.21 (1.02-1.43) Age 8-12 years (vs. 14 months) OR 1.61 (1..00-2.58) Physician used screening instruments on indication (vs. never) OR 1.53 (1.10-2.14) Stressors in child, not in parenting/context OR 6.20 (4.72-8.13) Stressors both in child and parenting/ context OR 7.84 (5.85-10.51) Child psychiatrist unavailable in community OR 1.40 (1.09-1.80)	Average educational level OR 0.72 (0.59-0.88) High educational level OR 0.70 (0.53-0.91)	Ethnicity Life events Average educational level Physician always used screening instrument (vs. never) Stressors in parenting/ context, not in child
			Co-located MH provider present Higher foster care prevalence

Supplement Table 3b. Continued

Year 1st author Country	Prevalence MHP based on tool	Prevalence MHP physician reported	% children of 'correctly' identified by physician[c]
2018 **Nichols (51) UK**			

Positive association with identified mental health problems OR/RR (when reported with 95% CI)			Negative association with identified mental health problems OR/RR (when reported with 95% CI)	No association with identified mental health problems
Factor:	Boys:	Girls:		Weight loss, excessive sweating, diabetes, epilepsy, asthma, alcohol misuse, neonatal health problems, developmental delay, work stress
Most deprived area	OR 1.56 (1.35-1.80)	OR 1.35 (1.23-1.47)		
Smoker	OR 1.88 (1.66-2.11)	OR 1.35 (1.27-1.44)		
Anxiety	OR 6.03 (4.49-8.09)	OR 3.26 (2.78-3.82)		
Low mood	OR 10.25 (7.38-14.23)	OR 5.49 (4.79-6.31)		
Tiredness	OR 3.10 (2.03-4.73)	OR 2.02 (1.72-2.37)		
Little sleep	OR 4.27 (2.40-7.62)	OR 2.51 (1.81-3.48)		
Bed wetting	OR 2.98 (1.56-5.70)	-		
Eating disorder	-	OR 2.30 (1.83-2.89)		
Self-harm	OR 8.22 (4.92-13.73)	OR 3.38 (2.81-4.06)		
Headache	OR 2.30 (1.99-2.67)	OR 1.75 (1.63-1.88)		
Dyspepsia	OR 1.74 (1.44-2.11)	OR 1.50 (1.37-1.64)		
Abdominal pain	-	OR 1.32 (1.19-1.46)		
Back pain	OR1.47 (1.23-1.75)	OR 1.29 (1.17-1.41)		
More visits past year	OR 1.17 (1.15-1.19)	OR 1.11 (1.10-1.12)		
Drug misuse	OR 2.51 (1.43-4.37)	-		
School problems	OR 5.84 (3.51-9.71)	OR 2.04 (1.52-2.73)		
Loss in family	OR 2.93 (1.59-5.38)	OR 2.24 (1.66-3.01)		
Abuse/ neglect	OR 1.64 (1.16-2.30)	OR 1.57 (1.30-1.89)		
Social services involved	OR 4.89 (1.79-13.35)	-		
OCD	OR 13.98 (7.07-27.66)	OR 8.57 (5.24-14.03)		
PTSS	-	OR 3.33 (1.66-6.70)		

Supplement Table 3b. Continued

[a] *Results in italics refer to factors associated with the identification of children with an elevated score on mental health problem assessment tools* [b] Mental health problems and psychosocial problems refer to the same concept, terms used refer to the wording used in the specific studies, factors are depicted as used in the specific studies. [c] 'Correctly' identified refers to the identification of children with an elevated score on MHP assessment tools. [$] = only results from univariable regression analysis, *Only results additional to the results of Horwitz et al 1998(40) are presented, as similar studies,

**Only results additional to the results of Kelleher et al 1999 (38) are presented, as similar studies; CBCL = Child behaviour checklist, C-disc = computerized diagnostic interview schedule for children, ECBI = Eyberg child behaviour inventory, GP = general practitioner, ITSEA = Infant toddler social and emotional assessment, NL = the Netherlands, OCD = obsessive compulsive disorder, OR = odds ratio, PsP = psychosocial problems, PTSS = post-traumatic stress disorder, PR = Puerto Rico, PSC = Paediatric symptom checklist, RR = relative risk, SDQ = Strengths and difficulties questionnaire, TRF = Teacher's report form UK = United Kingdom, US = United States, X2 = chi square, YSR = Youth self-report, 95% CI = 95% confidence interval

Chapter 3

Identification of children at risk for mental health problems in primary care - development of a prediction model with routine healthcare data

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Abstract

Background: Despite being common and having long lasting effects, mental health problems in children are often under-recognised and under-treated. Improving early identification is important in order to provide adequate, timely treatment. We aimed to develop prediction models for the one-year risk of a first recorded mental health problem in children attending primary care.

Methods: We carried out a population-based cohort study based on readily available routine healthcare data anonymously extracted from electronic medical records of 76 general practice centers in the Leiden area, the Netherlands. We included all patients aged 1-19 years on 31 December 2016 without prior mental health problems. Multilevel logistic regression analyses were used to predict the one-year risk of a first recorded mental health problem. Potential predictors were characteristics related to the child, family and healthcare use. Model performance was assessed by examining measures of discrimination and calibration.

Findings: Data from 70,000 children were available. A mental health problem was recorded in 27.7% of patients during the period 2007-2017. Age independent predictors were somatic complaints, more than two GP visits in the previous year, one or more laboratory test and one or more referral/contact with other healthcare professional in the previous year. Other predictors and their effects differed between age groups. Model performance was moderate (c-statistic 0.62-0.63), while model calibration was good.

Interpretation: This study is a first promising step towards developing prediction models for identifying children at risk of a first mental health problem to support primary care practice by using routine healthcare data. Data enrichment from other available sources regarding e.g. school performance and family history could improve model performance. Further research is needed to externally validate our models and to establish whether we are able to improve under-recognition of mental health problems.

Introduction

Mental health problems in children are relatively common, with estimated prevalences ranging from 10 to 20% worldwide(1). Mental health problems are generally characterised by some combination of abnormal thoughts, emotions, behaviour and relationships with others, and they can range from problems with mild to severe impairment. Half of all lifetime mental health problems occur by the age of 14 years and 75% by the age of 24 years(2). Most children visit primary care professionals, usually general practitioners (GPs) or paediatricians, at least once a year despite different healthcare systems across the world(3-5). Although children are regularly seen in primary care, mental health problems often remain under-recognised, with nearly half of the children with mental health problems not being recognised as such(1, 6-9). Early identification of mental health problems in children is important as they often have a negative effect on children's everyday functioning and wellbeing. It is also known that they have long lasting effects, resulting in for instance a higher risk of impairment due to a DSM-diagnosis later in life and poorer performances at school and/or on the job market(10, 11). Adequate treatment has fortunately proven to be effective and alleviate these long lasting effects(3).

In order to provide adequate and timely treatment for children, identification of mental health problems has to be improved. Risk prediction models based on a number of patient and disease characteristics available in medical registrations are an integral part of current clinical practice in primary care(12, 13) and might provide an efficient solution to improve early mental health problem recognition. Prediction models for anxiety and depression in adolescents(14) and adults(15, 16) in primary care have been developed and have shown good discriminative properties, with only the study on depression in adolescents solely based on readily available routine healthcare data. To our knowledge models based on readily available routine healthcare data that help identifying mental health problems in children and adolescents in primary care are not available yet. Such a model estimating the probability of a child having a mental health problem in the next year might help professionals to better recognise problems in daily practice, thereby improving timely recognition. Specific mental health problems have a higher incidence at different ages, which means that risk factors for mental health problems may vary across childhood and adolescence(17, 18). During childhood and adolescence, children might also experience events that alter their prognosis for a first mental health problem from that time onwards. The aim of our current study is therefore to develop a prediction model for the one-year risk of a first recorded mental health problem in general and internalizing problems (i.e. depression, anxiety or somatization) in particular in children and adolescents presenting in primary care; taking into account age and time-varying factors. We developed different risk prediction models for children in different age groups.

Methods

Study design and setting

We performed a population-based cohort study among primary care patients aged 1-19 years who were registered with 76 practice centers (107 GPs) that were affiliated with the ELAN primary care network (Extramural Leiden Academic Network) of the Leiden University Medical Centre (LUMC), the Netherlands. The participating practices are located in the greater Leiden area and are representative for Dutch primary care.
In general, all residents of the Netherlands, including children, are registered with a GP in his/her neighbourhood. Primary care is free of charge for children and no private primary healthcare system exists in the Netherlands. Dutch children visit their GP on average once a year. All children registered with participating GP practice centers were included in our study regardless of whether they have visited the GP during our study. The GP is the gatekeeper of the Dutch healthcare system and to enter secondary care, a referral from the GP is needed.

Our data consisted of the routine healthcare data anonymously extracted from the electronic medical records (EMRs) from the participating practices(19). Available patient data included demographics, consultation dates, symptoms and diagnoses coded according to the WHO International Classification of Primary Care (ICPC), prescribed medication coded according to the Anatomical Therapeutic Chemical (ATC) classification, laboratory test results, and descriptive or coded information of referrals and correspondence with other healthcare professionals e.g. profession/specialty of the other professional and date of referral and correspondence(20, 21).

Study population

All patients aged 1-19 years on 31 December 2016 and registered with participating practices between 1 January 2007 and 1 January 2017 were part of our cohort. We excluded patients who had missing data on gender (n=11), registration date with practice (n=961), patients with a negative follow up (n=852), or a missing postal code (n=1274). Patients who had a recorded mental health problem before 1 January 2007 (n=3415), or with an undated mental health problem diagnosis (n=7) were also excluded.

For each patient we determined an entry date to the cohort, which was the earliest of either date of registration with the practice plus one year or the beginning of the study period (1 January 2007). Patients were censored at the date of their first mental health problem, death, deregistration with a practice in the cohort, last upload of EMR data, or the study end date (31 December 2016).

Outcomes

Our main outcome was a first recorded child mental health problem based on the presence of at least one of the following: a recorded mental health problem, a referral to child mental healthcare and/or a mental health medication prescription between 1 January 2007 and 1 January 2017 (Supplement Table 1). We defined a recorded mental health problem when ICPC codes from the P (psychological) chapter or ICPC code T06 ('anorexia nervosa/bulimia') were present, including both mental health symptoms as well as hypothesised and confirmed disorders. Related mental health medication prescriptions were defined as prescriptions coded with ATC codes N05A, N05B, N05C, N06A, N06BA02, N06BA04, N06BA09, N07BA, or N07BB. Referrals to child mental healthcare were defined as referrals to a psychologist, psychiatry, or psychotherapy. We also investigated model development for first recorded internalizing mental health problems specifically, consisting of the most common registered internalizing mental health problems depression, anxiety, and somatisation symptom and disorder ICPC codes and medication ATC codes (Supplement Table1).

Predictor variables

As predictor variables we included characteristics related to the child (e.g. gender, age, somatic complaints and co-morbidities), social context (e.g. family history of mental health problems and parental divorce recorded in the child's EMR) and healthcare use (e.g. number of visits, referrals, and laboratory tests). As it is likely that interactions exist between the variables somatic complaints and chronic disease, we investigated this in all models. The predictor variables were identified based on a systematic review we conducted regarding predictors for identified mental health problems in primary care(22), current guidelines including risk factors for mental health problems and an expert panel consisting of authors NK and MC, two GPs, a preventive youth health physician, a paediatrician, a pharmacist, and two researchers from the Netherlands Centre for Youth health(18). We operationalised the predictor variables according to the available data from the EMRs based on ICPC coded diagnoses, ATC coded prescriptions, and count variables (Supplementary Table 2). Prior to the data analysis, the count variables were dichotomised according to expert opinion into more than two visits, one or more prescription(s), one or more laboratory test(s), and one or more referral(s)/ correspondence with other healthcare professionals.

Every first occurrence of a predictor was taken into account. As predictor variables for mental health problems may vary across childhood and adolescence, we investigated models for the following age groups separately: pre-school aged children (aged 1-3 years), primary school aged children (aged 4-11 years), and secondary school aged children (aged 12-19 years)(9, 23).

The same set of predictor variables was examined in the different age groups, however we required the prevalence of a predictor to be >1% per age group with regard to the clinical usefulness of the predictor. Continuous variables are presented as mean (SD) or as median (IQR) when appropriate. Categorical variables are presented as counts (%).

Model development

Statistical analyses were carried out with the programs SPSS (version 23) and R (version 3.5.1). To obtain the one-year risk of a first recorded mental health problem, we developed a multilevel logistic regression model per age group; pre-school aged children, primary school aged children, and secondary school aged children. Firstly, the data were split according to the children's age; age 4 years, age 5 years and so on. For every age the status of all predictor variables was updated at the same time at that specific age. We obtained a prediction model per age group by combining the data from those years (e.g. age 4-11 years) and fitting a logistic regression model including a cluster effect on the patient level. This to adjust for using different age years of one patient, for instance at age 4 years and age 5 years(24).

Model performance and internal validation

Model performance was evaluated by determining measures of discrimination and calibration. Discrimination, the ability of the model to distinguish between children who are diagnosed with a first mental health problem and those who are not, was assessed using the c-statistic.

The in-sample calibration of the model was assessed by the calibration plot of actual probabilities versus predicted probabilities. The models were internally validated using bootstrap resampling (500 bootstrap samples) and estimating a shrinkage factor. Brier scores were calculated to assess the average prediction error(25).

The Ethics Committee of the Leiden University Medical Centre issued a waiver of consent (G16.018).

Role of the funding source

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Results

Baseline characteristics and prevalence of mental health problems

Our cohort consisted of 70,000 children with a median age of 10.0 years (IQR 10 years) and 35,595 (50.9%) were male (Table 1). The median follow up was 6.4 years. In 19,420/70,000 (27.7%) patients a mental health diagnosis was recorded in the electronic medical record (Table 2). An internalizing problem was recorded in 3501 (5.0%) patients. A first mental health problem was recorded in 3.2-4.4% of children aged 1-3 years, in 4.7-6.7% of children aged 4-11 years, and in 3.8-6.4% of children aged 12-19 years. Most recorded MHPs (55%) were based on the presence of 1 of the 3 following criteria: a recorded ICPC code (81%), ATC code (9%) or a referral for an MHP (10%; Table 3). A first recorded internalizing mental health problem was recorded in 0.5-0.7% of children aged 1-11 years and in 1.0-3.7% of children aged 12-19 years. In adolescents aged 17 years and older, first internalizing mental health problems counted for over half of the first general mental health problems.

Prediction of a first mental health problem diagnosis

Predictors for a first recorded mental health problem one year later in all age groups were somatic complaints, and the healthcare use related variables more than two GP visits in the previous year, one or more laboratory test and one or more referral/contact with other healthcare professional in the previous year (Table 4). Boys aged 1-3 years (OR 1.60, 95%CI 1.43-1.77) and boys aged 4-11 years (OR 1.65, 95%CI 1.61-1.70) were more likely to have a first recorded mental health problem than girls, while boys aged 12-19 years were less likely to have a first recorded mental health problem than girls (OR 0.82, 95%CI 0.75-0.89). Chronic disease was only positively associated with a first recorded mental health problem in children aged 4-11 years. The co-occurrence of somatic complaints and chronic disease was not associated with a first record mental health problem one year later.

Table 1. Baseline characteristics study population

Characteristics	Children age 1-3 years N= 27,831 % (n)	Children age 4-11 years N= 44,622 % (n)	Children age 12-19 years N= 22,629 % (n)
Male gender	51.3 (14,276)	49.7 (22,178)	47.0 (10,628)
Low socioeconomic status	5.0 (1,396)	4.4 (1,975)	4.2 (957)
Perinatal morbidity	5.6 (1,550)	2.2 (995)	0.3 (69)
Congenital anomaly	10.5 (2,928)	12.4 (5,519)	14.6 (3,307)
Disabilities	0.9 (240)	0.9 (430)	0.9 (195)
Neoplasms	2.0 (558)	4.7 (2,086)	6.8 (1,534)
Chronic disease*	39.9 (11,098)	38.8 (17,302	38.8 (8,770)
Somatic complaints**	20.3 (5,650)	33.5 (14,953)	49.8 (11,280)
Tension headache***	0.2 (59)	3.7 (1,632)	9.3 (2,096)
Migraine***	0.0 (3)	0.4 (164)	2.4 (536)
Abdominal pain***	3.3 (917)	12.9 (5,759)	17.5 (3,953)
Constipation***	12.0 (3,335)	13.9 (6,186)	11. 2 (2,532)
Tiredness***	1.3 (353)	4.9 (2,193)	13.7 (3,096)
Other somatic complaints***	6.5 (1,804)	11.2 (4,991)	27.5 (6,216)
Life event	0.4 (109)	0.8 (376)	1.9 (421)
Academic problem	0.0 (1)	0.1 (62)	0.4 (82)
Developmental problem	3.5 (964)	7.1 (3,161)	3.7 (839)
Difficult temperament	9.7 (2,711)	3.6 (1,600)	0.1 (21)
>2 Visits	85.5 (23,789)	82.9 (37,002)	84.4 (19,101)
≥1 Medication prescript	72.4 (20,144)	68.5 (30,562)	69.6 (15,784)
≥1 Laboratory test	12.4 (3457)	23.2 (10,362)	35.5 (8,044)
≥1 Referral/correspondence other healthcare prof.	64.8 (18,036)	64.9 (28,942)	66.4 (15,017)

*Chronic disease when present one or more of the following: asthma, eczema, psoriasis, inflammatory bowel disease, epilepsy, diabetes mellitus, cystic fibrosis, rheumatoid arthritis.
**Somatic complaint when present one or more of the following: tension headache, migraine, abdominal pain, constipation, tiredness, irritable bowel syndrome IBS, musculoskeletal symptoms, dizziness, nausea, hyperventilation syndrome, palpitations, fainting.
***Separate somatic complaints do not add up to the total amount of somatic complaints as a child can have multiple somatic complaints.

Table 2. First recorded (Internalizing) MHPs per age

Child age (years)	Nr of children without previous MHP	Children with first recorded MHP % (n)	Children with first recorded Internalizing MHP % (n)
1	6,193	3.1 (191)	0.7 (41)
2	22,935	3.9 (903)	0.6 (129)
3	23,065	4.4 (1,020)	0.5 (114)
4	23,006	4.7 (1,070)	0.5 (122)
5	22,878	5.9 (1,348)	0.5 (125)
6	22,209	6.0 (1,322)	0.5 (122)
7	21,700	6.7 (1,464)	0.8 (183)
8	21,054	6.1 (1,278)	0.9 (189)
9	20,530	5.8 (1,190)	1.0 (203)
10	20,180	4.9 (995)	1.1 (213)
11	20,020	4.6 (912)	1.0 (197)
12	19,861	3.8 (757)	1.0 (206)
13	17,770	4.1 (720)	1.1 (190)
14	15,611	4.8 (750)	1.6 (242)
15	13,425	4.8 (647)	1.7 (229)
16	11,200	5.3 (591)	2.3 (254)
17	9,033	6.4 (575)	3.6 (322)
18	6,898	6.1 (421)	3.7 (252)
19	4,956	5.4 (266)	3.4 (168)

MHP = mental health problem

Lower neighbourhood socioeconomic status was positively associated with a first recorded mental health problem one year later in children age 1-3 and 12-19 years. A difficult temperament, such as excessive crying or feeding problems (OR 1.27, 95%CI 1.07-1.48) was associated with mental health problems in pre-school aged children but not in school-aged children. Prior developmental problems such as growth delay and speech disorders were related to a first recorded mental health problem in children aged 1-11 years, but not in the eldest age group. Life events were only associated to a first recorded mental health problem in children aged 12-19 years (OR 1.79, 95%CI 1.58-1.99) as they were not reported frequently enough to be included in our analyses for the younger age groups.

Table 3. Characteristics of first recorded MHP

MHP based on the presence of	**Percentage of children with first recorded MHP (n=19,420)**
1 criterion: either ICPC code or ATC code or referral	55
2 of the following 3 criteria: ICPC code or ATC code or referral	30
All 3 criteria: ICPC code, ATC code and referral	15
***MHP based on 1 of 3 criteria present:**	**Percentage of children**
Only ICPC code present	81
Only ATC code present	9
Only Referral to psychologist, psychiatry or psychotherapy present	10

MHP = mental health problem

One or more medication prescript was only associated with a first recorded mental health problem in the school aged children. Academic problems and disabilities were not recorded often enough to be included in the analyses for all age groups. In addition, family (mental) health problems were not registered with a specific ICPC code and could therefore not be included in our analyses.

Prediction of a first internalizing mental health problem diagnosis

Among boys aged 12-19 years, internalizing mental health problems were relatively less often found (OR 0.59, 95%CI 0.48-0.69) compared to girls aged 12-19 years (Table 5), whereas boys aged 4-11 years had an increased risk of a first recorded internalizing mental health problem one year later (OR 1.60 95% CI 1.56-1.64). The healthcare use related variables showed various associations with a first recorded mental health problems. The variables more than two visits in the previous year and one or more referral/contact with other healthcare professional in the previous year were only associated with a first internalizing mental health problem one year later in the school-aged children. One or more medication prescript in the previous year increased the risk of having a first recorded internalizing mental health problem in all age groups. One or more laboratory test in the previous year only resulted in more first recorded internalizing mental health problems in children aged 12-19 years old.

Somatic complaints, chronic disease and congenital anomaly were related to a recorded internalizing mental health problem among the school-aged children. A lower socio-economic status and the co-occurrence of somatic complaints and chronic disease were negatively associated with a first recorded internalizing mental health problem in children aged 4-11 years. A difficult temperament or perinatal morbidity were not associated with internalizing mental health problems in all age groups. Life events were associated with a first recorded mental health problem in children aged 12-19 years (OR 1.59, 95%CI 1.27-1.91) and were not included in the analyses in the younger age groups due to a low prevalence in our data. Again, academic problems and disabilities were not recorded often enough to be included in the analyses for all age groups.

Model performance

Internal validation for the models for a first recorded mental health problem showed shrinkage factors of 0.97 to 0.99. The model's discriminatory accuracy for the general mental health problem models was moderate with corrected c-statistics of 0.62 to 0.63 (Table 4). The Brier scores were 0.04-0.05, indicating good accuracy of probabilistic predictions. Most children had predicted probabilities of a first recorded mental health problem ≤8% with a good calibration (Figure 1 A-C). A minority of the children had higher predicted probabilities, which were overestimated.

The shrinkage factor for the model of a first recorded internalizing mental health problem in age group 1-3 years was with 0.81 lower than in the two older age groups 0.96 (age 4-11 years), and 0.98 (age 12-19 years). The corrected c-statistics of the models for a first recorded internalizing mental health problem were 0.64 (age 1-3 years and age 4-11 years), and 0.68 (age 12-19 years), (see Table 4). The Brier scores were low. Most children aged 1-11 years had a predicted probability ≤1% with good calibration (Figure 1 D-E). Children age 12-19 years mostly had a predicted probability ≤4% with good calibration.

Table 4. Results of Adjusted logistic regression analysis for the one-year risk of MHPs

Covariate	Age 1-3 years 52,193 person years, nr of events 2,114			
	Coefficient	**Odds ratio**	**Robust SE**	**95 % CI**
Intercept	-4.23			
Male gender	0.48	1.60	0.09	1.43-1.77
Low SES	0.47	1.57	0.05	1.49-1.66
Congenital anomaly	0.06	1.04	0.09	0.86-1.21
Perinatal morbidity	0.31	1.34	0.07	1.21-1.47
Developmental problem	0.38	1.44	0.08	1.29-1.59
Difficult temperament	0.26	1.27	0.10	1.07-1.48
Life events	NA	NA	NA	NA
Chronic disease*	0.11	1.11	0.05	0.99-1.19
Neoplasms	-0.01	0.96	0.15	0.68-1.25
Somatic complaints**	0.20	1.19	0.06	1.06-1.32
>2 Visits	0.31	1.34	0.08	1.19-1.49
≥1 Medication prescript	0.05	1.02	0.05	0.92-1.13
≥1 Laboratory test	0.17	1.16	0.07	1.23-1.31
≥1 Referral/correspondence other healthcare prof.	0.21	1.21	0.05	1.11-1.30
Somatic complaints* Chronic disease	0.10	1.08	0.08	0.91-1.24
Shrinkage factor, B=500		0.97		
C-statistic corrected		0.63		
Brier		0.04		

MHPs = mental health problems

NA = not applicable, when predictor was present in <1% of the children a particular age group

* one or more of the following: tension headache, migraine, abdominal pain, constipation, tiredness, irritable bowel syndrome

Age 4-11 years 171,577 person years, nr of events 8,204				Age 12-19 years 98,754 person years, nr of events 5,947			
Coefficient	**Odds ratio**	**Robust SE**	**95 % CI**	**Coefficient**	**Odds ratio**	**Robust SE**	**95 % CI**
3.60				-3.51			
0.50	1.65	0.02	1.61-1.70	-0.19	0.82	0.03	0.75-0.89
0.21	1.23	0.51	0.23-2.23	0.19	1.20	0.07	1.06-1.34
0.15	1.15	0.03	1.09-1.21	0.11	1.11	0.04	1.03-1.18
0.12	1.12	0.07	0.99-1.26	NA	NA	NA	NA
0.20	1.21	0.04	1.15-1.29	0.02	1.01	0.09	0.83-1.19
0.02	1.01	0.06	0.89-1.12	NA	NA	NA	NA
NA	NA	NA	NA	0.58	1.79	0.10	1.58-1.99
0.10	1.10	0.03	1.05-1.15	0.03	1.02	0.04	0.94-1.10
0.06	1.06	0.05	0.97-1.15	-0.02	0.97	0.07	0.84-1.10
0.19	1.20	0.02	1.16-1.24	0.20	1.21	0.02	1.17-1.15
0.23	1.26	0.03	1.20-1.31	0.21	1.22	0.04	1.14-1.30
0.10	1.10	0.02	1.05-1.15	0.27	1.30	0.04	1.23-1.37
0.09	1.09	0.04	1.02-1.16	0.17	0.17	0.04	1.09-1.25
0.29	1.33	0.02	1.28-1.38	0.26	1.28	0.03	1.22-1.35
-0.04	0.95	0.03	0.90-1.01	0.01	1.00	0.03	0.94-1.06
	0.99				0.99		
	0.62				0.63		
	0.05				0.05		

IBS, musculoskeletal symptoms, dizziness, nausea, hyperventilation syndrome, palpitations, fainting

** one or more of the following: asthma, eczema, psoriasis, Crohn, inflammatory bowel disease IBD, epilepsy, diabetes mellitus DM, cystic fibrosis CF, rheumatoid arthritis RA

Table 5. Results of Adjusted logistic regression analysis for the one-year risk of Internalizing MHPs

Covariate	Age 1-3 years 52,193 person years, nr of events 284			
	Coefficient	**Odds ratio**	**Robust SE**	**95 % CI**
Intercept	-5.98			
Male gender	0.11	0.94	0.10	0.74-1.13
Low SES	-0.05	0.77	0.24	0.29-1.24
Congenital anomaly	-0.08	0.74	0.97	0.42-2.65
Perinatal morbidity	0.23	1.08	0.18	0.72-1.44
Developmental problem	0.17	1.00	0.24	0.53-1.47
Difficult temperament	0.07	0.88	0.15	0.59-1.18
Life events	NA	NA	NA	NA
Chronic disease	0.17	1.00	0.12	0.77-1.23
Neoplasms	-0.05	0.76	0.44	0.09-1.61
Somatic complaints	0.17	1.01	0.15	0.71-1.30
>2 Visits	-0.08	0.74	0.18	0.38-1.09
≥1 Medication prescript	0.44	1.41	0.14	1.13-1.68
≥1 Laboratory test	0.06	0.87	0.16	0.56-1.19
≥1 Referral/correspondence other healthcare prof.	0.27	1.14	0.13	0.92-3.36
Somatic complaints* Chronic disease	0.14	0.97	0.18	0.61-1.32
Shrinkage factor, B=500		0.81		
C-statistic corrected		0.64		
Brier		0.005		

MHPs = mental health problems

NA = not applicable, when predictor was present in <1% of the children a particular age group

* one or more of the following: tension headache, migraine, abdominal pain, constipation, tiredness, irritable bowel syndrome

Age 4-11 years 171,577 person years, nr of events 552				Age 12-19 years 98,754 person years, nr of events 1,853			
Coefficient	**Odds ratio**	**Robust SE**	**95 % CI**	**Coefficient**	**Odds ratio**	**Robust SE**	**95 % CI**
-3.60				-4.58			
0.49	1.60	0.02	1.56-1.64	-0.51	0.59	0.05	0.48-0.69
0.20	1.19	0.05	1.09-1.28	0.19	1.19	0.12	0.96-1.42
0.14	1.11	0.03	1.06-1.17	0.22	1.23	0.0	1.11-1.34
0.12	1.09	0.08	0.96-1.21	NA	NA	NA	NA
0.19	1.17	0.04	1.10-1.25	-0.06	0.93	0.14	0.64-1.21
0.01	0.97	0.06	0.86-1.09	NA	NA	NA	NA
NA	NA	NA	NA	0.047	1.59	0.16	1.27-1.91
0.10	1.06	0.03	1.01-1.11	0.17	1.18	0.07	1.05-1.30
0.06	1.02	0.05	0.93-1.11	0.01	0.99	0.11	0.78-1.20
0.18	1.16	0.02	1.12-1.20	0.28	1.31	0.03	1.25-1.37
0.22	1.21	0.03	1.16-1.27	0.30	1.34	0.07	1.20-1.47
0.10	1.06	0.02	1.01-1.11	0.35	1.40	0.06	1.29-1.51
0.09	1.05	0.03	0.99-1.12	0.30	1.33	0.06	1.21-1.45
0.28	1.28	0.02	1.24-1.33	0.14	1.13	0.05	1.03-1.23
-0.41	0.63	0.03	0.58-0.68	-0.04	0.93	0.04	0.85-1.01
	0.96				0.98		
	0.63				0.68		
	0.008				0.02		

IBS, musculoskeletal symptoms, dizziness, nausea, hyperventilation syndrome, palpitations, fainting

** one or more of the following: asthma, eczema, psoriasis, Crohn, inflammatory bowel disease IBD, epilepsy, diabetes mellitus DM, cystic fibrosis CF, rheumatoid arthritis RA

Discussion

In this population-based cohort study among primary care patients we investigated the possibilities to predict the one-year risk of a first recorded general mental health problem and a first recorded internalizing mental health problem in children aged 1-3 years, 4-11 years, and 12-19 years based on readily available routine healthcare data. Predictors in all ages were the presence of somatic complaints, more than two GP visits in the previous year, one or more laboratory test and one or more referral/contact with other healthcare professional in the previous year. The occurrence of other potential predictors differed between age groups, advocating for the development of partially different models for different age groups. The models' discriminatory accuracy was moderate.

A recent case-control study with UK routine healthcare data investigating a prediction model for depression in males and females aged 15-19 years found a similar performance compared to our model(14). Similar patient characteristics like somatic complaints appeared to be predictive in that study(14). The models in the UK study also contained a more extensive set of predictors including mental health problem symptoms and family-related and social predictors. Healthcare use related variables were not investigated, which were important predictors in our study. Information on academic problems and family mental health problems were not well reported in our study and could unfortunately not be included in our analyses. Investigating the value of additional information on for instance school performance and family history might improve our models(14).

Age-dependent predictors we found were in line with the literature. Boys had a higher risk of a first mental health diagnosis in pre-school and primary school-aged children than girls, probably due to the higher prevalences of externalizing mental health problems (e.g. Attention Deficit and Hyperactivity Disorder) in boys. In adolescence, girls had a higher risk than boys due to a higher occurrence of internalizing mental health problems in girls as is shown in other studies(17). A history of developmental and temperament problems added to the prediction of a first recorded mental health problem, but only in younger children. At a younger age developmental problems, such as growth delay and speech disorders, and difficulties in temperament, such as excessive crying or feeding problems are most prevalent and have been found to be related to mental health disorders at a later age, e.g. attention deficit(26, 27). In primary school-aged children a difficult temperament was not associated with internalizing problems, confirming the association between difficult temperament and externalizing mental health problems(26, 27). In adolescence, the registered life-events seemed to

play a more prominent role in the identification of a first (internalizing) mental health problem, but they were not often enough recorded in our data to be included in the analyses in the younger age groups.

The combination of somatic complaints and chronic disease diagnoses decreased the likelihood of a recorded mental health problem in high school-aged children and was not significantly associated in the younger age groups. A possible explanation for this might be that physicians relate occurring problems to physical and not mental health issues.

The healthcare use related variables more than two GP visits in the previous year, one or more laboratory test and one or more referral/contact with other healthcare professional in the previous year were all associated with a first recorded mental health problem one year later. One or more medication prescriptions was only associated with a first record mental health problem one year later in the school-aged children. GPs might want to exclude a somatic cause for instance by consulting another healthcare professional or performing laboratory tests before relating problems to a mental health issue. An example for instance is tiredness, which can be caused by a somatic problem, but can also be a symptom of a mental health issue. It is common practice to perform laboratory tests to rule out a somatic cause before considering other possible causes. In addition, it might be that the visits, laboratory tests, contact/referral with other healthcare professionals and medication prescriptions are explained in the context of a co-occurring chronic disease or other somatic complaints. It would be interesting to assess the electronic medical records of children who are diagnosed with mental health problems in detail, including the complete free text, to see the course of symptoms, visits, medication prescriptions, referrals and performed laboratory tests to gain more insight in the actual process of diagnosing mental health problems in primary care.

Our study included over 70,000 children in primary care, allowing us to investigate a substantial number of potential predictors. The data consisted of readily available routine healthcare data reflecting daily practice in 'average' primary care. This makes the results potentially more suitable for implementation in practice compared to models requiring (additional) questionnaire information(15, 16) The key advantage of our approach is that it takes into account the time-varying effects of predictor variables, which to our knowledge has not been done in previous research.

A limitation of using routine healthcare data is that possibly useful information might be missing. When the patient consults his GP, the patient presents his symptoms in a specific manner to the GP. The GP then records the information in the medical record

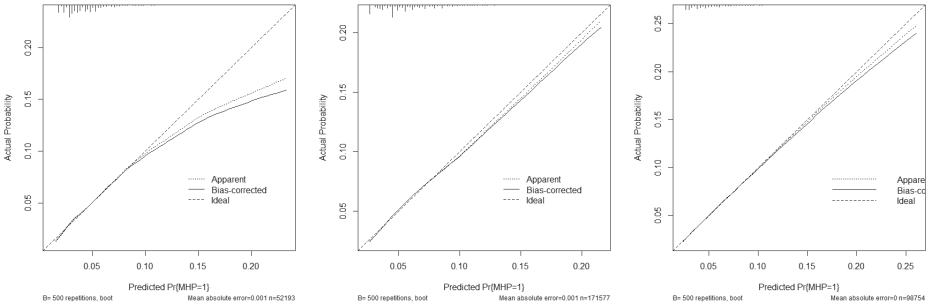
and codes this information. The information is not consistently recorded by GPs. A possible effect of this information bias might be an underestimation of the association between the outcome and for the patient less troublesome or less notable symptoms. This information recording process might also be an explanation for the low presence of school problems, life events, and family mental health problems in our data, variables that have shown to be important risk factors for child mental health problems(14, 18), but that will not always be recorded in the EMR of the children. On the other hand, overestimation of the association between outcome and predictors might occur when GPs already suspect mental health problems. For this study, we only had coded information available, we did not have full access to free text notes of the history of a patient for privacy reasons. However, we did have information about the presence of some often-used words in the free text of the patient's history, such as 'divorce' or 'school problem'. It is likely that information regarding school problems or life events such as a divorce, if they are registered, are recorded in the free text of the patients record.
It turned out that these words were not often recorded in the free text of the child's medical record and were not of influence on our predictions.

The extent to which the definitions used for our outcomes corresponded to an officially classified mental health disorder needs to be further investigated. For the definition of (internalizing) mental health problems, we included both mental health problem symptoms and recorded disorders, as according to our expert panel, GPs are cautious of labelling a child with an actual mental health disorder ICPC code. Our models intended to support the early identification of children at risk for mental health problems. It is known that almost half of the children with a mental problem are not being recognised as such in primary care(1, 6-9). Early identification and if needed treatment have shown to improve long-term prognosis. The inclusion of symptoms of mental health problems as outcome in our prediction model might therefore enable the early prevention of adverse outcomes. Research comparing our model estimations with screening tools for child mental health problems or official diagnosis from secondary mental healthcare is needed to investigate whether our models improve primary care identification rates. In addition, the used definition for internalizing mental health problems does not include all children with mental health problems according to the DSM 5 classification and referrals to psychology/ psychiatry could not be included in this outcome definition. Our aim was to explore the usefulness of the data in the development of a prediction model for the most registered internalizing mental health problems.

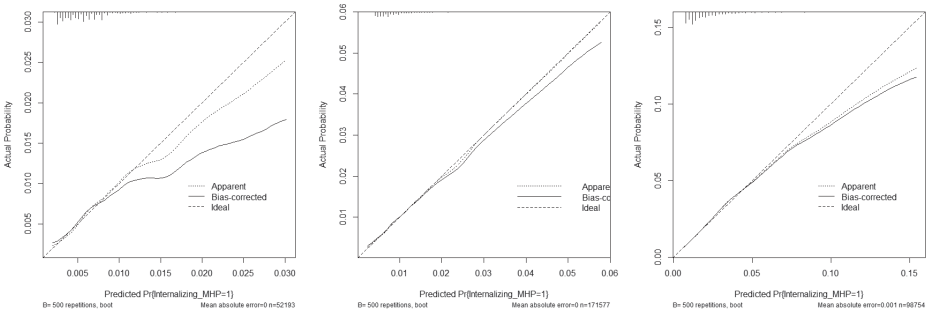
Our data give a fair representation of Dutch primary healthcare. As this research is performed in Dutch primary care, external validation is needed to investigate model performance in other populations with possible other healthcare systems.

Our developed predictions models estimating the one-year risk of a first recorded (internalizing) mental health problems in primary care showed a moderate performance. At this moment we are of the opinion that the models are not good enough yet to be applied in daily clinical practice. The next steps would involve investigating model performance when additional information is included about predictors which from literature are known to be important predictors for child mental health problems such as school performance, life events and family mental health problems. These predictors were not well recorded in the EMR data of the GPs. This information could be added by linking registry data from other sources, for instance from the preventive youth healthcare. In addition, more research is needed to investigate whether our models improve primary care identification rates and whether our models are identifying the right children, i.e. children who have an actual mental health problem. This can be done for instance by comparing our model estimations with screening tools for child mental health problems or official diagnosis from secondary mental healthcare. The healthcare use related variables in general were important predictors for a first recorded child mental health problem one year later. Research about the actual diagnostic process of mental health problems could give more insight in the course of symptoms, referrals, laboratory tests and prescriptions. Furthermore external validation, a key element in the development of a prediction model for use in daily clinical practice, is needed to validate the prediction model with external data(28).

In conclusion, our models estimating the one-year risk of a first recorded (internalizing) mental health problem identified in around two thirds of the children correctly whether a first mental health problem was present or not. Especially when multiple predictors are present, the identified predictors can aid mental health problem recognition in primary care. Further research is needed to investigate whether additional information e.g. regarding school performance and family history can improve the performance of the developed models and whether the models also aid mental health problem recognition in the children that are currently not being recognised with a mental health problem by their GP. Also, external validation is needed to investigate the generalizability of our findings.



A Age 1-3 years **B Age 4-11 years** **C Age 12-19 years**



D Age 1-3 years **E Age 4-11 years** **F Age 12-19 years**

Figure 1. Calibration plots general mental health problems (A-C) and internalizing mental health problems (D-F)

Calibration plots for predicting the 1-year risk of a first recorded general mental health problem (A, B, C) and internalizing mental health problem (D, E, F). In each plot, the actual observation and predicted probabilities were drawn on the y- and x-axes respectively. The 45-degree dotted line depicts complete agreement between the actual and predicted probabilities.

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Supplementary files

Supplement table 1. Outcome definitions

MHP based on the presence of ≥1 of the following:	Description
MHP ICPC code	P01 Feeling anxious P02 Acute stress reaction P03 Feeling depressed P04Feeling/behaving irritable P05 Senility, feeling/behaving old P06 Sleep disturbance P07 Sexual desire reduced P08 Sexual fulfilment reduced P09 Sexual preference concern P10 Stammering/ stuttering/tic P11 Eating problem in child P12 Bedwetting/enuresis P13 Encopresis/bowel training problem P15 Chronic alcohol abuse P16 Acute alcohol abuse P17 Tobacco abuse P18 Medication abuse P19 Drug abuse P20 Memory disturbance P21 P22 Child behaviour symptom P23 Adolescent behaviour symptom P24 Specific learning problem P25 Phase of life problem adult P27 Fear of mental disorder P28 Limited function P29 Psychological symptom other P71 Organic psychosis other P72 Schizophrenia P73 Affective psychosis P74 Anxiety disorder/anxiety state P75 Somatization disorder P76 Depressive disorder P77 Suicide/suicide attempt P78 Neurasthenia/ surmenage P79 Phobia/compulsive disorder P80 Personality disorder P81 Hyperkinetic disorder P82 post-traumatic stress disorder P85 Mental retardation P86 Anorexia nervosa/bulimia P98 Psychosis NOS/other P99 Psychological disorders, other T06 Anorexia/bulimia
MHP ATC Code	N05A Antipsychotic drugs, N05B Anxiolytic drugs, N05C Hypnotics and sedative drugs, N06A Antidepressant drugs, N06BA02 dexamfetamine, N06BA04 methylphenidate N06BA09 atomoxetine N07BA drugs used in nicotine dependence or N07BB drugs used in alcohol dependence
MHP Referral to psychologist, psychiatry or psychotherapy	'eerste-lijnspsychologie' 'EERSTE-LIJNSPSYCHOLOGIE', 'GGZ-instelling', 'psychiatrie''PSYCHIATRIE' 'psychologische zorg' 'PSYCHOLOGISCHE ZORG' 'psychotherapie' 'PSYCHOTHERAPIE', 'ELP' 'ELP eerste-lijnspsyc' 'ggz' 'GGZ' 'PSL' 'PSL psychologische z' 'PSL Psycholoog' 'PST' 'PST' 'PSY' 'PSY psychiatrie' 'PSY' 'Psychiatrie' 'PTH' 'PTH psychotherapie'
Internalizing MHP ICPC Codes	P01 Feeling anxious P02 Acute stress reaction P03 Feeling depressed P74 Anxiety disorder/anxiety state P75 Somatization disorder P76 Depressive disorder P77 Suicide/suicide attempt
Internalizing MHP ATC Codes	N05B Anxiolytic drugs N06A Antidepressant drugs

MHP = mental health problem, ICPC = International Classification of Primary Care, ATC = Anatomical Therapeutic Chemical, a medication classification(20, 21)

Supplement table 2. Definition of predictor variables

Variable
Age
Gender
Medical conditions
Congenital anomaly
Disabilities
Chronic Disease
Neoplasms

	Definition
	Age in years based on birth year
	Recorded as in EMR: male or female
	ICPC A90 Congenital anomaly OS/multiple, B78 Hereditary haemolytic anaemia, B79 Congenital anomaly Blood/lymph other, D81 Congenital anomaly digestive system, F81 Congenital anomaly eye other, H80 Congenital anomaly of ear, K73 Congenital anomaly cardiovascular, L82 Congenital anomaly musculoskeletal, N85 Congenital anomaly neurological, R89 Congenital anomaly respiratory, S81 Haemangioma/lymphangioma, S82 Naevus/mole, S83 Congenital skin anomaly other, T78 Thyroglossal duct/cyst, T80 Congenital anomaly endocrine/metabolic, U85 Congenital anomaly urinary tract, W76 Congenital anomaly complicate pregnancy, X83 Congenital anomaly genital female, Y82 Hypospadias, Y84 Congenital genital anomaly male other
	ICPC A28 Limited function/disability NOS; The remaining ICPC codes refer to the limited function/disability codes of the corresponding chapters B28, D28, F28, H28, K28, L28, N28, P28, R28, D28, T28, U28, X28, Y28, Z28,
	≥1 of the following: Asthma, Eczema, Psoriasis, Crohn, Inflammatory bowel disease IBD, Epilepsy, Diabetes Mellitus DM, Cystic Fibrosis CF, Rheumatoid Arthritis RA Asthma ICPC R96 ATC R03, Eczema/psoriasis ICPC S91 Psoriasis, IBD ICPC D94, S86 Dermatitis seborrhoeic S87 Dermatitis/atopic eczema S88 Dermatitis contact/allergic ATC D07 Dermatological corticosteroids, Epilepsy ICPC N88 ATC N03 anti-epileptics, DM ICPC T89 T90 ATC A10 drugs used in diabetes, CF T99.10, RA L88
	ICPC B75 Benign/unspecified neoplasm blood, D78 Neoplasm digest. benign/uncertain, F74 Neoplasm of eye/adnexa, H75 Neoplasm of ear, K72 Neoplasm cardiovascular, L71 Malignant neoplasm musculoskeletal N75 Benign neoplasm nervous system N76 Neoplasm nervous system unspecified, R86 Benign neoplasm respiratory, S78 Lipoma, S79 Neoplasm skin/benign/unspecified, S80 Solar keratosis/sunburn, T72 Benign neoplasm thyroid, T73 Neoplasm endocrine other/unspecified, U78 Benign neoplasm urinary tract, U79 Neoplasm urinary tract NOS, W73 Benign/unspecified. Neoplasm/pregnancy, X78 Fibromyoma uterus, X79 Benign neoplasm breast female, X80 benign neoplasm female genital, X81 genital neoplasm other/unspecified Y79 Benign/unspecified. Neoplasm gen. male, Y85 Benign prostatic hypertrophy, A79 Malignancy NOS, B72 Hodgkin's disease/lymphoma, B73 Leukaemia, B74 Malignant neoplasm blood other, B75 Benign/unspecified neoplasm blood, D74 Malignant neoplasm stomach, D75 Malignant neoplasm colon/rectum, D76 Malignant neoplasm pancreas, D77 Malignant neoplasm digest other/NOS, N74 Malignant neoplasm nervous system, R84 Malignant neoplasm bronchus/lunch, R85 Malignant neoplasm respiratory, other, S77 Malignant neoplasm skin, T71 Malignant neoplasm thyroid, U75 Malignant neoplasm of kidney, U76 Malignant neoplasm of bladder, U77 Malignant neoplasm urinary other, W72 Malignant neoplasm relate to pregnancy, X75 Malignant neoplasm cervix, X76 Malignant neoplasm breast female, X77 Malignant neoplasm genital other female, Y77 Malignant neoplasm prostate, Y78 Malignant neoplasm male genital other

Supplement table 2. Continued

Variable
Prematurity/other perinatal morbidity
Lower socioeconomic status
Life events in past year
Academic problems
Difficult temperament
Developmental problem
Chronic somatic disorder parent
Somatic complaints

Healthcare use
Number of primary care visits in past year
Number of laboratory tests in past year
Number of medication prescripts in past year
Number of referrals/correspondences with other healthcare professionals (non-mental health)

MHP = mental health problem, ICPC = International Classification of Primary Care, ATC = Anatomical Therapeutic Chemical, a medication classification(20, 21)

	Definition
	ICPC A93 Premature newborn, A94 Perinatal morbidity other
	Postcode marked as lower socioeconomic area: 0-20th percentile of Socioeconomic status (SES) score(29)
	ICPC Z15 Loss/death of partner problem, Z22 Illness problem parent/family, Z23 Loss/death parent/family problem, Z25 Assault/harmful event problem
	ICPC Z07 Education problem
	ICPC A14 Infantile colics, A15 Excessive crying infant, A16 Irritable Infant, T04 Feeding problem of infant/child
	ICPC T10 Growth delay, N19 Speech disorder
	No specific ICPC code, partly part of 'life event' with ICPC code Z22 Illness problem parent/family
	≥1 of the following: Tension headache, Migraine, Abdominal pain, Constipation, Tiredness, Irritable bowel syndrome IBS, Musculoskeletal symptoms, Dizziness, Nausea, Hyperventilation syndrome, Palpitations, Fainting. Tension headache ICPC N01 Headache N02 Tension headache, Migraine ICPC N89 ATC N02C, Abdominal pain ICPC D01 Abdominal pain/cramps general D06 Abdominal pain localized other, Constipation ICPC D12, ATC 06 Drugs for constipation, Tiredness ICPC A04 Weakness/ tiredness general. IBS ICPC D93, IBS ATC A03A Drugs for functional gastrointestinal disorders A03F Propulsives, Musculoskeletal symptoms ICPC symptom/complaint of: L01 Neck L02 Back L03 Lower back L08 L20 Joint, Dizziness ICPC H82 Vertiginous syndrome N17 Vertigo/ dizziness, Nausea ICPC D09 Nausea, Hyperventilation syndrome ICPC R98 Hyperventilation syndrome ICPC R86, Palpitations ICPC K04 palpitations K05 irregular heartbeat other, Fainting ICPC A06 Fainting/syncope

	Count per year
	Count per year
	Count per year
	Count per year

Chapter 4

The usefulness of electronic health records from preventive youth healthcare in the recognition of child mental health problems

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Abstract

Background and Objectives*:* Early identification of child mental health problems (MHPs) is important to provide adequate, timely treatment. Dutch preventive youth healthcare monitors all aspects of a child's healthy development. We explored the usefulness of their electronic health records (EHRs) in scientific research and aimed to develop prediction models for child MHPs.

Methods: Population-based cohort study with anonymously extracted electronic healthcare data from preventive youth healthcare centers in the Leiden area, the Netherlands, from the period 2005-2015. Data was analysed with respect to its continuity, percentage of cases and completeness. Logistic regression analyses were conducted to develop prediction models for the risk of a first recorded concern for MHPs in the next scheduled visit at age 3/4, 5/6, 10/11 and 13/14 years.

Results: We included 26,492 children. The continuity of the data was low and the number of concerns for MHPs varied greatly. A large number of determinants had missing data for over 80% of the children. The discriminatory performance of the prediction models was poor.

Conclusions: This is the first study exploring the usefulness of EHRs from Dutch preventive youth healthcare in research, especially in predicting child MHPs. We found the usefulness of the data to be limited and the performance of the developed prediction models was poor. When data quality can be improved, e.g. by facilitating accurate recording, or by data enrichment from other available sources, the analysis of EHRs might be helpful for better identification of child MHPs.

Introduction

Despite having different healthcare systems, most high-income countries provide some form of preventive childcare that aims to monitor a child's healthy development during the first years of life(1-3). In the Netherlands, preventive well-child care is separated from curative care. Nurses and community paediatricians (preventive youth healthcare professionals (PYHPs)) provide free of charge preventive healthcare for all children aged 0 to 19 years during periodic health check-ups(4). The goal of these check-ups is to prevent disease, promote health and allow early identification of health risks, disease, and developmental problems(4). Over 80-90% of children are regularly seen in preventive youth healthcare (PYH)(5, 6). PYHPs work closely together with, amongst others, professionals in schools and in case of issues, PYHPs can provide additional advice or schedule extra visits, or refer children to family physicians (FPs) or to specialized care(4). Part of the role of PYHPs also concerns prevention and early identification of mental health problems. Mental health problems (MHPs) affect 10-20% of children and adolescents worldwide(7). MHPs are the leading cause of health-related burden in the first three decades of life(8). Half of all lifetime MHPs occur by the age of 14 years and 75% by the age of 24 years(9). To minimize the impact of MHPs, early identification is important so that adequate treatment can be provided(10).

Although PYH has an important role in the identification of MHPs as most children are regularly seen in PYH, a substantial part of MHPs is not being recognized by PYHPs(11). In order to improve the identification of child MHPs, several studies investigated the development of prediction models to identify MHPs with routine healthcare data from British and Dutch FPs. The models showed moderate predictive performances(12, 13). In the Dutch study, information regarding risk factors for MHPs related to the child's family (e.g. parental education level, parental MHPs), environment (life events) and school performance was not well recorded in electronic health record (EHRs) of the child(13). These risk factors were important predictors for MHPs in a prospective cohort study among Dutch children from the general population in which the developed prediction model showed a good discriminative performance(14).

PYHPs gather this information regarding children and their families during check-ups and record this in the EHRs of the children, and so the information from these EHRs might potentially be useful in the identification of MHPs. For EHR data to be suitable for reuse in scientific research, the data needs to be complete, accurate and consistent(15). To our knowledge it is yet unknown how well and how complete the information is that is recorded in the EHRs. The aim of this study is to explore the usefulness of EHR data from Dutch PYH in predicting MHPs. Research questions are: what is the quality of the data and how well do they predict child MHPs?

Methods

Study design and setting

A population-based cohort study was carried out using data from children aged 0-19 years visiting PYH centers of the Regional Public Health Service Hollands Midden located in the greater Leiden area, the Netherlands. The data that was anonymously extracted from the EHRs included demographics, information regarding pregnancy, family and social circumstances and information from scheduled visits and extra consultations with PYH.

The data consisted of all EHR data from 2010-2015 and all summary data from a prior electronic registration system from 2005-2010 for children born between 1994 and 2012. During the first four years of life, around 15 PYH visits are scheduled. In both primary school (children age 4-11 years) and secondary school, (children age 12-18 years) children are generally seen twice(4). The routine visit in grade 4/5 of secondary school was implemented in 2014. For all school-aged children from one routine visit (timepoint 0 (T0)), we aimed to predict the presence of MHPs during the next routine visit (timepoint 1 (T1)), thereby creating four subpopulations (Table 1). This means that for children visiting PYH at age 5/6, we used the data at the previous standard routine visit at the age o 4 years to predict MHPs at age 5/6. We did the same for the other subpopulations.

Table 1. Overview of prediction moments and subpopulations

	T0 – Time point of measuring predictors	**T1 – Time point of measuring outcome determinants**
Population A	Last routine visit before primary school (age ±3-4 years)	Routine visit in grade 2 of primary school (age ±5-6 years)
Population B	Routine visit in grade 2 of primary school (age ±5-6 years)	Routine visit in grade 7 of primary school (age ±10-11 years)
Population C	Routine visit in grade 7 of primary school (age ±10-11 years)	Routine visit in grade 2 of secondary school (age ±13-14 years)
Population D	Routine visit in grade 2 of secondary school (age ±13-14 years)	Routine visit in grade 4 or 5 of secondary school (age ±15-16 years)

Outcomes

PYHPs are trained to recognize problems at an early stage. They can refer children to primary and secondary (mental) healthcare for further diagnostics or treatment. A PYHP's concern about MHPs can therefore be an early signal for child MHPs. Our main outcome was a first PYHP recorded concern for MHPs (CMHPs). We defined CMHPs 1) when PYHPs reported abnormal psychosocial functioning in the child's record, e.g.

problems in making contact with others or hyperactive behaviour and/or 2) when the child received extra healthcare regarding mental health (within PYH or within curative care) (Supplement Table 1). We also performed analyses with for when the outcome was only the element extra healthcare use for CMHPs as this reflects more severe MHPs.

Determinants

Possible determinants were selected based on a PYH guideline for psychosocial problems and a systematic review regarding determinants for identified MHPs in primary care (Supplement Table 2)(16, 17). In addition, an expert panel consisting of authors NK and MC, two FP's, a paediatrician and a PYHP, was consulted on possible determinants based on their knowledge and experience in addition to the systematic review and guidelines(13, 17). The determinants were measured up until T0. Most data was already labelled normal/abnormal. Validated cut off points, that are used in PYH, were applied to continuous data, e.g. for results of validated screening instruments Strengths and Difficulties Questionnaire (SDQ) and short indicative questionnaire for psychosocial problems among adolescents (KIVPA). The determinants number of extra healthcare visits in PYH and number of referrals were dichotomized into ≥1 yes/no. Some determinants can change over time, we then included either the first or last registered value at T0. For the other determinants we included the first known registered value. Due to sparseness of the data, we clustered closely related determinants: for example the determinant "Substance use" consisted of the items "alcohol use," "drugs use," "smoking," "water pipe us," and a more general item "substance abuse/addiction" (Supplement Table 2). PYHPs can also include information in free text fields, due to privacy reasons we did not have access to this free text.

Usefulness of the data for research

The usefulness, including completeness and validity, of the data was assessed by investigating the number of cases (children with CMHPs), missing data and the continuity of the data, i.e. the overlap in children between populations. As children are followed in time, we expected a continuity in the data, resulting in overlapping populations.

Most determinants should either be always present in EHRs as they would always be checked during visits, e.g. length and weight, or would only be recorded in case of abnormality, e.g. smoking. The determinants SDQ and KIVPA should always be recorded, so their absence could have significance. Missingness could also mean an abnormal value and could be predictive. We therefore included a missing category in the analyses for the SDQ and KIVPA(18, 19). For the other determinants we assumed that in case a determinant was not registered, the value of the determinant was normal(20).

Statistical analyses

Descriptive statistics were carried out with SPSS (version 25). If a determinant was present in <1% of the children in a subpopulation, the determinant was not included in the analysis of that subpopulation. As we aimed to predict a first recorded CMHP, we excluded children with CMHPs before or at T0. To develop prediction models for a first recorded CMHP, we performed logistic regression analyses with R (version 3.5.3)(21-24). The ability of the model to distinguish between children who are recognized with a first CMHP and those who are not (discrimination), was assessed using the c-statistic or concordance statistic(25). A c-statistic can have a value of 0 to 1, with a value of 0.5 meaning that the model is no better at predicting CMHP than random chance. The closer the value is to one the better the model. The in-sample calibration of the model was assessed by the calibration plot of actual probabilities versus predicted probabilities. The models were internally validated using bootstrap resampling (500 bootstrap samples) and estimating shrinkage factors(26). Brier scores were calculated to assess the average prediction error: it quantifies how close predictions are to the actual outcome and can range from 0 for a perfect model to 0.25 for a non-informative model with a 50% incidence of the outcome (with a lower incidence of the outcome the maximum score for a non-informative model is lower)(27, 28).

The Ethics Committee of the Leiden University Medical Centre issued a waiver of consent (G16.018).

Role of the funding source

This study was supported by ZonMW, the Netherlands, Organization for Health Research and Development (grant 839110012). ZonMW did not have any role in study design, the collection, analysis, and interpretation of data, the writing of the report and the decision to submit the paper for publication.

Results

Usefulness of the data for research

This study included 26,492 children. The number of children per subpopulation ranged between 1,265 (population D) and 10,789 children (population C) (Table 2). The number of children excluded because of CMHPs ≤T0 varied between 402 (population A) and 3,088 (population D). The overlap in children between subpopulations was low and the number of CMHPs varied greatly between populations. Population C had a high number of CMHPs, much higher than the other subpopulations, which might be largely explained by limited overlap in children between population B and C. We assumed that population C contained not only incident cases but also prevalent cases of CMHPs, which could not be excluded since no prior information of these children from before the age of 10 was present. For population B the overlap with previous years was also small, but in that population, it concerned data from the pre-school period. During the pre-school period MHPs are less frequently identified and therefore the CMHPs in population B were more likely to refer to incident CMHPs(29, 30).

Since our aim was to predict incident CMHPs and different determinants can play a role in incident or prevalent cases, we excluded population C from further analyses.

The amount of missing data from the determinants ranged from 4.4% to 100%, a large number of determinants had missing data for over 80% of the children (Supplement Table 3).

Table 2. Overview of subpopulation and outcomes

Study subpopulation	A	B	C	D
Number of children included (n)	10,146	6,606	10,779	1,265
Number of children excluded as CMHPs <T0 (n)	402	2494	1,599	3,088
Overlap in children with previous population (%)	Not applicable	0.3%	13.7%	64.7%
CMHPs, % (n)	35.8 (3,628)	8.5 (564)	57.8 (6,276)	7.1 (90)
a) Extra healthcare use only, % (n)	2.8 (283)	5.0 (327)	3.3 (362)	3.8 (48)
b) Abnormal mental health functioning only, % (n)	25.0 (2,538)	1.0 (63)	36.5 (3,962)	0.9 (12)
c) Both extra healthcare use and abnormal mental health functioning, % (n)	8.0 (807)	2.6 (174)	18.0 (1,952)	2.3 (30)
Extra healthcare use, total of a) and c)	10.7 (1,090)	7.6 (502)	21.4 (1,343)	6.2 (78)

CMHPs = concerns for mental health problems

Prediction of a first concern of mental health problems

Population A

Population A consisted of 10,146 children aged 3-4 years of which 3,628 children (35.8%) had a first recorded CMHPs during the next routine visit at age 5-6 years (Table 2). Determinants for CMHPs were male gender, developmental problems, family history of MHPs, extra healthcare visit in PYH and a negative balance in protective factors and risk factors for a child's healthy development (Tables 3 and 4). A non-spontaneous birth was associated with a decreased risk of CMHPs. Extra healthcare use for CMHPs was recorded in 10.7% of all children. Family history of MHPs and a negative balance were associated with this extra healthcare use (Table 5). In addition, children with an extra healthcare visit in PYH or environmental stressors were less likely to receive extra healthcare use for CMHPs.

Table 3. Baseline characteristics study population

Characteristics[a]	Population A N=10,146 % (n)	Population B N= 6,606 % (n)	Population C N= 10,789 % (n)	Population D N=1,265 % (n)
CMHPs	35.8 (3,628)	5.8 (564)	58.2 (6,276)	7.1 (90)
Age in years (mean, sd)	3.96 (0.14)	5.85 (0.46)	10.96 (0.52)	13.88 (0.53)
Male gender	50.3 (5,103)	48.1 (3,176)	49.5 (5,339)	48.8 (617)
Ethnicity	0.0 (0)	0,6 (42)	0.0 (0)	4.4 (56)
Premature	5.1 (518)	0.0 (0)	0.4 (41)	0.9 (12)
Neonatal problems	1.1 (116)	2.7 (181)	0.4 (48)	0.2 (3)
Non-spontaneous birth	9.0 (909)	0.0 (2)	1.1 (114)	3.9 (49)
Developmental problems	3.0 (304)	2.1 (136)	0.5 (49)	0.9 (11)
Incontinence	NA	0.6 (41)	0.7 (76)	0.9 (12)
Excessive crying	0.1 (12)	NA	NA	NA
Sleeping problems	0.2 (16)	0.1 (8)	0.0 (0)	0.1 (1)
Eating problem	0.0 (0)	0.2 (12)	0.0 (4)	0.0 (0)
Overweight	8.6 (871)	2.5 (167)	7.4 (802)	13.0 (164)
Underweight	14.2 (1,442)	4.8 (320)	4.6 (497)	10.4 (132)
School problem	0.1 (12)	1.5 (102)	0.5 (54)	0.9 (12)
Secondary school level low	NA	NA	15.1 (1,628)	31.9 (404)
Secondary school level high	NA	NA	0.0 (0)	28.7 (363)
Secondary school level other	NA	NA	0.0 (3)	0.6 (8)
Bullying/being bullied	NA	0.0 (2)	0.0 (4)	0.2 (2)

Table 3. Baseline characteristics study population

Characteristics[a]	Population A N=10,146 % (n)	Population B N= 6,606 % (n)	Population C N= 10,789 % (n)	Population D N=1,265 % (n)
Low self-confidence/resilience	0.1 (13)	0.1 (8)	0.0 (0)	0.0 (0)
Member of hobby/music club	NA	0.0 (1)	96.4 (10,405)	0.0 (0)
Insufficient physical exercise	0.0 (0)	0.0 (0)	1.0 (103)	0.2 (3)
Substance use	NA	NA	0.1 (8)	0.0 (0)
High technology use	0.0 (0)	0.0 (0)	6.8 (729)	0.4 (5)
SDQ borderline	NA	3.0 (197)	6.3 (682)	4.8 (61)
SDQ increased	NA	1.4 (95)	4.1 (447)	2.1 (27)
SDQ missing	NA	32.1 (2,121)	40.4 (4,364)	43.1 (545)
KIVPA increased	NA	NA	NA	6.2 (78)
KIVPA missing	NA	NA	NA	4.6 (58)
Under treatment	0.0 (0)	15.7 (1,035)	2.8 (306)	4.0 (51)
Total referral	6.1 (614)	0.1 (5)	0.1 (6)	0.7 (9)
Extra healthcare visit	33.5 (3,398)	9.4 (621)	11.2 (1,208)	26.1 (330)
Life events	4.4 (442)	9.8 (648)	6.6 (708)	7.5 (95)
Family related				
Family history of MHPs	2.1 (217)	1.8 (117)	0.5 (53)	0.9 (11)
Chronic illness parent	3.1 (315)	0.3 (21)	0.8 (81)	0.7 (9)
Risk factor parents	3.3 (334)	11.3 (749)	8.1 (870)	7.6 (96)
Prenatal risk factors	5.0 (503)	0.0 (0)	0.7 (75)	2.2 (28)
Non-traditional family composition	1.4 (146)	0.7 (49)	0.7 (79)	11.8 (149)
Negative balance	2.5 (253)	0.2 (10)	NA	NA
Little confidence in parenting skills	0.1 (15)	1.0 (66)	0.1 (14)	0.2 (2)
Environmental stressors	7.9 (799)	0.6 (38)	2.7 (287)	6.0 (76)
Nr of Contact moments available (median, IQR)	6 (5)	4 (2)	3 (2)	4 (2)

[a] Determinants were excluded from analysis when the determinant was present in <1% of the children of a population. The determinant incontinence is excluded in study population A because before primary school(T0) incontinence is considered normal. CMHPs = concerns for mental health problems, NA = not applicable, SDQ = Strengths and difficulties questionnaire, KIVPA = short indicative questionnaire for psychosocial problems among adolescents, MHPs = mental health problems

Table 4. Results of logistic regression analysis for a first recorded concern for MHPs

Characteristics	Study population A N=10,146 nr of events 3,628		
	Coefficient	**OR**	**95% CI**
Intercept	-0.91		
Male gender	0.31	1.30	1.20-1.41
Ethnicity			
Premature	0.19	1.14	0.95-1.37
Neonatal problems	0.02	0.95	0.64-1.42
Non-spontaneous birth	-0.17	0.77	0.66-0.90
Developmental problems	0.46	1.53	1.21-1.93
Overweight	0.20	1.15	0.99-1.33
Underweight	-0.02	0.91	0.81-1.03
Negative weight perception			
School problem			
Secondary school level low			
Secondary school level high			
SDQ borderline			
SDQ increased			
SDQ missing			
KIVPA increased			
KIVPA missing			
Under treatment			
Total referral	0.06	0.99	0.83-1.18
Extra healthcare visit	0.16	1.11	1.01-1.22
Life events	0.26	1.22	1.00-1.50
Family history of MHPs	0.50	1.60	1.21-2.12
Chronic illness parent	-0.08	0.85	0.67-1.09
Risk factor parents	0.03	0.96	0.76-1.22
Prenatal risk factors	0.04	0.97	0.79-1.18
Non-traditional family composition	0.06	0.99	0.69-1.41
Negative balance	0.77	2.12	1.64-2.75
Little confidence in parenting skills			
Environmental stressors	0.12	1.06	0.91-1.23
C-statistic corrected	0.54		
Shrinkage factor B=500	0.93		
Brier score	0.22		

SDQ = Strengths and difficulties questionnaire, KIVPA = short indicative questionnaire for psychosocial problems among adolescents, MHPs = mental health problems

Study population B N= 6,606 nr of events 564			Study population D N=1,265 nr of events 90		
Coefficient	**OR**	**95% CI**	**Coefficient**	**OR**	**95% CI**
-2.50			-1.90		
0.14	1.07	0.90-1.28	-0.12	0.48	0.31-0.75
			-0.39	0.30	0.09-1.04
-0.18	0.76	0.43-1.36			
0.69	1.94	1.22-3.09			
-0.24	0.71	0.39-1.30	-0.01	0.59	0.30-1.09
0.01	0.93	0.61-1.40	-0.20	0.42	0.19-0.94
0.72	2.02	1.21-3.38			
			0.19	0.81	0.47-1.41
			0.16	0.77	0.44-1.37
1.20	3.37	2.17-5.27	0.41	1.18	0.45-3.07
0.06	0.99	0.53-1.84	0.01	0.59	0.15-2.32
0.01	0.93	0.77-1.14	0.20	0.83	0.51-1.36
			0.71	1.95	1.00-3.80
			0.70	1.95	0.89-4.28
0.00	0.92	0.72-1.17	-0.47	0.26	0.07-0.92
0.07	1.00	0.77-1.33	0.35	1.06	0.64-1.75
0.70	1.97	1.55-2.49	0.71	1.98	0.96-4.09
0.55	1.67	1.00-2.79			
0.21	1.16	0.90-1.50	0.13	0.73	0.32-1.64
			-0.67	0.19	0.02-1.49
			0.01	0.59	0.30-1.17
0.66	1.88	1.03-3.44			
			-0.58	0.23	0.07-0.81
0.57			0.40		
0.92			0.59		
0.08			0.06		

Table 5. Results of logistic regression analysis for the first recorded Extra healthcare use for concerns for MHPs

Characteristics	Study population A N=10,146 nr of events 1,090		
	Coefficient	OR	95% CI
Intercept	-1.95		
Male gender	0.24	1.12	0.98-1.27
Ethnicity			
Premature	0.05	0.79	0.59-1.07
Neonatal problems	0.32	1.22	0.70-2.14
Non-spontaneous birth	-0.15	0.71	0.56-0.90
Developmental problems	0.28	1.17	0.84-1.63
Overweight	0.17	1.03	0.83-1.28
Underweight	0.00	0.84	0.70-1.01
School problem			
Secondary school level low			
Secondary school level high			
SDQ borderline			
SDQ increased			
SDQ missing			
KIVPA			
KIVPA missing			
Under treatment			
Total referral	0.12	0.97	0.75-1.26
Extra healthcare visit	-0.03	0.81	0.70-0.94
Life events	0.20	1.06	0.80-1.41
Family history of MHPs	0.66	1.85	1.31-2.62
Chronic illness parent	-0.15	0.70	0.48-1.03
Risk factor parents	0.29	1.18	0.86-1.62
Prenatal risk factors	-0.10	0.75	0.55-1.02
Non-traditional family composition	0.20	1.07	0.66-1.72
Negative balance	0.48	1.49	1.07-2.07
Little confidence in parenting skills			
Environmental stressors	-0.28	0.60	0.46-0.78
C-statistic corrected	0.48		
Shrinkage factor B=500	0.84		
Brier score	0.10		

SDQ = Strengths and difficulties questionnaire, KIVPA = short indicative questionnaire for psychosocial problems among adolescents, MHPs = mental health problems

	Study population B N= 6,606 nr of events 502			Study population D N=1,265 nr of events 78		
	Coefficient	**OR**	**95% CI**	**Coefficient**	**OR**	**95% CI**
	-2.58			-1.95		
	0.14	1.06	0.88-1.28	-0.20	0.41	0.25-0.66
				-0.33	0.32	0.09-1.12
	-0.12	0.79	0.43-1.44			
	0.76	2.10	1.31-3.36			
	-0.32	0.64	0.33-1.23	-0.11	0.47	0.23-0.97
	0.01	0.91	0.59-1.40	-0.23	0.39	0.16-0.91
	0.23	1.17	0.63-2.18			
				0.18	0.79	0.43-1.44
				0.23	0.86	0.47-1.58
	1.12	3.10	1.95-4.94	0.47	1.31	0.48-3.59
	0.20	1.12	0.59-2.14	-0.18	0.41	0.08-2.05
	-0.03	1.88	1.52-2.31	0.20	0.82	0.48-1.38
				0.65	1.79	0.88-3.64
				0.72	2.02	0.88-4.64
	0.02	0.92	0.72-1.19	-0.39	0.29	0.08-1.04
	0.09	1.01	0.74-1.36	0.33	1.03	0.60-1.75
	0.72	2.01	1.57-2.56	0.81	2.35	1.12-4.93
	0.53	1.62	0.95-2.76			
	0.24	1.18	0.90-1.54	0.24	0.88	0.38-2.00
				-0.66	0.18	0.02-1.48
				0.03	0.60	0.29-1.23
	0.60	1.76	0.94-3.30			
				-0.48	0.25	0.07-0.90
	0.57			0.41		
	0.91			0.57		
	0.07			0.06		

Population B

In 564 (8.5%) children aged 5-6 years, a first recorded CMHPs was found during the next visit at age 10-11 years (population B). Extra healthcare use for CMHPs was recorded in 502 (7.6%) of children. The determinants developmental problems, school problems, SDQ borderline test results, life events and parents' little confidence in parenting skills were associated with an increased risk of CMHPs. Other determinants were not associated with CMHPs. The analysis with extra healthcare use for CMHPs showed similar results apart from school problems and little confidence in parenting skills both showing no association with the outcome.

Population D

Population D included 1,265 children aged 13-14 years of which 90 (7.0%) had a first recorded CMHPs at age 15-16 years. Extra healthcare use for CMHPs was recorded in 78 (6.2%) children. Male gender, being underweight, being under treatment for any reason and environmental stressors were associated with a decreased risk of CMHPs. An increased KIVPA score was associated with an increased risk of CMHPs. Regarding the outcome extra healthcare use for CMHPs results were similar, apart from extra healthcare visit within PYH, being under treatment and environmental stressors not being associated with extra healthcare use for CMHPs. In addition, children being overweight or underweight were less likely to receive extra healthcare use for CMHPs. Other determinants, including increased SDQ scores were not associated with both outcomes.

Model performance

The models' discriminatory accuracies for a first recorded CMHPs were low with corrected c-statistics of, respectively, 0.54, 0.57 and 0.40 for populations A, B and D. Internal validation for the models showed shrinkage factors of 0.93 for population A, 0.82 for population B and 0.54 for population D and varying calibration (Supplement figure 1). The Briers scores varied from 0.07/0.08 (population D and B) to 0.22 (population A). Regarding the models for extra healthcare use for CMHPs, the c-statistics were slightly lower with a range of 0.41-0.57. Shrinkage factors and Brier scores were similar.

Discussion

In this population-based cohort study we explored the usefulness of routine healthcare data from Dutch PYH in predicting MHPs. The usefulness of the data was suboptimal as the number of cases differed greatly between subpopulations, a substantial part of the data was missing and the continuity of the data, i.e. following children for a longer time period resulting in overlapping populations, was much less than expected. We aimed to develop prediction models in school-aged children visiting PYH that would predict first concerns for MHPs during the next routine check-up in PYH. Unfortunately, the discriminatory performances of the models were poor and the models in their current form appeared not to be useful in the early identification of MHPs.

The use of data from routine EHRs has become increasingly popular over the past years, also for policy purposes(31). To our knowledge this is the first study exploring the usefulness of EHRs from Dutch PYH in predicting child MHPs. Our population-based cohort study reflects Dutch routine PYH and gives an insight in the current state of the electronic healthcare registration of PYH. Although we expected that there would be a continuity in the data as we aimed to follow children for a longer time, we observed little overlap between the different subpopulations. Our time window of 2005-2015 and the fact that children can go to secondary schools outside the region, meaning they are monitored by a different regional PYH of which we did not possess data, might play a role, but we expect other (technical) reasons we are not yet aware of to also play a role: such as changes in registration systems (e.g. the change from paper to digital in 2010) in which data from the old system needed to be migrated to the new system). This meant that it was difficult to exclude prevalent CMHP cases from successive populations. In population C for instance, 58% of the children were found to have CMHPs, much higher than expected according to literature(7, 17). Population D was small, as the timepoint 1 visit was only implemented in 2014, this resulted in less stable models.

The electronic system PYHPs use to record findings from clinical care is technically built in such a manner that important information from previous consultations should remain present in the system. For instance, information on ethnicity, pregnancy and birth weight would still be present during visits in primary school. However, in our extracted data, this was not always the case, resulting in substantial missing data for many of these unchangeable determinants. We do not think missing data played a large role in our outcome, as (extra healthcare use for) CMHPs when present, would be a specific finding PYHPs would register as it is part of the basic tasks of PYH. Missing data in routine healthcare datasets are a known problem(20). One way to reduce the effect of missing data is imputation. However within routine healthcare data, missing data is seldom solely missing at random, which means you

have to carefully choose your method of imputation and choosing not to impute might even be the better option(18, 20). In this study, we applied the commonly used assumption that a missing value would indicate a negative value, or in other words 'if it is not mentioned, it is not there'(20) for most determinants. Given the large amount of missing data, we question whether this assumption still holds as prevalence rates of determinants such as family MHPs or smoking were lower than expected from literature(32, 33). For determinants SDQ and KIVPA, which should be filled out by all parents of primary school students and adolescents in secondary schools prior to visiting a PYH and is registered standardly in the registration system, we included a missing category as missing data could refer to parents not being able (illiteracy, non-Dutch) or wanting to fill out the questionnaire, which could be predictive. This did not result in better performing models. Our study was the first study examining routine healthcare data from preventive youth healthcare with regards to child MHP identification. Such medical registries were originally built to assist healthcare professionals in daily practice, they were not built for research purposes. It is known that it takes time to improve medical registries in such way that they can be better used for research purposes(34).

Several strategies to improve the quality of electronic healthcare data are suggested in the literature, which could also apply to the electronic health data of PYH(20). Training professionals in accurate recording has proven to enhance the quality of registered data in primary care(34). Another suggested strategy is the implementation of information from external sources(20). Part of the missing data in this study, e.g. information regarding parental educational level, financial problems, and information regarding birth and pregnancy, could possibly be improved by linking data from Statistics Netherlands and the Dutch Perinatal Registry(35, 36). Another solution might be the implementation of short electronic questionnaires prior to scheduled visits in which parents fill out relevant information with an automatic upload into the child's EHR. Or, like the Dutch Perinatal Registry, create a national dataset with key information which is gathered in a standardized way. An even more advanced option would be a shared digital record in which parents and PYHPs can both record information. PYHPs can also include relevant information regarding determinants in free text which we did not have in our extraction due to privacy reasons. We recommend to repeat this study with improved data and to investigate the usefulness of free text, for instance with natural language processing techniques(37).

The developed models in this study had a poor predictive performance, however we found that some known risk factors for MHPs had a predictive value. In addition, several determinants such as previous extra PYH visits and school problems, were associated with CMHPs, but not with extra healthcare use for CMHPs, meaning that PYHPs have concerns and monitor, but do not opt for extra care. Determinants like environmental

stressors and parental concerns regarding parenting skills were even associated with a decreased risk of extra healthcare use for CMHPs. This could indicate that PYHs have concerns regarding the child's environment rather than regarding MHPs of the child itself. One can imagine that PYPHs in this case would use preventive interventions aimed at the child's environment, like Triple P, which could affect children positively(38). Regarding life events, our study suggests that PYHPs are less likely to monitor as life events in the older age groups were associated with an increased risk of (extra healthcare use for) CMHPs. In addition, because our outcome measurement CMHPs is based on the judgement of PYHPs and is not an objective measurement, this makes predicting CMHPs more difficult to begin with.

Increased SDQ-scores for psychosocial problems had limited prognostic value, whereas borderline increased SDQ-scores were associated with an increased risk of (extra healthcare use for) CMHPs. This can be explained by the fact that SDQ-scores were measured at T0. We saw that children with increased SDQ-scores at T0 were more likely to have registered CMHPs at the same T0 and would therefore be excluded from our study. This was less likely for the borderline scores. Another explanation can be that screening instruments are not always predictive for PYHPs' actions and concerns. Mieloo and colleagues found that when using a screening instrument, 38% of the children with an increased score on that instrument were registered as such by the PYHP and 22% of the children with an increased score were referred for extra care(39). It would be interesting to investigate what PYHPs do with increased SDQ-scores, also during later visits.

In contrast to our findings, a prospective cohort study in the Dutch general population which developed models that estimated the risk of MHPs in adolescents showed a good performance(14). In this study, information on determinants was collected via questionnaires that were sent to the parents. Important determinants for MHPs were, amongst others, maternal educational level, family history of psychopathology and environmental stressors such as frequently moving house, severe disease or death in the family, and parental divorce(14). A lot of these determinants did not show a positive association with CMHPs in our study although they are known risk factors for MHPs(16). A possible explanation for this might be the high number of missing values in this study.

We are aware that the data we used in this study is specific to the Dutch healthcare system and the registration used in this particular region, and we expect the generalizability of our findings to be limited in other settings. However, many countries do have a form a preventive youth healthcare or well-child clinics, that monitor a child's healthy development in some way(1-3). In addition, validated mental health screening instruments are widely used(40).

Depending on the type of preventive youth healthcare and digital registration used, we would recommend adapting our current approach to different settings and available routine healthcare data to explore the possibilities of digital information from preventive youth healthcare for the early identification of child MHPs.

Conclusion

In conclusion, this study explored the usefulness of data acquired from EHRs from Dutch PYH in estimating the risk of mental health problems in children. The data quality was sub-optimal and the developed prediction models showed poor performances. When data quality can be improved by facilitating accurate recording and increasing the proportion of data that can be entered through forms of structured input, EHR data from PYH is likely to be valuable in its contribution to the timely recognition of child MHPs.

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Supplementary Files

Supplement Table 1. Definition of outcome concerns for mental health problems (CMHPs)

Outcome	Definition
Extra healthcare use for MHPs (≥1 components)	≥1 referral to a mental health specialist with indication mental health
	≥1 consultation with a mental health specialist with indication mental health
	Extra healthcare use between standard visits with indication mental health
	≥1 intervention for mental health: -Triple P[a] level 3 or higher and tip sheets (fears in children, stealing, dealing with fear or depression)
Finding of abnormal mental health functioning (≥1 components)	Atypical mental health functioning (single examination by a community pediatrician)
	≥1 abnormal specific mental health functioning recorded

[a]Triple P = "Positive Parenting Program", a multilevel program to support parents with children aged 0-16 years with the aim of reducing the prevalence of MHPs, emotional and behavioural problems in children by teaching parents parenting skills. The multilevel program has 5 intensity levels, with level 5 as the most intensive program.(38, 41)
MHPs = mental health problems

Supplement Table 2. Definition of determinants

Determinant	Definition[a]	Timing: first or last recorded measurement ≤T0
Gender	First recorded gender in electronical child record	First
Premature	Pregnancy duration <37 weeks or 259 days	First
Ethnicity	Immigrant/refugee Country of birth of ≥1 parent is other than the Netherlands or Western-Europe (e.g. Suriname Dutch Antilles, Turkey, Morocco, Eastern Europe, other non-Western countries)	First
Nonspontaneous birth	Caesarean section, vaginal birth with forceps or vacuum extraction	First
Delay in development	General developmental delay and/or speech and language delay at age 7 years and older	First

Supplement Table 2. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤To
Incontinence for urine or faeces	Incontinent for urine or faeces at age 4 years and older	Last
Excessive crying	Excessive crying, more than a short phase	First
Sleeping problems	Sleeping problems	Last
Eating Problem	Eating Problem	Last
Overweight	BMI classified as overweight or obese according to international age and gender specific standards(33, 34)	To
Underweight	BMI classified as underweight according to international age and gender specific standards(42, 43)	To
Negative weight perception	Negative perception of own weight (too light or too heavy)	To
School problem	Any reported problems in school e.g. dyslexia, difficulty focusing, motivation problems, absenteeism or declining school performance	First
Secondary school education level	Secondary school education level divided into 3 categories according to the Dutch school system: -low: VMBO or lower -middle: HAVO (reference category) -high: VWO -Other: in case of special education or no education; HAVO is reference category) When combined education levels were recorded, the lowest level was chosen, e.g. HAVO for HAVO/VWO(44)	Last
Bullying/being bullied	Bullying or being bullied	First
Bad relationship with at least one parent	Bad relationship with at least one parent	Last
Low self-confidence/ resilience	Low self-confidence/ resilience	Last
Self-harm	Self-mutilation or suicidal thoughts	First
Female genital mutilation	Female genital mutilation	First

Supplement Table 2. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤T0
Unemployment or financial distress of the child	Unemployment or financial distress of the child	Last
Member of hobby of music club	Member of a hobby or music club	Last
Insufficient physical exercise	Less than one hour of exercise a day and/or not enough physical exercise according to the EMOVO[b] questionnaire: cycling or walking to school or an internship less than 1 day a week	Last
Substance use	Alcohol use: at least once a week an alcoholic consumption	Last
	Drugs use: using or ever used hard drugs or soft drugs	Last
	Smoking: smoking or ever smoked	Last
	Water pipe use, at least once a week	Last
	Substance abuse/addiction (sum of the use of alcohol, drugs, smoking, waterpipe) and additional element	Last
Excessive Energy drink consumption	Energy drink abuse/addiction, consumes more than 1 energy drink a day	Last
Technology use	Gaming: more than 3 days a week	Last
	Social media use more than 3 days a week	Last
	Screen use on average daily over 2 hours of television or computer use	Last
SDQ borderline	SDQ total score between normal and increased limits (borderline) -total score 3 years: 9-11 -total score 4-7 years: 11-14 -total score 8-14 years: 11-13 -total score 15-19 years: 13-15	Last
SDQ increased[c]	Increased SDQ total score -total score 3 years: 12-40 -total score 4-7 years: 15-40 -total score 8-14 years: 14-40 -total score 15-19 years:16-40	Last

Supplement Table 2. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤T0
KIVPA[d]	Increased KIVPA score ≥6 is an indication for consultation with PYHP. Maximum is 25 points	Last
Under treatment	Already perceiving any form of treatment	Last
Medical referral	Medical referral	until T0
Paramedical referral	Referral to speech therapist, dietician of physical therapist	until T0
Other referral	All referrals except medical or paramedical referrals, e.g. parenting support, home counselling, program for overweight children	until T0
Total referral	Sum of all above referrals	
Extra healthcare visit	Extra healthcare visit in preventive youth healthcare on top of standard visits, excluding visits for MHP and vaccinations	Until T0
Life events	Looked after children (children who are (temporarily) in a foster family, living in an institution only when parents cannot take care of the child or custody by other person than family member	First
	Conflicts within household/hostile atmosphere	First
	Death of parent(s), sibling or another significant person.	First
	Victim of violence/abuse	First
	Divorce parent(s) or abandonment by parent	First
	Adoption	First
	Immigrant/refugee	First
Mental health in family history	Parents with any mental health problem	First
	Siblings with any mental health problem	First
Chronic Illness parent	Parent with chronic illness	First

Supplement Table 2. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤T0
Risk factors parents	Parent victim of abuse in youth	Last
	Start of parenting support program "Stevig ouderschap", which helps parent(s) with a difficult start, for example due to the medical history of the parent or child, personal problems, insufficient supportive environment	Last
	Little support from social network parents	Last
	Unemployment or financial distress parents	Last
	Both parents with low level of completed education according to the International Standard Classification of Education (35): no, primary or lower secondary education	Last
Prenatal risk factors	Substance abuse (smoking, alcohol or drugs) of the mother during pregnancy	First
	Young parenthood: 1 or more parent <20 years old at birth	First
	Complications during pregnancy (IVF/ICSI, blood loss in 1st or 2nd trimester, hypertension, diabetes)	First
	Medication use during pregnancy (all prescribed oral medication to mother during pregnancy)	First
	Substance abuse (smoking, alcohol or drugs) of the mother during pregnancy	First
Non-traditional family composition	All non-two parent family compositions, e.g. co-parent family composition, stepparent family composition	Last
Negative balance	Based on the model of Bakker (36) which combines different protective factors and risk factors for a child's healthy development on micro- meso- and macro level	Last
Parental concerns	Parents have concerns about any aspect of their child	Last
Little confidence parenting skills, non-optimal parenting skills	Little confidence in parenting skills and/or parents with problems with parenting according to triple P multilevel program with level 3 or higher	First

Supplement Table 2. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤To
Environmental stressors	Long hospital admittance child	Last
	Long hospital admittance sibling	Last
	Expansion in the family by sister, brother or stepparent, stepbrother or stepsister	Last
	Move/migration	Last
	Conflict outside of household	Last

[a]All definitions of the determinants are binary (yes/no). Information regarding developmental delay, incontinence, school problems including bullying, substance use, mental health problem (MHP) screening tools Strengths and difficulties questionnaire (SDQ) and short indicative questionnaire for psychosocial problems among adolescents (KIVPA), life events, family MHPs and parental educational level was available from the period 2005-2015. Information regarding the other predictors was available from the period 2010-2015.

[b]EMOVO = a digital questionnaire of Dutch preventive youth healthcare (PYH) to monitor the health and well-being of second and fourth graders of secondary school(45)

[c]Strengths and difficulties questionnaire (SDQ) = short screening questionnaire to screen for MHPs in children 2-17 years old(46)

[d]KIVPA = a short indicative questionnaire for psychosocial problems among adolescents(47)

Supplement Table 3. Missing data of determinants per subpopulation

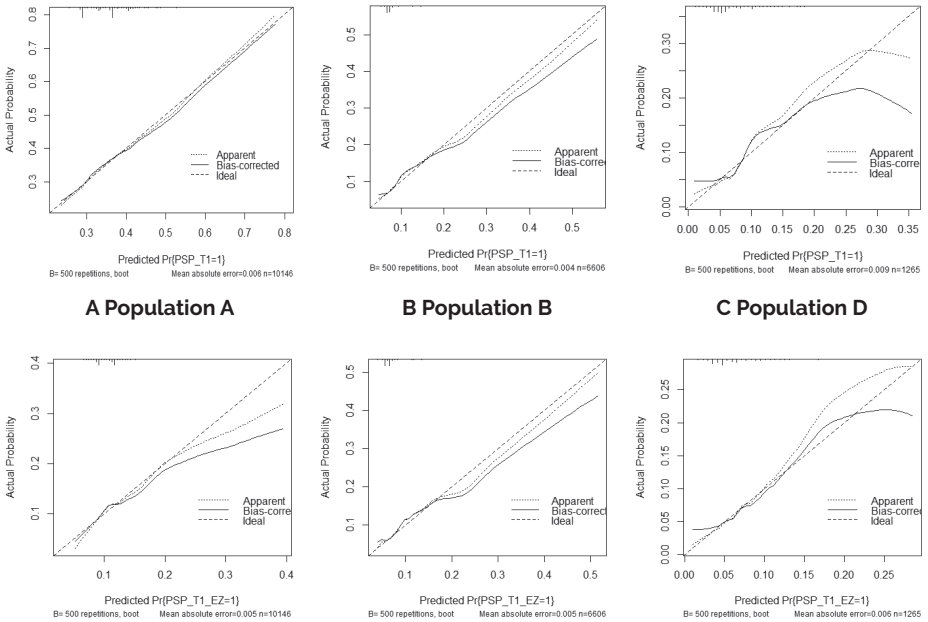
Characteristics	Population A N=29,504	
	% (n)	% missing data
Age in years (mean, std)	3.96 (0.14)	
Male gender	50.3 (5,103)	0.0
Ethnicity	0.0 (0)	100
Premature	5.1 (518)	27.5
Neonatal problems	1.1 (116)	70.4
Non-spontaneous birth	9.0 (909)	72.4
Developmental problems	3.0 (304)	43.4
Incontinence	NA	NA
Excessive crying	0.1 (12)	99.6
Sleeping problems	0.2 (16)	99.8
Eating problem	0.0 (0)	100
Overweight	8.6 (871)	0.4
Underweight	14.2 (1,442)	0.4
School problem	0.1 (12)	99.6
Secondary school level low	NA	NA
Secondary school level high	NA	NA
Secondary school level other	NA	NA
Bullying/being bullied	NA	NA
Low self-confidence/resilience	0.1 (13)	99.6
Member of hobby/music club	NA	NA
Insufficient physical exercise	0.0 (0)	100
Substance use	NA	NA
High technology use	0.0 (0)	100
SDQ borderline	NA	NA
SDQ increased	NA	NA
KIVPA	NA	NA
Under treatment	0.0 (0)	100
Total referral	6.1 (614)	NA
Extra healthcare visit	33.5 (3,398)	NA
Life events	4.4 (442)	85.5
Family history of MHP	2.1 (217)	79.4
Chronic illness parent	3.1 (315)	79.7

Population B N= 6,606		Population C N= 10,789		Population D N=1,265	
% (n)	% missing data	% (n)	% missing data	% (n)	% missing data
5.85 (0.46)		10.96 (0.52)		13.88 (0.53)	
48.1 (3,176)	0.0	49.5 (5,339)	0.0	48.8 (617)	0.0
0.6 (42)	96.7	0.0 (0)	100	4.4 (56)	80.6
0.0 (0)	99.8	0.4 (41)	94.6	0.9 (12)	81.0
2.7 (181)	93.3	0.4 (48)	22.1	0.2 (3)	63.2
0.0 (2)	99.9	1.1 (114)	95.3	3.9 (49)	85.4
2.1 (136)	95.3	0.5 (49)	22.7	0.9 (11)	37.8
0.6 (41)	94.7	0.7 (76)	15.6	0.9 (12)	37.8
NA	NA	NA	NA	NA	NA
0.1 (8)	6.9	0.0 (0)	25.4	0.1 (1)	45.6
0.2 (12)	6.9	0.0 (4)	25.4	0.0 (0)	45.6
2.5 (167)	74.2	7.4 (802)	50.7	13.0 (164)	1.6
4.8 (320)	74.2	4.6 (497)	50.7	10.4 (132)	1.6
1.5 (102)	6.9	0.5 (54)	25.4	0.9 (12)	45.5
NA	NA	15.1 (1628)	NA	31.9 (404)	NA
NA	NA	0.0 (0)	NA	28.7 (363)	NA
NA	NA	0.0 (3)	NA	0.6 (8)	NA
0.0 (2)	6.4	0.0 (4)	24.3	0.2 (2)	43.6
0.1 (8)	6.9	0.0 (0)	25.4	0.0 (0)	45.5
0.0 (1)	100	96.4 (10,405)	0.0	NA	NA
0.0 (0)	100	1.0 (103)	86.1	0.2 (3)	99.1
NA	NA	0.1 (8)	17.0	0.0 (0)	44.8
0.0 (0)	100	6.8 (729)	85.8	0.4 (5)	99.0
3.0 (197)	32.1	6.3 (682)	40.4	4.8 (61)	43.1
1.4 (95)	32.1	4.1 (447)	40.4	2.1 (27)	43.1
NA	NA	NA	NA	6.2 (78)	4.6
15.7 (1,035)	84.3	2.8 (306)	97.2	4.0 (51)	96.0
0.1 (5)	NA	0.1 (6)	NA	0.7 (9)	NA
9.4 (621)	NA	11.2 (1,208)	NA	26.1 (330)	NA
9.8 (648)	5.1	6.6 (708)	20.4	7.5 (95)	37.4
1.8 (117)	4.4	0.5 (53)	20.6	0.9 (11)	40.2
0.3 (21)	97.4	0.8 (81)	91.7	0.7 (9)	89.6

Supplement Table 3. Continued

Characteristics	Population A N=29,504	
	% (n)	% missing data
Risk factor parents	3.3 (334)	64.2
Prenatal risk factors	5.0 (503)	82.0
Non-traditional family composition	1.4 (146)	72.0
Negative balance	2.5 (253)	51.0
Little confidence in parenting skills	0.1 (15)	88.8
Environmental stressors	7.9 (799)	85.6

NA = not applicable, SDQ = Strengths and difficulties questionnaire, KIVPA = short indicative questionnaire for psychosocial problems among adolescents, MHPs = mental health problems



A Population A **B Population B** **C Population D**

D Population A **E Population B** **F Population D**

Supplement Figure 1. Calibration plots concerns for mental health problems (CMHPs) (A, B, C) and extra healthcare use for CMHPs (D, E, F)

Calibration plots for predicting the 1-year risk of a first recorded CMHP (A, B, C) and extra healthcare use for CMHPs (D, E, F). In each plot, the actual observation and predicted probabilities were drawn on the y- and x-axes respectively. The 45-degree dotted line depicts complete agreement between the actual and predicted probabilities.

Population B N= 6,606		Population C N= 10,789		Population D N=1,265	
% (n)	% missing data	% (n)	% missing data	% (n)	% missing data
11.3 (749)	5.1	8.1 (870)	46.3	7.6 (96)	53.8
0.0 (0)	96.1	0.7 (75)	97.2	2.2 (28)	71.9
0.7 (49)	93.2	0.7 (79)	94.3	11.8 (149)	15.6
0.2 (10)	96.1	NA	NA	NA	NA
1.0 (66)	5.4	0.1 (14)	24.7	0.2 (2)	44.5
0.6 (38)	98.3	2.7 (287)	91.1	6.0 (76)	89.6

Chapter 5

Identification of child mental health problems by combining electronic health record information from different primary healthcare professionals – a population-based cohort study

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Abstract

Objectives: To investigate the potential value of combining information from electronic health records from Dutch general practice and preventive youth healthcare in predicting child mental health problems (MHPs).

Setting: Population-based retrospective cohort with children aged 0-19 years who were registered with 76 general practice centres that were affiliated with the Leiden University Medical Centre (LUMC) primary care academic network ELAN (Extramural LUMC Academic Network) in the Leiden area, the Netherlands. For the included children we obtained anonymously extracted data from preventive youth healthcare centres that were part of the Regional Public Health Service Hollands Midden in the same region.

Participants: 48,256 children aged 0-19 years old who were registered with participating general practitioners (GPs) between 2007 and 2017 and who also had data available from preventive youth healthcare professionals (PYHPs) from the period 2010-2015. Children with MHPs before 2007 were excluded (n=3,415).

Results: In 51% of the children who had MHPs according to GPs between 2007 and 2015, PYPHs also had concerns for MHPs. In nearly a third of the children who had no MHPs according to GPs, PYHPs had recorded concerns for MHPs. Combining their information did not result in better performing prediction models than the models based on GP data alone. Important determinants from PYHPs in the identification of MHP one year later were concerns for MHP by PHYPs, borderline or increased problem scores on mental health screening tools, life events, family history of MHP, and an extra visit in preventive youth healthcare.

Conclusions: Several determinants from preventive youth healthcare were individual risk factors for MHPs. Although this information did not improve prediction models based on GP data alone, it could still be useful information for GPs in daily practice to improve child MHP identification as both professionals have previously expressed the need of better information exchange.

Introduction

Worldwide, on average one in five adults experienced a mental health problem (MHP) within the previous 12 months(1). With the majority of MHPs originating in childhood and adolescence, early identification of child MHPs is important to be able to provide adequate treatment strategies and enable prevention of adverse outcomes later in life(2-5). Over the past years, the use of information from electronic health records (EHRs) for research, proactive care interventions and healthcare innovations has become increasingly popular. These often very large datasets contain an abundance of detailed information on individual members of diverse patient populations and provide opportunities for all kinds of research, including the development of prediction models that can be used in daily clinical care to identify high risk individuals and sub-populations(6, 7). When integrated in daily routine, such prediction models might also be able to support professionals in the timely recognition of child MHPs in an efficient manner.

Recently, several studies have investigated possibilities to predict child MHPs with data from EHRs extracted from British and Dutch general practices respectively, in order to improve MHP recognition(8, 9). In the latter study, information regarding known social risk factors for child MHPs (e.g. regarding the child's family and environment) was not available since it is not a standard part of extractable data from primary care EHRs(9, 10). Combining information gathered by different healthcare professionals might enable to meet this objection and lead to more complete information. In this way MHP recognition might be facilitated by including social risk factors, that in previous research have appeared to be important predictors for child MHPs(11). So, the EHRs extracted from Dutch preventive youth healthcare (PYH) might be a useful additional source of information regarding social risk factors for child MHPs in general, as well as for prediction purposes. Preventive youth healthcare paediatricians and nurses (preventive youth healthcare professionals, PYHPs) are, together with general practitioners (GPs), the key professionals in (preventive) primary healthcare for children(12). Children aged 0-19 years visit PYHPs during regularly scheduled free of charge check-ups during which all aspects of a child's healthy development are monitored, including social risk factors(13). Validated MHP screening instruments such as the Strengths and Difficulties Questionnaire (SDQ) and short indicative questionnaire for psychosocial problems among adolescents (KIVPA) are filled in during the screening visits, and nurses or doctors working in PYH will report concerns for MHPs(13).

GPs on the other hand, are the gatekeepers of the Dutch healthcare system. They provide primary healthcare to children and related family members that are registered with their practice centres, free of charge, usually reacting on what patients present, and care is usually related to acute and chronic diseases. In case of more severe problems, children will be referred to secondary (mental) healthcare. With their own specific knowledge and tasks within the Dutch healthcare system, PYHPs and GPs each register different information on children and their families(12).

The aim of this retrospective population-based cohort study was to investigate the potential value of combining and analysing the information from electronic health records from both general practice and preventive youth healthcare, into one decision supporting model that might be used for the prediction of child MHPs in daily practice.

Methods

Study design, setting and population

To predict first recorded MHPs based on general practice (GP) data, we used data from two different sources, namely EHR data extracted from GP centres and from preventive youth healthcare (PYH) centres. The nature and quality of the data are previously described in more detail by Koning and colleagues(9, 14).

The GP data consisted of demographics, consultation dates, symptoms and diagnoses coded according to the WHO/WONCA accredited International Classification of Primary Care (ICPC), prescribed medication coded according to the Anatomical Therapeutic Chemical (ATC) classification, laboratory test results, as well as descriptive or coded information from referrals and correspondence with other healthcare professionals(9, 15, 16). From these data we created a population-based cohort including children aged 0-19 years who were registered with 76 practice centres (107 GPs) that were affiliated with the ELAN primary care network (Extramural LUMC Academic Network) of the Leiden University Medical Centre (LUMC), the Netherlands. The participating practices were located in Leiden and surroundings. All patients aged 0-19 years on 31 December 2016 and registered with participating GP centres between 1 January 2007 and 1 January 2017 for at least one year were part of our cohort. Patients were excluded if an MHP had been recorded before 1 January 2007 (n=3,415).

For the included children we obtained anonymously extracted data from PYH centres that were part of the Regional Public Health Service Hollands Midden. All PYH electronic healthcare data from the period 2010-2015 and all available summary data from a prior electronic registration system from 2005-2010 for children born between 1994 and 2012 were available. The coded data, not including free text, from GP and PYH centres were anonymously linked by a trusted third party (TTP)(17).

Outcome

Our outcome was a first recorded child MHP based on GP data, and was defined when at least one of the following was present: a recorded MHP, a referral to child mental healthcare and/or a mental health medication prescription between 1 January 2007 and 1 January 2017 (Supplement Table 1). We defined a recorded MHP when ICPC codes from the P (psychological) chapter or ICPC code T06 ('anorexia nervosa/bulimia') were present, including both mental health symptoms as well as hypothesized and confirmed disorders. Related mental health medication prescriptions were defined as prescriptions coded with ATC codes N05A, N05B, N05C, N06A, N06BA02, N06BA04,

N06BA09, N07BA, or N07BB which includes all relevant psychiatric medication (such as antidepressants and medication for attention deficit hyperactivity disorder). Referrals to child mental healthcare were defined as referrals to a psychologist, psychiatry, or psychotherapy(9).

Determinants

Potential determinants were related to the child (e.g. gender, developmental characteristics, somatic complaints and co-morbidities), the family (e.g. parental education, parental divorce and MHPs occurring with other family members), healthcare in general (e.g. number of visits or prescriptions) and determinants related to possible MHPs registered in PYH (Supplement Table 2 and 3). PYHPs register results of validated MHP screening tools such as the SDQ, but they can also record their concerns for MHPs. Concerns for MHPs were defined when either abnormal psychosocial functioning in the child was reported (e.g. problems in making contact with others or hyperactive behaviour) during the check-up, and/or when the child received extra healthcare regarding mental health (within PYH or within curative care).

Determinants were selected based on literature regarding risk factors for MHPs and an expert panel(10, 18). Regarding the GP data, every first occurrence of a determinant was taken into account as GPs see patients on an irregular, patient-determined basis. We assumed that if a determinant was not registered, it was not there(19).

PYHPs see children regularly during standard visits in which specific items are checked and recorded. During the first four years of life, around 15 PYH visits are scheduled. Subsequently, in both primary- (children age 4-11 years) and secondary school years, (children age 12-19 years), children are generally seen twice(13). Regarding PYH determinants presumed to be registered by PYHPs, we assumed that in case of missingness the determinants were normal(19). Since some determinants can change over time, we included either the first (e.g. for bullying or school problems) or last (e.g. for overweight) registered value at the moment of prediction. For the other determinants we included the first known registered value (Supplement Table 3). Due to sparseness of the data, we clustered closely related determinants(14).

As determinants for MHPs may vary across childhood and adolescence, we investigated models for the age groups primary school-aged children (age 4-11 years) and secondary school-aged children (age 12-19 years) separately. The same set of determinants was examined in the different age groups; however we required the prevalence of a determinant to be >1% per age group with regard to the clinical usefulness of the determinant.

Statistical analyses

Descriptive statistics, including percentages of missing data for determinants registered by PYHPs, were carried out with SPSS (version 25). We also looked at the overlap between concerns for MHPs in PYH and MHPs based on GP data. To obtain the one-year risk of a first recorded MHP, we developed a multilevel logistic regression model per age group. First, the data were split according to the children's age; age 4 years, age 5 years and so on. For every age, (timepoint 0 (T0)) the status of all determinants was updated, and the outcome was assessed 1 year later (timepoint 1 (T1)). We obtained a prediction model per age group by combining the data from the different ages and fitting a logistic regression model including a cluster effect on the patient level with R (version 3.5.3), to adjust for using different age years of one patient (20).

We investigated several models for MHPs in three steps for both age groups: 1) determinants based on GP data, 2) determinants based on GP data and PYH results of validated MHP screening tools and PYHPs' concerns for MHPs, 3) determinants based on all available GP and PYH data (Figure 1). The PYH determinants in step 2 were chosen because we hypothesized, they would be important determinants for child MHP. As data from both GP and PYH were not available for all children, we also explored models with complete cases, i.e. with the patients that had no missing data for the PYH determinants. We excluded all children whose first recorded MHP was before T0.

The ability of the model to distinguish between children who are recognized with a first MHP and those who are not (discrimination), was assessed using the c-statistic(21). The in-sample calibration of the model was assessed by the calibration plot of actual probabilities versus predicted probabilities. The models were internally validated using bootstrap resampling (500 bootstrap samples) and estimating shrinkage factors. Brier scores were calculated to assess the average prediction error(22).

Patients and Public Involvement

Due to the nature of the data, patients and the public were not directly involved in this study. The Ethics Committee of the Leiden University Medical Centre issued a waiver of consent (G16.018).

Results

Our cohort of GP data consisted of 70,000 children. From 48,256 children (68,9% of those included), data registered in PYH could be individually linked by our TTP (Figure 1). The median follow-up time of children in the GP data was 6.4 years, in the PYH data 3.6 years. Of the children aged 4-11 years, 48.8% were male and 3.0% had an increased SDQ score (Table 1). Of the children aged 12-19 years, 46.7% were male and 3.9% had an increased SDQ score. Over half of the determinants supposed to be registered in PYH had more than 50% missing data.

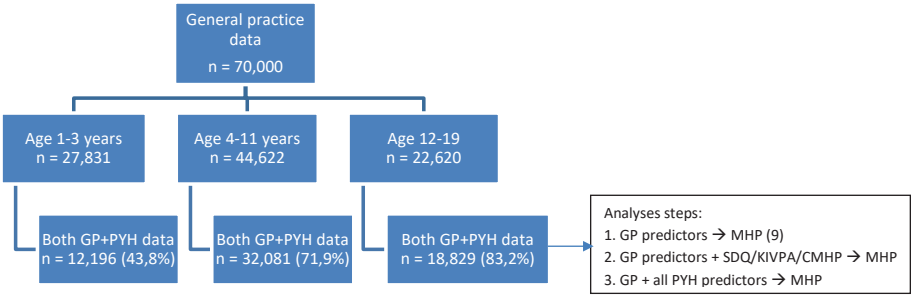

Figure 1. Overview of cohort and different performed analyses

Analyses steps:
1. GP predictors → MHP (9)
2. GP predictors + SDQ/KIVPA/CMHP → MHP
3. GP + all PYH predictors → MHP
CMHP = concerns for MHP based on PYH data, GP = general practice, KIVPA = short indicative questionnaire for psychosocial problems among adolescents , MHP = mental health problem, PYH = preventive youth healthcare, SDQ = Strengths and difficulties questionnaire

Prevalence of (concerns for) mental health problems

We were able to include data registered at PYH centres for the period 2005-2015, while GP data were available for the period 2007-2016. In the period 2007-2015, 15,823 of 48,256 (32,7%) included children had a first recorded MHP based on GP data and 18,092 of 48,256 (37.5%) children had first recorded concerns for MHP based on PYH data (Table 2). In the 15,823 children with MHP according to GPs, 8079 (51%) children had concerns for MHPs according to PYHPs. In 10,013 of 32,433 (30.9%) children in whom the GP did not have a recorded MHP in that period, PYH had registered concerns for MHPs in the same period. In 7,744 of 30,164 (25.7%) children in whom PYH did not have concerns for MHPs, GPs had recorded MHPs.

Prediction of a first mental health problem

Determinants of a first recorded MHP one year later based on GP data in the school-aged children were similar in all models (Table 3). In the GP data, determinants of a first recorded MHP were somatic complaints, life events and the healthcare use related variables more than two GP visits, one or more medication prescriptions, one or more laboratory tests and one or more referrals to or contact with other healthcare professional all measured in the previous year. Low socioeconomic neighbourhood status (SES) in children aged 12-19 years, developmental problems and a recorded chronic disease in children aged 4-11 years, were only related to MHP in step 1 when not including data registered in PYH. Male gender was related to an increased likelihood of a recorded MHP compared to female gender in children aged 4-11 years and a lower likelihood in children aged 12-19 years in all models.

PYH determinants (step 2 and 3) that were associated with an increased risk of first recorded MHPs based on GP data one year later in both age groups were concerns for MHP according to PYHPs, elevated problem scores on MHP screening instrument SDQ, extra healthcare visit in PYH, life events and family history of MHP. Protective PYH determinants registered in PYH in both age groups were non-Western ethnicity of one or both parents, child low secondary school level and high technology use (e.g. on average over 2 hours of daily screen use, Supplement Table 2). Incontinence, sleeping problems and school problems were positively associated with a first recorded MHP one year later only in age group 4-11 years, while prenatal risk factors such as substance abuse by mother during pregnancy and young parenthood, were negatively associated with MHPs in this age group.

In age group 12-19 years, an increased problem score on MHP screening instrument KIVPA was positively associated with a first recorded MHP. In this age group, a relatively higher or lower secondary school level of the child and being under treatment outside PYH were negatively associated with a first recorded MHP. All other determinants were not found to be associated with a first recorded MHP.

The prediction of a first MHP one year later based on combined data from GPs and (partly) PYH did not result in better performing prediction models than the models based on GP data only, c-statistics ranged between 0.62 and 0.64. Internal validation was good (Supplement Figures 1 and 2).

Table 1. Baseline characteristics

	Children age 1-3 years N= 12,196	
GP Characteristics	**% (n)**	**Missings % (n)**
Male gender	51.0 (6,221)	NA
Low socioeconomic status	4.2 (510)	NA
Perinatal morbidity	6.4 (785)	NA
Congenital anomaly	11.0 (1,339)	NA
Disabilities	0.9 (109)	NA
Neoplasms	2.4 (297)	NA
Chronic disease*	48.8 (5,950)	NA
Somatic complaints**	25.2 (3,078)	NA
Tension headache***	0.3 (33)	NA
Migraine***	0.0 (3)	NA
Abdominal pain***	4.0 (487)	NA
Constipation***	14.8 (1,805)	NA
Tiredness***	1.6 (192)	NA
Other somatic complaints***	8.6 (1,051)	NA
Life event	0.4 (51)	NA
Academic problem	0.0 (1)	NA
Developmental problem	4.5 (545)	NA
Difficult temperament	12.2 (1,483)	NA
>2 Visits	91.3 (11,133)	NA
≥1 Medication prescript	78.5 (9,569)	NA
≥1 Laboratory test	14.6 (1,782)	NA
≥1 Referral/correspondence other healthcare prof·	70.1 (8,544)	NA
PYH characteristics		
CMHPs	4.9 (592)	39.5 (4,812)
Ethnicity	8.5 (1,036)	54.2 (6,613)
Premature	5.4 (654)	23.2 (2,825)
Neonatal problems	7.4 (903)	43.0 (5,241)
Non-spontaneous birth	18.7 (2,281)	42.5 (5,179)
Developmental problems	4.2 (516)	41.4 (5,055)
Incontinence	NA	NA
Excessive crying	0.3 (31)	98.1 (11,969)

Children age 4-11 years N= 32,081		Children age 12-19 years N= 18,829	
% (n)	Missings % (n)	% (n)	Missings % (n)
48.8 (15,656)	NA	46.7 (8,788)	NA
3.4 (1,079)	NA	3.4 (644)	NA
2.9 (923)	NA	0.3 (62)	NA
12.2 (3,908)	NA	15.2 (2,854)	NA
1.2 (383)	NA	1.0 (181)	NA
5.6 (1,797)	NA	7.4 (1,397)	NA
46.5 (14,912)	NA	41.7 (7,845)	NA
39.9 (12,793)	NA	53.0 (9,986)	NA
4.2 (1,354)	NA	9.8 (1,847)	NA
0.4 (129)	NA	2.4 (460)	NA
15.5 (4,961)	NA	19.1 (3,589)	NA
17.1 (5,501)	NA	12.3 (2,316)	NA
5.9 (1,877)	NA	14.5 (2,723)	NA
13.5 (4,317)	NA	29.2 (5,503)	NA
1.0 (313)	NA	2.0 (373)	NA
0.2 (51)	NA	0.4 (68)	NA
8.8 (2,817)	NA	4.1 (776)	NA
4.8 (1,546)	NA	0.1 (19)	NA
87.5 (28,065)	NA	87.6 (16,489)	NA
71.2 (22,848(	NA	71.9 (13,539)	NA
24.1 (7,742)	NA	36.4 (6,848)	NA
68.0 (21,817)	NA	69.4 (13,062)	NA
22.4 (7,197)	11.6 (3,707)	42.9 (8,078)	9.7 (1,820)
7.8 (2,498)	60.2 (19,303)	3.1 (588)	86.5 (16,288)
3.5 (1,117)	48.9 (15,682)	1.4 (256)	79.7 (15,010)
3.7 (1,191)	26.4 (8,465)	1.3 (251)	23.8 (4,478)
12.7 (4,071)	58.5 (18,766)	4.4 (833)	82.8 (15,598)
4.5 (1,439)	21.9 (7,018)	1.6 (292)	22.3 (4,191)
3.3 (1,071)	23.3 (7,490)	3.2 (600)	16.4 (3,097)
0.4 (119)	98.5 (31,606)	0.1 (10)	99.9 (18,806)

Table 1. Continued

	Children age 1-3 years N= 12,196	
PYH characteristics	**% (n)**	**Missings % (n)**
Sleeping problems	0.7 (82)	99.3 (12,114)
Eating problem	0.0 (0)	100 (12,196)
Overweight	5.7 (693)	13.5 (1,646)
Underweight	15.3 (1,867)	13.5 (1,646)
Negative weight perception	0.0 (0)	100 (12,196)
School problem	0.3 (31)	98.2 (11,982)
Secondary school level low	NA	NA
Secondary school level high	NA	NA
Secondary school level other	NA	NA
Bullying/being bullied	0.3 (31)	93.9 (11,457)
Bad relationship with ≥1 parent	NA	NA
Low self-confidence/resilience	0.3 (34)	98.2 (11,980)
Self-harm	NA	NA
Female genital mutilation	0.1 (15)	95.9 (11,697)
Unemployment/financial distress of the child	0.0 (6)	95.6 (11,664)
Member of hobby/music club	NA	NA
Insufficient physical exercise	NA	NA
Substance use	NA	NA
Energy drink consumption	NA	NA
High technology use	NA	NA
SDQ borderline	0.5 (59)	96.8 (11,801)
SDQ increased	0.4 (43)	96.8 (11,801)
KIVPA	NA	NA
Poorly experienced health	NA	NA
Under treatment	NA	NA
Total referral in past year	13.9 (1700)	NA
Extra PYH healthcare visit	32.6 (3977)	NA
Life events	3.6 (441)	74.2 (9,049)
Family history of MHPs	3.8 (463)	59.0 (7,200)
Chronic illness parent	3.7 (453)	59.9 (7,301)
Risk factor parents	9.1 (1,112)	39.1 (4,766)

Children age 4-11 years N= 32,081		Children age 12-19 years N= 18,829	
% (n)	Missings % (n)	% (n)	Missings % (n)
1.0 (334)	64.5 (20,679)	5.3 (1,006)	29.6 (5,566)
0.7 (240)	59.5 (19,101)	1.5 (274)	25.9 (4,868)
9.7 (3,110)	19.9 (6,381)	14.9 (2,810)	13.0 (2,456)
13.1 (4,199)	19.9 (6,381)	9.0 (1,690)	13.0 (2,456)
NA	NA	3.7 (706)	96.3 (18,123)
3.0 (966)	61.4 (19,692)	8.5 (1,599)	27.5 (5,182)
3.9 (1,241)	96.1 (30,833)	16.6 (3,129)	43.5 (8,192)
0.0 (0)	73.9 (23,718)	9.4 (1,763)	43.5 (8,192)
0.0 (6)	73.9 (23,718)	0.1 (27)	43.5 (8,192)
1.2 (377)	53.9 (17,277)	5.2 (984)	23.6 (4,448)
NA	NA	0.9 (167)	99.1 (18,662)
0.9 (297)	63.6 (20,398)	1.5 (290)	30.8 (5,793)
0.0 (0)	100.0 (32,081)	1.1 (209)	98.9 (18,620)
0.0 (14)	97.5 (31,287)	0.0 (1)	99.7 (18,766)
0.1 (30)	93.8 (30,106)	0.1 (19)	95.3 (17,940)
99.6 (31,937)	0.0 (0)	96.6 (18,180)	0.0 (0)
0.7 (210)	89.0 (28,544)	5.4 (1,008)	68.8 (12,958)
0.1 (20)	60.9 (19,522)	8.9 (1,685)	18.7 (3527)
0.0 (0)	100.0 (32,081)	1.7 (316)	98.3 (18,513)
4.8 (1,547)	88.8 (28,493)	15.4 (2,892)	69.7 (13,132)
5.7 (1,821)	32.3 (10,361)	5.6 (1,049)	35.2 (6,626)
3.0 (966)	32.3 (10,361)	3.9 (736)	35.2 (6,626)
0.0 (1)	100.0 (32,079)	7.6 (1,424)	46.1 (8,680)
0.0 (0)	99.9 (32,058)	2.3 (426)	97.6 (18,378)
5.1 (1,622)	94.9 (30,459)	10.9 (2,048)	89.1 (16,781)
10.2 (3,273)	NA	2.1 (392)	NA
40.3 (12,920)	NA	23.3 (4,379)	NA
12.8 (4,116)	39.4 (12,626)	17.3 (3,262)	22.7 (4,277)
4.6 (1,467)	31.2 (10,006)	2.1 (394)	24.4 (4,590)
4.6 (1,464)	62.2 (19,949)	1.9 (359)	81.7 (1,5377)
12.7 (4,066)	15.1 (4,858)	12.5 (2,356)	28.6 (5,384)

Table 1. Continued

	Children age 1-3 years N= 12,196	
PYH characteristics	**% (n)**	**Missings % (n)**
Prenatal risk factors	31.1 (3,794)	44.9 (5,478)
Non-traditional family composition	3.2 (396)	42.5 (5,188)
Negative balance	4.3 (519)	32.3 (3,934)
Parental concerns about child	NA	NA
Little confidence in parenting skills	0.4 (51)	64.0 (7,811)
Environmental stressors	6.3 (763)	88.3 (10,769)

*Chronic disease when present one or more of the following: asthma, eczema, psoriasis, inflammatory bowel disease, epilepsy, diabetes mellitus, cystic fibrosis, rheumatoid arthritis.
**Somatic complaint when present one or more of the following: tension headache, migraine, abdominal pain, constipation, tiredness, irritable bowel syndrome IBS, musculoskeletal symptoms, dizziness, nausea, hyperventilation syndrome, palpitations, fainting.
***Separate somatic complaints do not add up to the total amount of somatic complaints as a child can have multiple somatic complaints.

Table 2. Overlap in MHPs according to GPs and preventive youth healthcare professionals' concerns for MHPs between 2007 and 2015

		Preventive youth healthcare concerns for MHPs 2007-2015		
		Yes	**No**	**Total**
MHPs 2007-2015	**Yes**	8,079 (51.0%)	7,744 (48.9%)	15,823 (100%)
	No	10,013 (30.9%)	22,420 (69.1%)	32,433 (100%)
	Total	18,092 (37.5%)	30,164 (62.5%)	48,256 (100%)

GPs = general practitioners, MHPs = mental health problems

Children age 4-11 years N= 32,081		Children age 12-19 years N= 18,829	
% (n)	Missings % (n)	% (n)	Missings % (n)
13.7 (4,383)	47.2 (15,153)	2.7 (501)	77.2 (14,527)
5.7 (1,824)	38.1 (12,219)	9.0 (1,702)	47.3 (8,911)
2.3 (738)	60.6 (19,433)	0.1 (23)	99.0 (18,829)
NA	NA	0.2 (30)	99.8 (18,799)
1.4 (465)	40.0 (12,484)	1.1 (202)	29.2 (5,498)
10.8 (3,464)	77.0 (2,4702)	6.6 (1,235)	82.0 (15,441)

CMHPs = concern for mental health problems according to preventive youth healthcare, GP = general practice, KIVPA = short indicative questionnaire for psychosocial problems among adolescents, MHPs = mental health problems, NA= not applicable, e.g. when determinant is not applicable for a specific age (e.g. member of hobby/music club in children age 1-3 year), or in case no missing (e.g. for extra PYH healthcare visit yes/no), PYH = preventive youth healthcare, SDQ = Strengths and difficulties questionnaire.

Complete case analysis

Complete case analyses, analyses with patients who had no missing data regarding determinants registered in PYH, were only possible for the models investigating SDQ, KIVPA and concerns for MHPs registered during PYH visits (step 2). These models did not perform better than models with all available data. We could not carry out complete case analyses for the models incorporating all determinants registered at PYH centres (step 3), since too many patients had missing data.

Table 3. Results of Adjusted logistic regression analysis for the one-year risk of MHPs

	Step 1[a]					
	Age 4-11 years 171,577 person years, nr of events 8,204			Age 12-19 years 98,754 person years, nr of events 5,947		
GP covariates	**Coef**	**OR**	**95% CI**	**Coef**	**OR**	**95% CI**
Intercept	3.60			-3.51		
Male gender	0.50	1.65	1.61-1.70	-0.19	0.82	0.75-0.89
Low SES	0.21	1.23	0.23-2.23	0.19	1.20	1.06-1.34
Congenital anomaly	0.15	1.15	1.09-1.21	0.11	1.11	1.03-1.18
Perinatal morbidity	0.12	1.12	0.99-1.26	NA	NA	NA
Developmental problem	0.20	1.21	1.15-1.29	0.02	1.01	0.83-1.19
Disabilities						
Difficult temperament	0.02	1.01	0.89-1.12	NA	NA	NA
Life events	NA	NA	NA	0.58	1.79	1.58-1.99
Chronic disease*	0.10	1.10	1.05-1.15	0.03	1.02	0.94-1.10
Neoplasms	0.06	1.06	0.97-1.15	-0.02	0.97	0.84-1.10
Somatic complaints**	0.19	1.20	1.16-1.24	0.20	1.21	1.17-1.15
>2 Visits	0.23	1.26	1.20-1.31	0.21	1.22	1.14-1.30
≥1 Medication prescript	0.10	1.10	1.05-1.15	0.27	1.30	1.23-1.37
≥1 Laboratory test	0.09	1.09	1.02-1.16	0.17	0.17	1.09-1.25
≥1 Referral/contact other healthcare prof.	0.29	1.33	1.28-1.38	0.26	1.28	1.22-1.35
Somatic complaints * Chronic disease	-0.04	0.95	0.90-1.01	0.01	1.00	0.94-1.06
PYH covariates						
CMHPs						
Ethnicity						
Premature						
Neonatal problems						
Non-spontaneous birth						
Developmental problems						
Incontinence						
Sleeping problems						
Eating problem						
Overweight						
Underweight						
Negative weight perception						
School problem						
Secondary school level low						

Step 2						Step 3					
Age 4-11 years 105,371 person years, nr of events 6,236			Age 12-19 years 75,106 person years, nr of events 3,664			Age 4-11 years 105,371 person years, nr of events 6,236			Age 12-19 years 75,106 person years, nr of events 3,664		
Coef	**OR**	**95% CI**	**Coef**	**OR**	**95% CI**	**Coef**	**OR**	**95 % CI**	**Coef**	**OR**	**95 % CI**
-3.63			-3.62			-3.61			-3.78		
0.47	1.59	1.51-1.68	-0,21	0.79	0.74-0.85	0.46	1.56	1.48-1.64	-0.20	0.77	0.72-0.83
0.11	1.10	0.95-1.27	0.11	1.10	0.91-1.32	0.12	1.11	0.95-1.28	0.11	1.07	0.89-1.28
0.12	1.12	1.03-1.20	0.12	1.11	1.02-1.21	0.12	1.10	1.02-1.19	0.11	1.07	0.99-1.17
0.13	1.12	0.97-1.30	NA	NA	NA	0.15	1.13	0.97-1.33	NA	NA	NA
0.12	1.12	1.02-1.22	0.09	1.08	0.90-1.30	0.11	1.09	1.00-1.20	0.12	1.08	0.89-1.30
0.20	1.21	0.96-1.52	0.32	1.36	0.98-1.87	0.19	1.19	0.94-1.50	0.34	1.36	0.98-1.87
0.02	1.01	0.89-1.14	NA	NA	NA	0.04	1.02	0.90-1.15	NA	NA	NA
0.49	1.62	1.28-2.05	0.48	1.60	1.28-2.01	0.44	1.52	1.20-1.93	0.41	1.46	1.16-1.83
0.06	1.05	0.98-1.12	-0.01	0.98	0.88-1.09	0.07	1.05	0.98-1.13	0.02	0.97	0.87-1.08
0.06	1.05	0.94-1.16	0.01	1.00	0.86-1.15	0.06	1.04	0.93-1.31	0.02	0.98	0.85-1.13
0.20	1.21	1.12-1.30	0.27	1.29	1.18-1.41	0.22	1.21	1.12-1.31	0.27	1.27	1.16-1.39
0.20	1.21	1.12-1.30	0.15	1.14	1.04-1.26	0.19	1.19	1.10-1.28	0.14	1.10	1.00-1.22
0.11	1.10	1.04-1.17	0.24	1.26	1.16-1.36	0.10	1.08	1.02-1.15	0.23	1.22	1.13-1.32
0.10	1.09	1.01-1.19	0.17	1.16	1.07-1.27	0.10	1.08	1.00-1.17	0.16	1.13	1.03-1.23
0.26	1.28	1.21-1.36	0.28	1.31	1.21-1.41	0.24	1.24	1.17-1.31	0.26	1.26	1.17-1.36
0.00	0.99	0.89-1.10	0.06	1.05	0.91-1.21	0.00	0.97	0.87-1.08	0.06	1.02	0.89-1.18
0.50	1.64	1.55-1.73	0.32	1.36	1.27-1.46	0.36	1.41	1.32-1.50	0.28	1.27	1.18-1.38
						-0.15	0.83	0.74-0.94	-0.28	0.71	0.55-0.92
						0.00	0.97	0.83-1.15	0.10	1.06	0.72-1.54
						-0.05	0.92	0.79-1.09	-0.31	0.69	0.46-1.03
						-0.03	0.94	0.85-1.03	-0.11	0.85	0.68-1.07
						0.17	1.16	1.03-1.30	-0.08	0.88	0.64-1.20
						0.25	1.25	1.11-1.41	0.14	1.10	0.90-1.34
						0.05	1.02	0.79-1.31	0.05	1.00	0.83-1.22
						NA	NA	NA	0.06	1.02	0.78-1.33
						-0.04	0.93	0.84-1.03	-0.05	0.91	0.82-1.00
						-0.01	0.96	0.89-1.05	-0.07	0.89	0.77-1.02
						NA	NA	NA	-0.10	0.85	0.66-1.11
						0.27	1.28	1.12-1.46	0.14	1.10	0.97-1.25
						-0.28	0.73	0.55-0.95	-0.20	0.77	0.70-0.86

Table 3. Continued

	Step 1[a]					
	Age 4-11 years 171,577 person years, nr of events 8,204			Age 12-19 years 98,754 person years, nr of events 5,947		
PYH covariates	**Coef**	**OR**	**95% CI**	**Coef**	**OR**	**95% CI**
Secondary school level high						
Bullying/being bullied						
Low self-confidence/resilience						
Self-harm						
Member of hobby/music club						
Insufficient physical exercise						
Substance use						
Energy drink consumption						
High technology use						
SDQ borderline						
SDQ increased						
KIVPA						
Poorly experienced health						
Under treatment						
Total referral in past year						
Extra healthcare visit						
Life events						
Family history of MHPs						
Chronic illness parent						
Risk factor parents						
Prenatal risk factors						
Non-traditional family composition						
Negative balance						
Little confidence in parenting skills						
Environmental stressors						
Shrinkage factor B=500	0.99			0.99		
C-statistic corrected	0.62			0.63		
Brier	0.05			0.05		

[a]The first two columns Age 4-11 years and Age 12-19 years are regarding the full population of 70,000 children and are shown for comparison as they were published before (9), data regarding the remaining columns are calculated with the children with both preventive youth healthcare (PYH) and general practice (GP) data.

Step 2						Step 3					
Age 4-11 years 105,371 person years, nr of events 6,236			Age 12-19 years 75,106 person years, nr of events 3,664			Age 4-11 years 105,371 person years, nr of events 6,236			Age 12-19 years 75,106 person years, nr of events 3,664		
Coef	OR	95% CI	Coef	OR	95% CI	Coef	OR	95 % CI	Coef	OR	95 % CI
						NA	NA	NA	-0.11	0.85	0.75-0.97
						0.10	1.08	0.87-1.35	-0.02	0.93	0.80-1.09
						NA	NA	NA	-0.15	0.81	0.58-1.13
						NA	NA	NA	0.06	1.02	0.68-1.53
						0.00	0.97	0.67-1.42	0.29	1.29	0.95-1.74
						NA	NA	NA	-0.05	0.90	0.72-1.13
						NA	NA	NA	0.02	0.98	0.84-1.14
						NA	NA	NA	-0.24	0.74	0.48-1.13
						-0.34	0.68	0.53-0.88	-0.19	0.78	0.68-0.89
0.33	1.38	1.23-1.54	0.22	1.24	1.06-1.43	0.31	1.34	1.20-1.49	0.21	1.19	1.02-1.38
0.51	1.65	1.44-1.90	0.43	1.52	1.29-1.79	0.45	1.54	1.34-1.77	0.41	1.47	1.24-1.74
			0.56	1.75	1.57-1.94	NA	NA	NA	0.54	1.67	1.50-1.86
						NA	NA	NA	-0.05	0.91	0.66-1.25
						0.05	1.02	0.93-1.13	-0.12	0.84	0.74-0.94
						0.14	1.13	0.99-1.28	-0.04	0.92	0.62-1.34
						0.19	1.18	1.10-1.26	0.31	1.32	1.18-1.48
						0.12	1.10	1.02-1.20	0.19	1.16	1.05-1.28
						0.22	1.22	1.08-1.37	0.29	1.30	1.03-1.62
						0.10	1.08	0.95-1.23	-0.08	0.87	0.65-1.18
						0.00	0.98	0.90-1.06	-0.03	0.93	0.84-1.03
						-0.26	0.74	0.67-0.83	-0.17	0.80	0.60-1.05
						0.03	1.01	0.89-1.14	0.23	1.21	1.07
						0.07	1.05	0.88-1.24	NA	NA	NA
						0.11	1.09	0.89-1.33	0.21	1.19	0.88-1.60
						0.03	1.00	0.91-1.09	-0.11	0.85	0.71-1.01
0.99			0.98			0.97			0.95		
0.63			0.64			0.63			0.63		
0.06			0.05			0.06			0.05		

CMHPs = concerns for MHPs, Coef = coefficient, KIVPA = short indicative questionnaire for psychosocial problems among adolescents, GP = general practice, MHPs = mental health problems, PYH = preventive youth healthcare, OR = odds ratio, SDQ = Strengths and difficulties questionnaire, SES = socioeconomic status, 95% CI = 95% confidence interval

Discussion

This population-based cohort study investigated the possibilities of combining data registered at preventive youth healthcare (PYH) centres with general practice (GP) data for the prediction of a first MHP as recorded by general practitioners (GPs). Combining information from PYH and GP centres to predict MHPs based on GP data, did not result in better performing prediction models than the models based on analysis of GP data alone. Determinants derived from PYH registries for the prediction of a first MHP one year later were contextual determinants, concerns for MHPs as registered by PYHPs and elevated scores on MHP screening tools. Furthermore, our study showed that in 51% of the children who had a recorded MHP according to GPs between 2007 and 2015, concerns for MHP were also registered by PYHPs in the same period. In nearly a third of the children who had no MHPs according to GPs, PYHPs had recorded concerns for MHPs in the same period. In 25% of the children in whom PYHPs did not register concerns for MHPs, GPs had recorded MHPs in the same period.

We used a large population-based sample of 70,000 children. For the vast majority of these children, we were able to link data registered in PYH centres at an individual level. To our knowledge, this is the first study that investigated the combination of routine healthcare data from different healthcare providers as the basis for identification of child MHPs in primary care. As GPs and PYHPs have different positions and complementing roles(13), linkage of EHR data from both sources provides a potentially valuable source of information regarding child development and health. We aimed to incorporate all available information regarding known risk factors for child MHPs and explored whether information exchange would result in better prediction models based on routine healthcare data that could be used in daily practice to improve MHP identification in an efficient manner. By using this population-based cohort, our study gives a more comparable reflection of the whole population than studies that actively recruit patients, studies in which it is known that minority populations (either ethnic or socio-economically defined) are represented less(23).

Although data registered in PYH was available in nearly 70% of the children we originally included, over half of the determinants presumed to be registered in PYH showed more than 50% missing data and the prevalence of determinants like family history of MHPs was lower than expected from literature(24). The electronic system used at PYHCs to record findings from clinical care is technically built in such a manner that important information from previous consultations remains present in the system: e.g. birthweight and prematurity. However, in the extracted data for this research, this was not always the case, resulting in substantial missing of data from potential determinants(14). By design,

we could not actively ask patients about specific risk factors. As missingness was likely to be missing not at random, we chose to not use multiple imputation techniques(25). In addition, our aim was to explore which specific information from PYH could be useful to exchange with GPs to enhance MHP identification. Imputing data missing from our extracted data, eventually potentially used to share with GPs for clinical practice purposes, seemed not justifiable too.

Combining information from PYH and GP centres did not show an added value in our study. However, as expected from literature, MHP screening tools and concerns for MHPs appeared to be determinants usable to recognize MHPs(10). The quality of our data and not having information available regarding important determinants of MHPs, such as academic achievement might be reasons for the lack of added value we found from adding PYH data in our analyses. In a prospective cohort study in which parents of Dutch children aged 11 years filled out questionnaires, a prediction model for adolescent MHP was derived which showed good discriminatory power (c-statistic 0.75)(11). Apart from similar predictors gender, family history of psychopathology, and life events such as parental divorce and moving house, this study also found mathematical achievement at school and maternal educational level to be predictors(11). These predictors were not, or not well reported in our study.

In addition, we have chosen to predict a first recorded MHP one year later. This time interval of a one-year prediction might be of influence. The question might be for which time interval it is possible to predict MHP with sufficient accuracy based on routine healthcare data. A recent case-control study with British GP data predicting a first episode of depression in adolescents showed a better performance (c-statistics approximately 0.71)(8). However, this study had a cross-sectional design and also included symptoms of depression such as low mood and anxiety as possible predictors. In our study, MHP symptoms with specific ICPC codes such as 'feeling depressed' were included as outcome, as according to our expert panel GPs are more cautious to label children with an actual mental health disorder ICPC code(9). Moreover, we aimed to improve the early recognition of child MHP and the inclusion of MHP symptoms as outcome might enable early identification. Furthermore, previous studies investigating the diagnostic properties of screening tools have shown that screening tools have added value in the (longer term) identification of child MHP but are not able to identify all children correctly(26, 27).

Our study showed that several determinants registered in PYH, e.g. increased problem scores on routinely used MH screening tools and registered concerns for MHPs, were identified as risk factors for MHPs. Although this information did not substantially improve the prediction models, it could still be useful information for GPs in daily

practice. Especially as our study reported that nearly a third of the children for whom concerns for MHP were registered by PYHPs, had no registered MHPs in the GP data. The purpose of combining data from both professions was to explore the benefits of information exchange between PYHPs and GPs. From qualitative research it is known that Dutch GP's currently in general have no structural interactions with PYHPs other than occasional referral letters and that both professionals feel the need of better information exchange(28). The standard exchange of for example the results of MHP screening instruments might therefore be useful for GPs. Future studies should investigate whether this type of information is indeed what GPs need and the practical implications of structural information exchange.

This study used amongst others coded information regarding symptoms and diagnoses from general practice. Due to privacy reasons, in this case we had no access to free text notes in which GPs and PYHPs would describe the subjective patient's story and symptoms. These notes could typically contain important information regarding social risk factors for MHPs, such as functioning at school, family environment and life events(10). Machine learning techniques and in particular natural language processing techniques have shown promising results with EHR data including free text(29). We recommend future studies to apply these techniques and also to investigate what the views of clinical professionals are regarding the use of the often called 'black box' models developed with these techniques in daily practice.

In addition, this study explored the development of prediction models for MHP recognition based on GP data, to support clinical MHP recognition. By doing so we only predicted problems that were recognised by GPs, not the problems that were not recognised. More adequately performing models based on EHR data might be developed making use of linkage with other domains like secondary care, thus enriching data to improve confirmation of diagnoses. Once this has been achieved, it should be investigated whether the resulting algorithms indeed improve recognition of MHPs in children that currently remain unrecognised by healthcare professionals.

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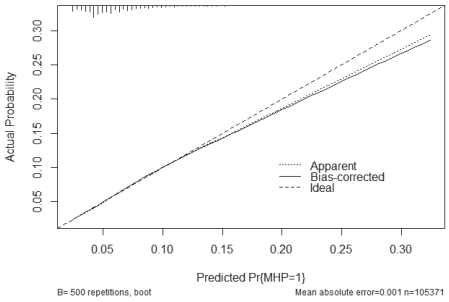
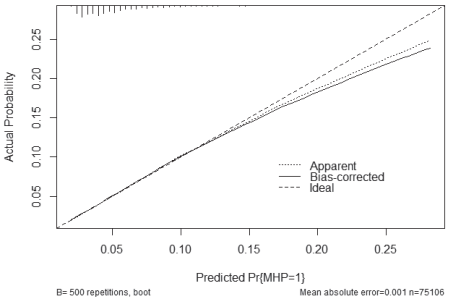
Supplementary files



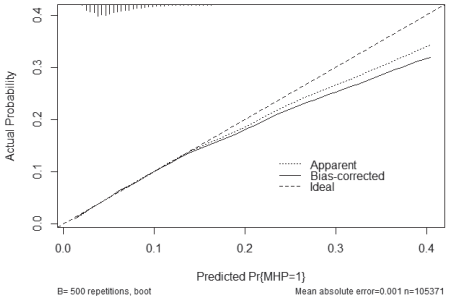
1a Children age 4-11 years



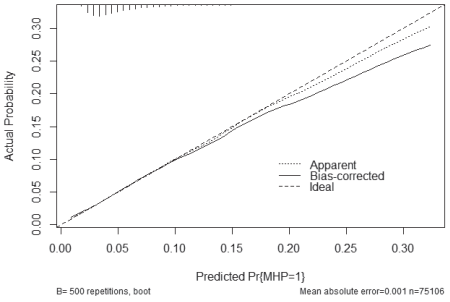
1b Children age 12-19 years

Supplement Figure 1. Calibration plots for models predicting mental health problems (MHPs) for model with general practice determinants and part of the preventive youth healthcare determinants (step 2)

Calibration plots for the models with only general practice determinants (step 1) were published previously and showed similar results(9). In each plot, the actual observation and predicted probabilities were drawn on the y- and x-axes respectively. The 45-degree dotted line depicts complete agreement between the actual and predicted probabilities.



2a Children age 4-11 years



2b Children age 12-19 years

Supplement Figure 2. Calibration plots for models predicting mental health problems (MHP) for models with general practice determinants and all preventive youth healthcare determinants (step 3)

Calibration plots for the models with only general practice determinants (step 1) were published previously and showed similar results(9). In each plot, the actual observation and predicted probabilities were drawn on the y- and x-axes respectively. The 45-degree dotted line depicts complete agreement between the actual and predicted probabilities.

Supplement Table 1. Outcome definition

MHP based on the presence of ≥1 of the following:	Description
MHP ICPC code	P01 Feeling anxious P02 Acute stress reaction P03 Feeling depressed P04Feeling/behaving irritable P05 Senility, feeling/behaving old P06 Sleep disturbance P07 Sexual desire reduced P08 Sexual fulfilment reduced P09 Sexual preference concern P10 Stammering/stuttering/tic P11 Eating problem in child P12 Bedwetting/enuresis P13 Encopresis/bowel training problem P15 Chronic alcohol abuse P16 Acute alcohol abuse P17 Tobacco abuse P18 Medication abuse P19 Drug abuse P20 Memory disturbance P21 P22 Child behaviour symptom P23 Adolescent behaviour symptom P24 Specific learning problem P25 Phase of life problem adult P27 Fear of mental disorder P28 Limited function P29 Psychological symptom other P71 Organic psychosis other P72 Schizophrenia P73 Affective psychosis P74 Anxiety disorder/anxiety state P75 Somatization disorder P76 Depressive disorder P77 Suicide/suicide attempt P78 Neurasthenia/surmenage P79 Phobia/compulsive disorder P80 Personality disorder P81 Hyperkinetic disorder P82 post-traumatic stress disorder P85 Mental retardation P86 Anorexia nervosa/bulimia P98 Psychosis NOS/other P99 Psychological disorders, other T06 Anorexia/bulimia
MHP ATC Code	N05A Antipsychotic drugs, N05B Anxiolytic drugs, N05C Hypnotics and sedative drugs, N06A Antidepressant drugs, N06BA02 dexamphetamine, N06BA04 methylphenidate N06BA09 atomoxetine N07BA drugs used in nicotine dependence or N07BB drugs used in alcohol dependence
MHP Referral to psychologist, psychiatry or psychotherapy	'eerste-lijnspsychologie' 'EERSTE-LIJNSPSYCHOLOGIE', 'GGZ-instelling', 'psychiatrie''PSYCHIATRIE' 'psychologische zorg' 'PSYCHOLOGISCHE ZORG' 'psychotherapie' 'PSYCHOTHERAPIE', 'ELP' 'ELP eerste-lijnspsyc' 'ggz' 'GGZ' 'PSL' 'PSL psychologische z' 'PSL Psycholoog' 'PST' 'PST' 'PSY' 'PSY psychiatrie' 'PSY' 'Psychiatrie' 'PTH' 'PTH psychotherapie'

MHP = mental health problem, ICPC = International Classification of Primary Care, ATC = Anatomical Therapeutic Chemical, a medication classification (15, 16)

Supplement Table 2. Definition of determinants based on general practice data

Variable
Age
Gender
Medical conditions
Congenital anomaly
Disabilities
Chronic Disease
Neoplasms

	Definition
	Age in years based on birth year
	Recorded as in EMR: male or female
	ICPC A90 Congenital anomaly OS/multiple, B78 Hereditary haemolytic anaemia, B79 Congenital anomaly Blood/lymph other, D81 Congenital anomaly digestive system, F81 Congenital anomaly eye other, H80 Congenital anomaly of ear, K73 Congenital anomaly cardiovascular, L82 Congenital anomaly musculoskeletal, N85 Congenital anomaly neurological, R89 Congenital anomaly respiratory, S81 Haemangioma/lymphangioma, S82 Naevus/mole, S83 Congenital skin anomaly other, T78 Thyroglossal duct/cyst, T80 Congenital anomaly endocrine/metabolic, U85 Congenital anomaly urinary tract, W76 Congenital anomaly complicate pregnancy, X83 Congenital anomaly genital female, Y82 Hypospadias, Y84 Congenital genital anomaly male other
	ICPC A28 Limited function/disability NOS; The remaining ICPC codes refer to the limited function/disability codes of the corresponding chapters B28, D28, F28, H28, K28, L28, N28, P28, R28, D28, T28, U28, X28, Y28, Z28,
	≥1 of the following: Asthma, Eczema, Psoriasis, Crohn, Inflammatory bowel disease IBD, Epilepsy, Diabetes Mellitus DM, Cystic Fibrosis CF, Rheumatoid Arthritis RA Asthma ICPC R96 ATC R03, Eczema/psoriasis ICPC S91 Psoriasis, IBD ICPC D94, S86 Dermatitis seborrhoeic S87 Dermatitis/atopic eczema S88 Dermatitis contact/allergic ATC D07 Dermatological corticosteroids, Epilepsy ICPC N88 ATC N03 anti-epileptics, DM ICPC T89 T90 ATC A10 drugs used in diabetes, CF T99.10, RA L88
	ICPC B75 Benign/unspecified neoplasm blood, D78 Neoplasm digest. benign/uncertain, F74 Neoplasm of eye/adnexa, H75 Neoplasm of ear, K72 Neoplasm cardiovascular, L71 Malignant neoplasm musculoskeletal N75 Benign neoplasm nervous system N76 Neoplasm nervous system unspecified, R86 Benign neoplasm respiratory, S78 Lipoma, S79 Neoplasm skin/benign/unspecified, S80 Solar keratosis/sunburn, T72 Benign neoplasm thyroid, T73 Neoplasm endocrine other/unspecified, U78 Benign neoplasm urinary tract, U79 Neoplasm urinary tract NOS, W73 Benign/unspecified. Neoplasm/pregnancy, X78 Fibromyoma uterus, X79 Benign neoplasm breast female, X80 benign neoplasm female genital, X81 genital neoplasm other/unspecified Y79 Benign/unspecified. Neoplasm gen. male, Y85 Benign prostatic hypertrophy, A79 Malignancy NOS, B72 Hodgkin's disease/lymphoma, B73 Leukaemia, B74 Malignant neoplasm blood other, B75 Benign/unspecified neoplasm blood, D74 Malignant neoplasm stomach, D75 Malignant neoplasm colon/rectum, D76 Malignant neoplasm pancreas, D77 Malignant neoplasm digest other/NOS, N74 Malignant neoplasm nervous system, R84 Malignant neoplasm bronchus/lunch, R85 Malignant neoplasm respiratory, other, S77 Malignant neoplasm skin, T71 Malignant neoplasm thyroid, U75 Malignant neoplasm of kidney, U76 Malignant neoplasm of bladder, U77 Malignant neoplasm urinary other, W72 Malignant neoplasm relate to pregnancy, X75 Malignant neoplasm cervix, X76 Malignant neoplasm breast female, X77 Malignant neoplasm genital other female, Y77 Malignant neoplasm prostate, Y78 Malignant neoplasm male genital other

Supplement Table 2. Continued

Variable
Prematurity/other perinatal morbidity
Lower socioeconomic status
Life events in past year
Academic problems
Difficult temperament
Developmental problem
Chronic somatic disorder parent
Somatic complaints

Healthcare use
Number of primary care visits in past year
Number of laboratory tests in past year
Number of medication prescripts in past year
Number of referrals/correspondences with other healthcare professionals (non-mental health)

MHP = mental health problem, ICPC = International Classification of Primary Care, ATC = Anatomical, Therapeutic Chemical, a medication classification(15, 16)

	Definition
	ICPC A93 Premature newborn, A94 Perinatal morbidity other
	Postcode marked as lower socioeconomic area: 0-20th percentile of Socioeconomic status (SES) score(30)
	ICPC Z15 Loss/death of partner problem, Z22 Illness problem parent/family, Z23 Loss/death parent/family problem, Z25 Assault/harmful event problem
	ICPC Z07 Education problem
	ICPC A14 Infantile colics, A15 Excessive crying infant, A16 Irritable Infant, T04 Feeding problem of infant/child
	ICPC T10 Growth delay, N19 Speech disorder
	No specific ICPC code, partly part of 'life event' with ICPC code Z22 Illness problem parent/family
	≥1 of the following: Tension headache, Migraine, Abdominal pain, Constipation, Tiredness, Irritable bowel syndrome IBS, Musculoskeletal symptoms, Dizziness, Nausea, Hyperventilation syndrome, Palpitations, Fainting. Tension headache ICPC N01 Headache N02 Tension headache, Migraine ICPC N89 ATC N02C, Abdominal pain ICPC D01 Abdominal pain/cramps general D06 Abdominal pain localized other, Constipation ICPC D12, ATC 06 Drugs for constipation, Tiredness ICPC A04 Weakness/ tiredness general. IBS ICPC D93, IBS ATC A03A Drugs for functional gastrointestinal disorders A03F Propulsives, Musculoskeletal symptoms ICPC symptom/complaint of: L01 Neck L02 Back L03 Lower back L08 L20 Joint, Dizziness ICPC H82 Vertiginous syndrome N17 Vertigo/ dizziness, Nausea ICPC D09 Nausea, Hyperventilation syndrome ICPC R98 Hyperventilation syndrome ICPC R86, Palpitations ICPC K04 palpitations K05 irregular heartbeat other, Fainting ICPC A06 Fainting/syncope

	Count per year
	Count per year
	Count per year
	Count per year

Supplement Table 3. Definition of determinants based on preventive youth healthcare data

Determinant	Definition[a]	Timing: first or last recorded measurement ≤To
Concerns for MHPs	-≥1 referral to a mental health specialist with indication mental health -≥1 consultation with a mental health specialist with indication mental health - Extra healthcare use in PYH between standard visits with indication mental health -≥1 intervention for mental health: -Triple P level 3 or higher and tip sheets (fears in children, stealing, dealing with fear or depression)(31) -Atypical mental health functioning (single examination in PYH) -≥1 abnormal specific mental health functioning recorded	First
Premature	Pregnancy duration <37 weeks or 259 days	First
Ethnicity	Immigrant/refugee Country of birth of ≥1 parent is other than the Netherlands or West-Europe (e.g. Suriname Dutch Antilles, Turkey, Morocco, Eastern Europe, other non-Western countries)	First
Nonspontaneous birth	Caesarean section, vaginal birth with forceps or vacuum extraction	First
Delay in development	General developmental delay and/or speech and language delay at age 7 years and older	First
Incontinence for urine or faeces	Incontinent for urine or faeces at age 4 years and older	Last
Excessive crying	Excessive crying, more than a short phase	First
Sleeping problems	Sleeping problems	Last
Eating Problem	Eating Problem	Last
Overweight	BMI classified as overweight or obese according to international age and gender specific standards(32, 33)	To
Underweight	BMI classified as underweight according to international age and gender specific standards(32, 33)	To
Negative weight perception	Negative perception of own weight (too light or too heavy)	To

Supplement Table 3. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤To
School problem	Any reported problems in school e.g. dyslexia, difficulty focusing, motivation problems, absenteeism or declining school performance	First
Secondary school education level	Secondary school education level divided into 3 categories according to the Dutch school system: -low: VMBO or lower -middle: HAVO (reference category) -high: VWO -Other: in case of special education/no education; HAVO is reference category. When combined education levels were recorded, the lowest level was chosen, e.g. HAVO for HAVO/VWO	Last
Bullying/being bullied	Bullying or being bullied	First
Bad relationship with at least one parent	Bad relationship with at least one parent	Last
Low self-confidence/ resilience	Low self-confidence/ resilience	Last
Self-harm	Self-mutilation or suicidal thoughts	First
Female genital mutilation	Female genital mutilation	First
Unemployment or financial distress of the child	Unemployment or financial distress of the child	Last
Member of hobby of music club	Member of a hobby or music club	Last
Insufficient physical exercise	Less than one hour of exercise a day and/or not enough physical exercise according to the EMOVO[b] questionnaire: cycling or walking to school or an internship less than 1 day a week	Last

Supplement Table 3. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤T0
Substance use	Alcohol use: at least once a week an alcoholic consumption	Last
	Drugs use: using or ever used hard drugs or soft drugs	Last
	Smoking: smoking or ever smoked	Last
	Water pipe use, at least once a week	Last
	Substance abuse/addiction (sum of the use of alcohol, drugs, smoking, waterpipe) and additional element	Last
Excessive Energy drink consumption	Energy drink abuse/addiction, consumes more than 1 energy drink a day	Last
High technology use	Gaming: more than 3 days a week	Last
	Social media use more than 3 days a week	Last
	Screen use on average daily over 2 hours of television or computer use	Last
SDQ borderline[c]	SDQ total score between normal and increased limits (borderline) -total score 3 years: 9-11 -total score 4-7 years: 11-14 -total score 8-14 years: 11-13 -total score 15-19 years: 13-15	Last
SDQ increased[c]	Increased SDQ total score -total score 3 years: 12-40 -total score 4-7 years: 15-40 -total score 8-14 years: 14-40 -total score 15-19 years:16-40	Last
KIVPA[d]	Increased KIVPA score ≥6 is an indication for consultation with PYHP. Maximum is 25 points	Last
Under treatment	Already perceiving any form of treatment	Last
Medical referral	Medical referral	until T0
Paramedical referral	Referral to speech therapist, dietician or physical therapist	until T0
Other referral	All referrals except medical or paramedical referrals, e.g. parenting support, home counselling, program for overweight children	until T0
Total referral	Sum of all above referrals	

Supplement Table 3. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤T0
Extra healthcare visit	Extra healthcare visit in preventive youth healthcare on top of standard visits, excluding visits for MHP and vaccinations	Until T0
Life events	Looked after children (children who are (temporarily) in a foster family, living in an institution only when parents cannot take care of the child or custody by other person than family member	First
	Conflicts within household/hostile atmosphere	First
	Death of parent(s), sibling or another significant person.	First
	Victim of violence/abuse	First
	Divorce parent(s) or abandonment by parent	First
	Adoption	First
	Immigrant/refugee	First
Mental health in family history	Parents with any mental health problem	First
	Siblings with any mental health problem	First
Chronic Illness parent	Parent with chronic illness	First
Risk factors parents	Parent victim of abuse in youth	Last
	Start of parenting support program "Stevig ouderschap", which helps parent(s) with a difficult start, for example due to the medical history of the parent or child, personal problems, insufficient supportive environment	Last
	Little support from social network parents	Last
	Unemployment or financial distress parents	Last
	Both parents with low level of completed education according to the International Standard Classification of Education(34): no, primary or lower secondary education	Last

Supplement Table 3. Continued

Determinant	Definition[a]	Timing: first or last recorded measurement ≤To
Prenatal risk factors	Substance abuse (smoking, alcohol or drugs) of the mother during pregnancy	First
	Young parenthood: 1 or more parent <20 years old at birth	First
	Complications during pregnancy (IVF/ICSI, blood loss in 1st or 2nd trimester, hypertension, diabetes)	First
	Medication use during pregnancy (all prescribed oral medication to mother during pregnancy)	First
Non-traditional family composition	All non-two parent family compositions, e.g. co-parent family composition, stepparent family composition	Last
Negative balance	Based on the model of Bakker(35) which combines different protective factors and risk factors for a child's healthy development on micro- meso- and macro level	Last
Parental concerns	Parents have concerns about any aspect of their child	Last
Little confidence parenting skills, non-optimal parenting skills	Little confidence in parenting skills and/or parents with problems with parenting according to triple P multilevel program with level 3 or higher	First
Environmental stressors	Long hospital admittance child	Last
	Long hospital admittance sibling	Last
	Expansion in the family by sister, brother or stepparent, stepbrother or stepsister	Last
	Move/migration	Last
	Conflict outside of household	Last

[a]All definitions of the determinants are binary (yes/no). Information regarding developmental delay, incontinence, school problems including bullying, substance use, mental health problem (MHP) screening tools Strengths and difficulties questionnaire (SDQ) and short indicative questionnaire for psychosocial problems among adolescents (KIVPA), life events, family MHPs and parental educational level was available from the period 2005-2015. Information regarding the other predictors was available from the period 2010-2015. [b]EMOVO = a digital questionnaire of Dutch preventive youth healthcare (PYH) to monitor the health and well-being of second and fourth graders of secondary school(36). [c]Strengths and difficulties questionnaire (SDQ) = short screening questionnaire to screen for MHPs in children 2-17 years old(37). [d]KIVPA = a short indicative questionnaire for psychosocial problems among adolescents(38).

Chapter 6

Characteristics of youth in mental healthcare - can we identify different groups with routine healthcare data?

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Abstract

Objectives: To gain insight into the characteristics of children using child and adolescent mental healthcare (CAMH) derived from primary care electronic health records.

Methods: Population-based retrospective cohort with children aged 0-19 years registered with 76 general practice (GP) centres in the Leiden area, the Netherlands. Anonymous data from GP centres, preventive youth healthcare (PYH) centres, and information regarding CAMH use from Statistics Netherlands was extracted and linked on an individual level. We investigated which children in CAMH were also identified with mental health problems (MHPs) in primary care, the timeline between recognition in primary care and CAMH use, and which characteristics were associated with CAMH use.

Results: Depending on age, 3 to 10% of the children either had first GP registered MHPs and/or were recorded in CAMH. Children only registered in CAMH without GP registered MHPs were less likely to have registered somatic complaints, chronic diseases, medication, laboratory tests, or high scores on MHP screening tools. PYH concerns for MHPs was a risk factor for CAMH use and/or GP recorded MHPs. Children with both MHPs and CAMH use were more often bullying/being bullied, underweight (age 12-18 years), or registered with school problems (age 4-11 years).

Conclusions: A limited number of characteristics were related to different groups of CAMH use. Future studies should further investigate children with CAMH use in absence of GP registered MHPs and explore structural information exchange between PYH and GP, as PYH concerns for MHPs was a risk factor for CAMH use and/or GP recorded MHPs.

Introduction

With a worldwide prevalence of 13.7%, mental health problems (MHPs) in children and adolescents are common(1). MHPs do not only impact the daily life and wellbeing of children and their families(2-4), but are also related to long-term effects such as adverse health, academic, work and social outcomes(4-7). The majority of MHPs start in childhood and adolescence(5, 8). As child MHPs can be treated effectively, early identification of child MHPs is important to provide adequate treatment and enable prevention of adverse outcomes later in life(9, 10). However, not all young people with MHPs receive help from mental health services(11, 12). National surveys in the UK, Australia and USA have estimated that only between one third and two thirds of young people with MHPs access mental health services(11-15).

Several stages and processes involved in the access to treatment for child MHPs have been described(15-17). The stages refer to 1) child and parental recognition of the problematic nature of the child's behaviour and the subsequent decision to consult a general practitioner (GP), 2) recognition of the child's problems by the GP, and 3) the GP's decision to refer to child and adolescent mental healthcare (CAMH). Characteristics of the child and the parents, such as symptom severity, MHP knowledge and perceived views towards MHPs and treatment, are found to influence these stages and thus access to treatment(15, 18-21). In addition, GPs perceived barriers to the recognition and effective management of child MHPs such as a lack of time, knowledge and resources including a shortage of providers and waiting lists(22).

Primary care practitioners are usually the first contacted professionals in case of health-related problems. In the UK and the Netherlands, GPs see children on average once a year and they are the main gatekeepers to specialized care, including CAMH(23, 24). In fact, approximately 80% of children and adolescents with MHPs consulted their GP within the preceding year(25). However, these children were often visiting for physical rather than psychological reasons and were often not recognized by their GP as having MHPs(25).

Not every child with MHPs needs CAMH. However, insight into the characteristics of children who use CAMH might support GPs in the identification of children in need of mental healthcare and might aid adequate treatment provision and prevent adverse outcomes later in life. The aim of this study was to gain more insight in which children used CAMH with information from electronic health records from primary care providers, including GPs and preventive youth healthcare professionals (see box 1) and information

regarding CAMH use. We investigated which children in CAMH were also identified with MHPs in primary care, what the timeline was between recognition in primary care and CAMH use, and which characteristics of the child, family and healthcare were associated with CAMH use.

Box 1- Primary care for children in the Netherlands

In the Netherlands, next to GPs, physicians and nurses working in preventive youth healthcare (preventive youth healthcare professionals, (PYHPs)) are the key players in providing primary care for children(26). GPs provide acute and chronic care for children and their families. PYHPs see all children under 19 year regularly during standardized visits to monitor a child's healthy development(27).

Methods

Study design, setting and population

Data from three different sources were used: routine electronic health record data extracted from general practice centres and from preventive youth healthcare centres, and health costs related to child and adolescent mental healthcare (CAMH). This study is part of a larger research project, the nature and quality of the data extracted from GPs(28) and PYHPs centres (Koning et al, Identification of child mental health problems by combining electronic health record information from different primary healthcare professionals – a population-based cohort study. Under revision, BMJ Open) are described elsewhere in more detail.

A population-based retrospective cohort including children registered with 76 general practice centres that were affiliated with the ELAN primary care network (Extramural LUMC Academic Network) of the Leiden University Medical Centre (LUMC), the Netherlands was used. All patients aged 0-19 years on 31 December 2016 and registered with participating general practice centres between 1 January 2007 and 1 January 2017 for at least one year were part of the original cohort(28). The GP data consisted of demographics, consultation dates, symptoms and diagnoses coded according to the WHO International Classification of Primary Care (ICPC), prescribed medication coded according to the Anatomical Therapeutic Chemical (ATC) classification, laboratory test results, and descriptive or coded information from referrals and correspondence with other healthcare professionals(28-30). For the included children we obtained anonymously extracted data from preventive youth healthcare (PYH) centres that were part of the Regional Public Health Service Hollands Midden. The PYH data included demographics, information regarding pregnancy, family and social circumstances and information from scheduled visits and extra consultations with PYH(31). Because of policy changes, information regarding costs made in CAMH was only available for the period between 2009 and 2014. And so for this present study, we included children with data from general practice and PYH from the period between 2008 and 2014, and with data regarding CAMH use from the period between 2009 and 2014 (Figure 1).The coded data from general practice and PYH were anonymously linked by a third trusted party(32). The linked general practice and PYH data were then anonymously linked to data from Statistics Netherlands, so that access to non-public microdata regarding healthcare insurances and subsequently (mental) healthcare costs could be organized. Information regarding CAMH use was based on mental healthcare cost data.

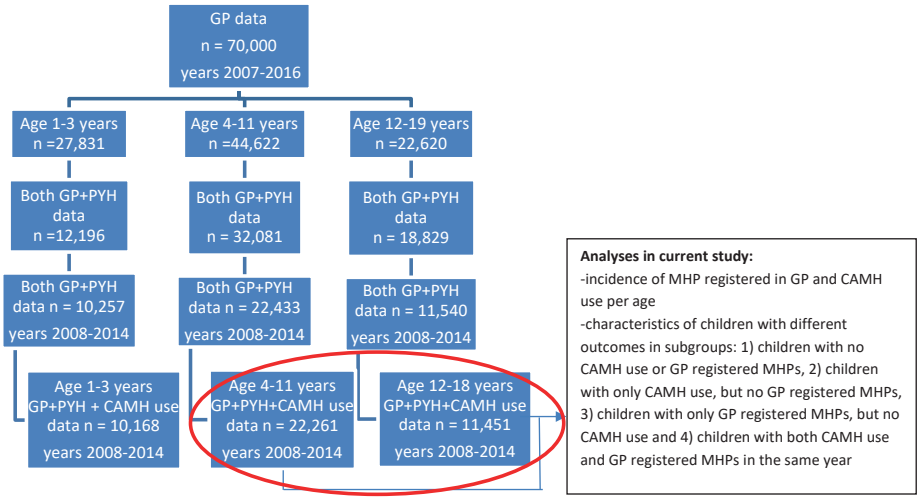

Figure 1. Flowchart of original cohort and the children included in the current study

Analyses in current study:
-incidence of MHP registered in GP and CAMH use per age
-characteristics of children with different outcomes in subgroups: 1) children with no CAMH use or GP registered MHPs, 2) children with only CAMH use, but no GP registered MHPs, 3) children with only GP registered MHPs, but no CAMH use and 4) children with both CAMH use and GP registered MHPs in the same year
CAMH = child and adolescent mental healthcare, GP = general practice, MHPs = mental health problems, PYH = preventive youth healthcare

Outcomes

We categorized first recorded child and adolescent mental healthcare use (CAMH use) and/or GP registered MHPs in the same year into different subgroups: 1) children with neither in that year, 2) children with only CAMH use, but no GP registered MHPs, 3) children with only GP registered MHPs, but no CAMH use and 4) children with both CAMH use and GP registered MHPs in the same year.

The first recorded use of child and adolescent mental healthcare (CAMH use) was based on the presence of any healthcare costs made for mental health other than in general practice per calendar year in the microdata from Statistics Netherlands. A first recorded child MHP based on general practice data was defined when at least one of the following was present: a recorded MHP, a referral to child mental healthcare and/or a mental health medication prescription between 1 January 2009 and 1 January 2015 (Supplement Table 1). We defined a recorded MHP when ICPC codes from the P (psychological) chapter and/or ICPC code T06 ('anorexia nervosa/bulimia') were

present, including both mental health symptoms as well as hypothesized and confirmed disorders. Related mental health medication prescriptions were defined as prescriptions coded with ATC codes N05A, N05B, N05C, N06A, N06BA02, N06BA04, N06BA09, N07BA, or N07BB. Referrals to child mental healthcare were defined as referrals to a psychologist, psychiatry, or psychotherapy(28).

Characteristics of youth in child and adolescent mental healthcare

Characteristics of CAMH use were related to the child (e.g. gender, developmental characteristics), medical history (e.g. somatic complaints, co-morbidities, number of GP visits), possible MHPs (e.g. results of validated mental health screening tools such as the Strengths and Difficulties Questionnaire (SDQ)), and the family/context (e.g. parental education, socioeconomic status and family MHPs) (Supplement Table 2 and 3). Characteristics were selected based on literature regarding risk factors for MHPs and an expert panel(33, 34). Regarding the general practice data, every first occurrence of a characteristic was taken into account as GPs see patients on an irregular, patient-determined basis. We assumed that in case a characteristic was not registered, it was absent(35).

PYHPs see children regularly during routine visits in which standard items should be checked and recorded. During the first four years of life, about 15 PYH visits are scheduled. In both primary school (children age 4-11 years) and secondary school, (children age 12-18 years) children are generally seen twice(27). Regarding PYH characteristics we assumed that in case of missingness the characteristics were normal(35). Some PYH characteristics can change over time, we then included either the first (e.g. for bullying or school problems) or last (e.g. for overweight) registered value at T0. For the other characteristics we included the first known registered value (Supplement Table 3). Due to sparseness of the data, we clustered closely related characteristics(31).

As characteristics may vary across childhood and adolescence, we investigated the characteristics for the age groups primary school aged children (aged 4-11 years) and secondary school aged children (aged 12-19 years) separately. The same set of characteristics was examined in the different age groups; however we required the prevalence of a characteristic to be >1% per subgroup with regard to the clinical usefulness of the characteristic.

Statistical analyses

Descriptive statistics were carried out with IBM SPSS (version 25, Armonk, NY). We investigated the incidence of CAMH use per age, and the overlap in children in CAMH and children with recorded MHPs by GPs for the period between 2009 and 2014. A

timeline of recorded MHPs by GPs versus CAMH use was made. We calculated the prevalence of characteristics for all children and the subgroups children with only CAMH use, only MHPs, and both MHPs and CAMH use in each specific year.

To examine which characteristics were related to the different subgroups, we used multilevel logistic regression analysis per age group, primary school aged children and secondary school aged children. First, the data were split according to the children's age; age 4 years, age 5 years and so on. For every age, (timepoint 0 (T0)) the status of all characteristics was updated at the same time at that specific age and the outcomes CAMH use and/or MHPs based on GP data were assessed 1 year later (timepoint 1 (T1), Figure 2)(28). As CAMH use (T1) was available between 2009 and 2014, the status of characteristics (T0) was assessed between 2008 and 2013. By combining the data from those years (e.g. age 4-11 years) and fitting a logistic regression model including a cluster effect on the patient level with R (version 3.5.3, Vienna, Austria), we obtained the characteristics of the different subgroups per age group. This to adjust for using different age years of one patient, for instance at age 4 years and age 5 years(36). Children with CAMH use and/or MHPs before T0 were excluded from the analyses. The Ethics Committee of the Leiden University Medical Centre issued a waiver of consent (G16.018).

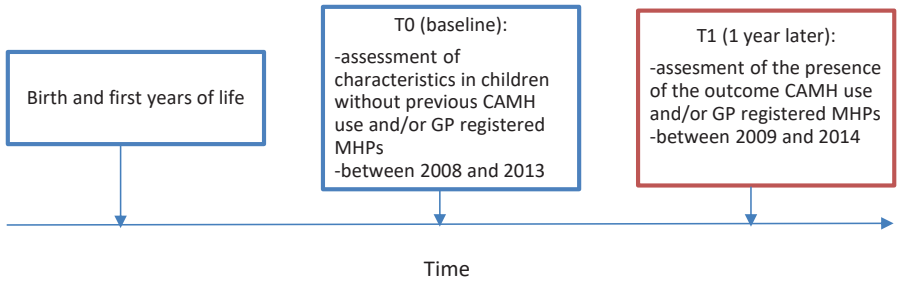

Figure 2. Timeline of analyses in children under 19 years old

CAMH = child and adolescent mental healthcare, GP = general practitioner, MHPs = mental health problems

Results

Our original cohort of general practice data from the period between 2007 and 2017 included 70,000 children(28). From 48,256 children (68.9% of those included in the original cohort), data extracted from PYH could be individually linked to the general practice data and for 63,675 children (91% of those included), data from Statistics Netherlands were available. For the period between 2008 and 2014, we could link information from general practice and PYH to information regarding CAMH use for 22,261 children aged 4-11 years and for 11,451 children aged 12-18 years (Figure 1) and those children were included in the present study. Characteristics of the children in these two age cohorts can be found in Table 1 and Table 2.

Prevalence of MHP and CAMH use

For 48,915 children who were enlisted with participating general practice centres between 2008 and 2014, information regarding CAMH use was available. Over the whole period, the prevalence of children registered with both MHPs according to GPs and CAMH use was about ten percent (n=5,283) Six percent were registered as using CAMH but had no GP recorded MHPs and vice versa 12% of the children were registered with MHPs recorded by GPs but were not registered in CAMH. In about half of the 5,283 children with both MHPs and CAMH use, these occurred in the same calendar year (Figure 3). In 18% of the children with both MHPs and CAMH use, CAMH use was recorded before MHPs were recorded by GPs.

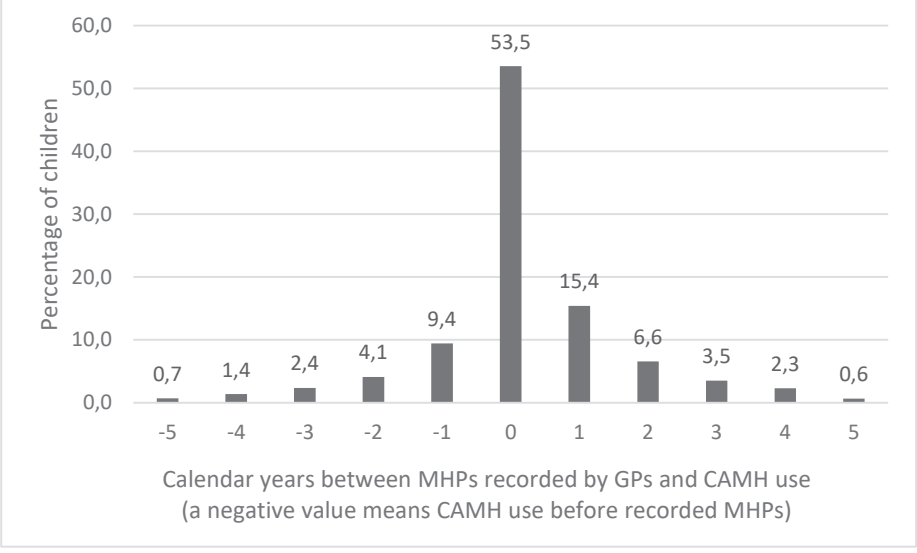

Figure 3. Timeline between GP recorded MHPs and CAMH use between 2009 and 2014 in children under 19 years old

Table 1. Baseline characteristics of children age 4-11 years, including subgroups with different outcomes compared to children without any outcome[a]

Characteristics	**All children n=22,261, %(n)**
Child	
Male gender	48.1 (10,713
Ethnicity[b]	3.1 (698)
Developmental problems	
Developmental problems[b]	3.0 (658)
Difficult temperament	2.7 (611)
Incontinence[b]	3.4 (750)
Sleeping problems[b]	0.6 (244)
Eating problem[b]	0.9 (198)
Overweight[b]	8.2 (1,822)
Underweight[b]	11.0 (2,444)
School problem	2.6 (569)
Secondary school level low[b]	X (X)
Bullying/being bullied[b]	0.8 (188)
Low self-confidence/resilience[b]	0.6 (142)
High technology use[b]	2.0 (455)
Life events	0.7 (148)
Life events[b]	10.6 (2,354)
Medical history	
Non-spontaneous birth[b]	8.0 (1,777)
Premature[b]	2.7 (603)
Perinatal morbidity	2.9 (433)
Neonatal problems[b]	1.5 (328)
Congenital anomaly	12.7 (2,827)
Chronic disease[c]	42.2 (9,403)
Somatic complaints[d]	35.0 (7,789)
Tension headache[e]	3.4 (759)
Migraine[e]	0.4 (81)
Abdominal pain[e]	12.8 (2,841)
Constipation[e]	14.4 (3,201)
Tiredness[e]	4.8 (1,065)
Other somatic complaints[e]	11.6 (2,593)

	Children with only CAMH use n=1,284 [a], %(n)	Children with only MHP use n=2,065[a], %(n)	Children with MHP and CAMH use n=882[a], %(n)
	56.2 (722)	57.8 (1,194)	60.1 (530)
	0.9 (11)	2.6 (53)	1.9 (17)
	4.2 (54)	4.7 (97)	6.1 (54)
	1.0 (13)	3.6 (75)	1.5 (13)
	5.1 (65)	7.1 (147)	4.2 (37)
	1.4 (18)	1.4 (29)	X (X)
	1.5 (19	1.5 (30)	1.4 (12)
	4.3 (55)	7.3 (150)	6.2 (55)
	7.6 (97)	9.5 (197)	7.9 (70)
	4.8 (61)	3.5 (73)	6.5 (57)
	1.2 (16)	X (X)	1.8 (16)
	1.2 (16)	1.3 (26)	2.9 (26)
	1.2 (15)	1.0 (20)	1.2 (11)
	X (X)	X (X)	X (X)
	0.9 (12)	1.3 (27)	X (X)
	163 (12.7)	11.6 (239)	12.0 (106)
	1.5 (19)	4.8 (99)	3.3 (29)
	0.8 (10)	2.4 (50)	1.2 (11)
	1.0 (13)	2.6 (53)	1.7 (15)
	2.3 (29)	1.8 (37)	2.0 (18)
	13.6 (175)	14.2 (293)	15.0 (132)
	35.9 (461)	44.9 (927)	45.1 (398)
	32.6 (418)	37.5 (775)	37.4 (330)
	3.7 (48)	3.9 (81)	4.9 (43)
	X (X)	X (X)	X (X)
	11.3 (145)	13.7 (283)	13.5 (119)
	12.9 (165)	17.4 (359)	14.6 (129)
	6.0 (77)	5.2 (107)	6.6 (58)
	9.6 (123)	11.6 (240)	12.4 (109)

Table 1. Continued

Characteristics	**All children n=22,261, %(n)**
Neoplasms	4.8 (1,066)
>2 GP Visits in previous year	85.3 (18,982)
≥1 Medication prescript in previous year	67.5 (15,025)
≥1 Laboratory test in previous year	18.4 (4,107)
≥1 Referral/correspondence other healthcare professional in previous year	61.5 (13,694)
Under treatment other than PYH[b]	6.8 (1,522)
Total referral by PYH[b]	7.9 (1,752)
Extra healthcare visit in PYH[b]	33.9 (7,544)
MHP related	
cMHP[b]	18.9 (4,202)
SDQ borderline[b]	4.2 (929)
SDQ increased[b]	2.2 (489)
Parent/family/environment	
Family history of MHP[b]	3.5 (773)
Chronic illness parent[b]	3.2 (713)
Risk factor parents[b]	10.9 (2,435)
Prenatal risk factors[b]	3.2 (717)
Non-traditional family composition[b]	4.0 (889)
Low Socioeconomic status	3.1 (694)
Negative balance	1.3 (289)
Little confidence in parenting skills	1.3 (292)
Environmental stressors[b]	8.1 (1,796)

CAMH = child and adolescent mental healthcare, cMHP = concern for mental health problem according to preventive youth healthcare, GP = general practice, KIVPA = short indicative questionnaire for psychosocial problems among adolescents, MHP = mental health problem, PYH = preventive youth healthcare, SDQ = Strengths and difficulties questionnaire, X = when prevalence of characteristic <10, related percentages was then also blinded

[a] Subgroups are compared with children without any outcome, i.e. with no CAMH use and no MHP registered by GP.

[b] Characteristic based on information from PYH, other characteristics are based on information from GP.

[c] Chronic disease when present one or more of the following: asthma, eczema, psoriasis, inflammatory bowel disease, epilepsy, diabetes mellitus, cystic fibrosis, rheumatoid arthritis.

Children with only CAMH use n=1,284 [a], %(n)	Children with only MHP use n=2,065[a], %(n)	Children with MHP and CAMH use n=882[a], %(n)
5.7 (73)	5.5 (114)	6.5 (57)
85.8 (1,102)	89.2 (1,842)	89.7 (791)
68.1 (874)	71.5 (1,477)	75.3 (664)
19.7 (253)	19.4 (400)	21.8 (192)
66.0 (848)	66.3 (1,369)	69.0 (609)
13.7 (176)	10.4 (214)	12.8 (113)
4.8 (61)	9.0 (186)	7.4 (65)
34.6 (444)	37.0 (765)	36.4 (321)
29.6 (380)	24.8 (51.3)	35.6 (314)
6.2 (80)	4.9 (102)	10.5 (93)
3.9 (50)	3.4 (71)	6.1 (54)
3.8 (49)	3.8 (79)	5.1 (45)
1.3 (17)	2.8 (57)	2.2(19)
11.3 (145)	11.5 (238)	12.9 (114)
1.1 (14)	1.7 (35)	1.5 (13)
2.5 (32)	3.5 (72)	2.9 (26)
1.8 (23)	3.0 (62)	2.4 (21)
0.9 (11)	1.9 (40)	1.2 (11)
2.8 (36)	1.8 (38)	3.5 (31)
3.2 (41)	6.0 (123)	5.4 (48)

[d] Somatic complaint when present one or more of the following: tension headache, migraine, abdominal pain, constipation, tiredness, irritable bowel syndrome IBS, musculoskeletal symptoms, dizziness, nausea, hyperventilation syndrome, palpitations, fainting.
[e] Separate somatic complaints do not add up to the total amount of somatic complaints as a child can have multiple somatic complaints.
Characteristics prevalent in <1% of all children and therefore not included in table:
-GP based characteristics: academic problems, disabilities
-PYH based characteristics: excessive crying, negative weight perception, school level high and other, bad relationship with ≥1 parent, unemployment/financial distress of the child, self-harm, female genital mutilation, insufficient physical exercise, substance use, energy drink consumption, KIVPA increased, poorly experienced health, parental concerns about child.
Characteristic 'member of hobby/music club' was registered in >90% of all (subgroup) children

Table 2. Baseline characteristics of children age 12-18 years, including subgroups with different outcomes compared to children without any outcome[a]

Characteristics	**All children n=11,451, %(n)**
Child	
Male gender	46.8 (5,355)
Ethnicity	1.2 (133)
Developmental problems	2.5 (282)
Developmental problems[b]	1.1 (131)
Incontinence	2.3 (265)
Sleeping problems[b]	1.2 (136)
Eating problem[b]	1.3 (147)
Overweight[b]	13.9 (1,586)
Underweight[b]	7.6 (874)
School problem	5.4 (615)
Secondary school level low[b]	12.3 (1,407)
Secondary school level high[b]	7.1 (814)
Bullying/being bullied[b]	4.5 (511)
Substance use[b]	3.2 (352)
High technology use[b]	3.2 (352)
Life events	1.2 (133)
Life events[b]	11.7 (1,345)
Medical history	
Non-spontaneous birth[b]	1.5 (171)
Congenital anomaly	17.2 (1,965)
Disabilities	X (X)
Chronic disease[c]	33.7 (3,856)
Somatic complaints[d]	41.9 (4,794)
Tension headache[e]	7.0 (804)
Migraine[e]	1.8 (202)
Abdominal pain[e]	13.5 (1,546)
Constipation[e]	8.5 (979)
Tiredness[e]	9.7 (1,116)
Other somatic complaints[e]	21.8 (2,498)
Neoplasms	5.2 (596)
>2 GP Visits in previous year	83.5 (9,558)

	Children with only CAMH use n=528[a], %(n)	Children with only MHP use n=811[a], %(n)	Children with MHP and CAMH use n=482[a], %(n)
	39.0 (206)	41.6 (337)	36.7 (177)
	X (X)	X (X)	X (X)
	2.3 (12)	1.6 (13)	X (X)
	X (X)	X (X)	X (X)
	X (X)	2.8 (23)	X (X)
	1.9 (10)	X (X)	2.3 (11)
	X (X)	2.6 (21)	X (X)
	8.3 (44)	12.0 (97)	11.2 (54)
	4.2 (22)	5.8 (47)	3.5 (17)
	6.1 (32)	5.5 (45)	7.3 (35)
	4.5 (24)	10.6 (86)	9.1 (44)
	3.4 (18)	5.3 (43)	5.0 (24)
	3.0 (16)	4.2 (34)	4.8 (23)
	2.3 (12)	4.4 (36)	2.9 (14)
	X (X)	1.4 (11)	X (X)
	X (X)	2.5 (20)	X (X)
	12.3 (65)	13.6 (110)	13.5 (65)
	X (X)	X (X)	X (X)
	21.6 (114)	20.3 (165)	22.0 (106)
	X (X)	X (X)	X (X)
	29.7 (157)	35.9 (291)	35.7 (172)
	35.2 (186)	47.0 (381)	47.1 (227)
	6.8 (36)	9.1 (74)	7.5 (36)
	X (X)	2.3 (19)	2.3 (11)
	10.0 (53)	15.3 (124)	16.2 (78)
	9.1 (48)	7.4 (60)	11.6 (56)
	8.7 (46)	11.2 (91)	11.0 (53)
	17.8 (94)	25.9 (210)	25.7 (124)
	3.8 (20)	4.3 (35)	4.8 (23)
	82.6 (436)	86.4 (701)	85.9 (414)

Table 2. Continued

Characteristics	**All children n=11,451, %(n)**
≥1 Medication prescript in previous year	67.1 (7,681)
≥1 Laboratory test in previous year	27.4 (3,140)
≥1 Referral/correspondence other healthcare professional in previous year	60.2 (6,899)
Under treatment other than PYH[b]	6.7 (770)
Total referral in past year by PYH[b]	1.9 (216)
Extra healthcare visit in PYH[b]	22.1 (2,532)
MHP related	
cMHP[b]	38.3 (4,385)
SDQ borderline[b]	3.7 (421)
SDQ increased[b]	2.2 (253)
KIVPA increased[b]	7.2 (819)
Parent/family/environment	
Family history of MHP[b]	1.2 (143)
Chronic illness parent[b]	0.8 (96)
Risk factor parents[b]	11.2 (1,283)
Non-traditional family composition[b]	5.9 (678)
Low Socioeconomic status	3.5 (397)
Environmental stressors[b]	3.4 (391)

CAMH = child and adolescent mental healthcare. cMHP = concern for mental health problem according to preventive youth healthcare, GP = general practice, KIVPA = short indicative questionnaire for psychosocial problems among adolescents

MHP = mental health problem, PYH = preventive youth healthcare, SDQ = Strengths and difficulties questionnaire

X = when prevalence of characteristic <10, related percentages was then also blinded. However, this percentage could still be ≥1%, so that characteristic could still be included in logistic regression analyses

[a] Subgroups are compared with children without any outcome, i.e. with no CAMH use and no MHP registered by GP.

[b] Characteristic based on information from PYH, other characteristics are based on information from GP.

[c] Chronic disease when present one or more of the following: asthma, eczema, psoriasis, inflammatory bowel disease, epilepsy, diabetes mellitus, cystic fibrosis, rheumatoid arthritis.

Children with only CAMH use n=528[a], %(n)	Children with only MHP use n=811[a], %(n)	Children with MHP and CAMH use n=482[a], %(n)
63.3 (334)	71.5 (580)	74.1 (357)
24.2 (128)	32.8 (266)	30.5 (147)
58.1 (307)	65.1 (528)	69.9 (337)
6.3 (33)	7.8 (63)	7.1 (34)
X (X)	1.2 (10)	X (X)
27.3 (144)	28.9 (234)	26.8 (129)
38.6 (204)	41.6 (337)	43.8 (211)
5.1 (27)	4.4 (36)	5.4 (26)
3.8 (20)	2.7 (22)	4.1 (20)
8.5 (45)	11.8 (96)	12.4 (60)
2.8 (15)	1.8 (15)	2.3 (11)
X (X)	x (X)	X (X)
10.2 (54)	15.7 (127)	12.2 (59)
3.0 (16)	6.4 (52)	4.8 (23)
2.7 (14)	2.2 (18)	3.1 (15)
2.7 (14)	X (X)	X (X)

[d] Somatic complaint when present one or more of the following: tension headache, migraine, abdominal pain, constipation, tiredness, irritable bowel syndrome IBS, musculoskeletal symptoms, dizziness, nausea, hyperventilation syndrome, palpitations, fainting.
[e] Separate somatic complaints do not add up to the total amount of somatic complaints as a child can have multiple somatic complaints.
Characteristics prevalent in <1% of all children and therefore not included in table:
-GP based characteristics: academic problems, disabilities, perinatal problems
-PYH based characteristics: difficult temperament, parental concerns about child, negative balance, poorly experienced health, energy drink consumption, self-harm, female genital mutilation, secondary school level other, negative weight perception, little confidence parenting skills, insufficient physical exercise, excessive crying, premature, neonatal problems, unemployment/financial distress of the child, low self-confidence/resilience, bad relationship with ≥1 parent, prenatal risk factors
Characteristic 'member of hobby/music club' was registered in >90% of all (subgroup) children

The incidence of children with either a first GP registered MHPs or first recorded CAMH use in the same year ranged between 5.6% and 9.6% for children aged 4-11 years and between 4.9% and 6.8% for children aged 12-18 years (Table 3). The majority of the youngest (4 to 7 years) and oldest (17 and 18 years) children had a GP registered MHP and were less often found in the CAMH use registration. Children aged 7 to 14 were most often found in either the CAMH or in the GP registration but less often in both registrations.

Characteristics of children with MHPs and/or CAMH use

The characteristics of children in the subgroups children with only CAMH use, only GP registered MHPs, and both CAMH use and GP registered MHPs are depicted in Table 4 (children aged 4-11 years) and Table 5 (children aged 12-18 years).

Characteristics of the child

In children aged 4-11 years, boys more often used CAMH and/or were registered with MHPs by the GP compared to the group of children without any MHPs or CAMH use. School problems were associated with CAMH use with and without GP registered MHPs. Bullying/being bullied was associated with having both recorded CAMH use and GP registered MHPs. Difficult temperament and incontinence were related to GP registered MHPs without recorded CAMH use.

In contrast to the primary school-aged children, adolescents in the age group 12-18 years were more often female when having GP registered MHPs with and without CAMH use. In addition, exposure to life events was associated with GP registered MHPs with and without CAMH use. Being underweight or being a member of a hobby or music group made it more likely to be registered with both MHPs and CAMH use.

Characteristics of the child's medical history

Regarding children aged 4-11 years old, children with only CAMH use and no GP registered MHPs had less chronic diseases, were less overweight, and they were more often under treatment elsewhere (not in PYH) compared to the other subgroups. The adolescents aged 12-18 years who used CAMH but who were not registered with MHPs by the GP did not differ significantly from the group without both CAMH use and GP registered MHPs regarding most characteristics related to the medical history. They only more often had an extra health care visit in PYH. In contrast, the adolescents with a GP registered MHP with or without CAMH use were more often known with chronic diseases, somatic complaints, and medication prescriptions or laboratory tests in the previous year. The adolescents with only CAMH use were less often registered with a lower secondary school level and were also less overweight.

Table 3. First recorded GP recorded MHPs and CAMH use per age between 2009 and 2014

Child age (years)	Nr of children without previous MHP or CAMH use at T0, n	Children with only MHP at T1, % (n)	Children with only CAMH use at T1, % (n)	Children with both MHP and CAMH use at T1, % (n)	Total Children with MPH and/ or CAMH % (n)
1	3,580	3.0 (109)	X (X)	X (X)	3.0 (109)
2	13,327	3.8 (511)	0.4 (56)	0.3 (34)	4.5 (601)
3	13,254	3.9 (522)	0.5 (68)	0.5 (64)	4.9 (654)
4	13,079	4.3 (558)	1.0 (127)	0.6 (77)	5.9 (762)
5	12,895	4.9 (636)	1.4 (181)	1.0 (126)	6.3 (943)
6	12,543	4.1 (508)	2.0 (248)	1.7 (215)	7.8 (971)
7	12,211	4.2 (513)	3.1 (379)	2.3 (285)	9.6 (1,177)
8	11,837	3.2 (380)	3.8 (453)	2.2 (259)	9.2 (1,092)
9	11,614	3.4 (394)	3.5 (402)	1.8 (203)	8.7 (999)
10	11,330	2.9 (323)	3.4 (385)	1.5 (167)	7.8 (875)
11	11,044	2.2 (244)	2.0 (225)	1.4 (152)	5.6 (621)
12	11,022	1.8 (201)	1.9 (206)	1.2 (133)	4.9 (540)
13	10,946	1.8 (199)	1.8 (197)	1.4 (150)	5.2 (546)
14	8,928	2.4 (216)	2.1 (185)	1.5 (130)	6.0 (531)
15	6,913	2.5 (173)	1.7 (118)	1.6 (113)	5.8 (404)
16	4,970	2.7 (135)	1.7 (83)	1.6 (79)	6.0 (297)
17	3,206	4.2 (136)	1.3 (43)	1.3 (43)	6.8 (222)
18	1,506	4.6 (69)	X (X)	1.2 (18)	5.8 (87)

CAMH = child and adolescent mental healthcare, MHP = mental health problem, T0 = timepoint 0, timepoint of measurement of baseline characteristics, T1 = timepoint 1, timepoint of measuring outcomes, 1 year after T0, X = number of children <10, subsequent percentage was therefore also erased

Characteristics related to MHPs

PYH concerns for MHPs were associated with MHPs registered by the GP and/or CAMH use in primary and secondary school-aged children in nearly all subgroups. Only in children aged 4-11 years it was not associated with children having both MHPs and CAMH use. Regarding scores on mental health screening tools, only increased KIVPA scores were associated with an increased risk of GP registered MHPs with and without CAMH use in secondary school-aged children.

Table 4. Characteristics of children age 4-11 years with only CAMH use, only MHPs and both CAMH use and MHPs

Characteristics	**Children with only CAMH use n=1,284[a] Total person years 51,432 OR (95% CI)**
Child	
Male gender	1.44 (1.28-1.61)
Ethnicity[b]	NA
Developmental problems	
Developmental problems[b]	
Difficult temperament	0.57 (0.33-0.98)
Incontinence[b]	
Sleeping problems[b]	
Eating problem[b]	
Overweight[b]	0.69 (0.52-0.91)
Underweight[b]	
School problem	1.36 (1.02-1.80)
Secondary school level low[b]	
Bullying/being bullied[b]	
Low self-confidence/resilience[b]	
Member of hobby or music club	
Life events	NA
Life events[b]	1.28 (1.07-1.52)
Medical history	
Non-spontaneous birth[b]	0.48 (0.30-0.76)
Premature[b]	NA
Perinatal morbidity	
Neonatal problems[b]	
Congenital anomaly	
Chronic disease[c]	0.39 (0.34-0.44)
Somatic complaints[d]	
Neoplasms	
>2 GP Visits in previous year	
≥1 Medication prescript in previous year	
≥1 Laboratory test in previous year	
≥1 Referral/correspondence other healthcare professional in previous year	1.21 (1.07-1.37)

	Children with only MHP n=2,065[a] Total person years 52,213 OR (95% CI)	Children with MHP and CAMH use n=882[a] Total person years 51,030 OR (95% CI)
	1.54 (1.41-1.69)	1.61 (1.40-1.86)
	1.38 (1.10-1.73)	1.44 (1.06-1.95)
	1.45 (1.13-1.85)	
	1.72 (1.42-2.09)	0.61 (0.43-0.86)
		1.151 (1.12-2.05)
	NA	
		2.48 (1.52-4.04)
	2.27 (1.51-3.42)	NA
		1.23 (1.02-1.49)
	1.15 (1.05-1.27)	1.19 (1.03-1.37)
	1.25 (1.14-1.37)	1.26 (1.09-1.45)
	1.29 (1.13-1.47)	
		1.31 (1.11-1.54)
	1.25 (1.13-1.38)	1.21 (1.04-1.40)

Table 4. Continued

Characteristics	**Children with only CAMH use n=1,284[a] Total person years 51,432 OR (95% CI)**
Under treatment other than PYH[b]	1.20 (1.02-1.43)
Total referral by PYH[b]	
Extra healthcare visit in PYH[b]	
MHP related	
cMHP[b]	1.63 (1.41-1.88)
SDQ borderline[b]	
SDQ increased[b]	
Parent/family/environment	
Family history of MHP[b]	
Chronic illness parent[b]	
Risk factor parents[b]	
Prenatal risk factors[b]	
Non-traditional family composition[b]	
Low Socioeconomic status	
Negative balance	NA
Little confidence in parenting skills	
Environmental stressors[b]	

Only characteristics with significant associations with the outcome (i.e. OR doesn't contain 1) are presented, characteristics that were not included in the model with the specific outcome in this age group because of a prevalence <1% are presented with not applicable (NA)

	Children with only MHP n=2,065[a] Total person years 52,213 OR (95% CI)	Children with MHP and CAMH use n=882[a] Total person years 51,030 OR (95% CI)
	1,20 (1,07-1,35)	
	1.16 (1.02-1.31)	
		2.00 (1.51-2.65)
	1.54 (1.13-2.09)	

Table 5. Characteristics of children age 12-18 years with only CAMH use, only MHPs and both CAMH use and MHPs

Characteristics	**Children with only CAMH use n= 528 Total person years 32,293 OR (95% CI)**
Child	
Male gender	0.70 (0.59-0.84)
Ethnicity[b]	
Developmental problems	
Developmental problems[b]	
Incontinence	
Sleeping problems[b]	
Eating problem[b]	
Overweight[b]	0.70 (0.50-0.96)
Underweight[b]	
School problem	
Secondary school level low[b]	0.53 (0.34-0.82)
Secondary school level high[b]	
Bullying/being bullied[b]	
Substance use[b]	
Member of hobby or music club	
High technology use[b]	
Life events	NA
Life events[b]	
Medical history	
Congenital anomaly	
Disabilities	NA
Chronic disease[c]	
Somatic complaints[d]	
Neoplasms	
>2 GP Visits in previous year	
≥1 Medication prescript in previous year	
≥1 Laboratory test in previous year	
≥1 Referral/correspondence other healthcare professional in previous year	1.26 (1.04-1.54)
Under treatment other than PYH[b]	
Total referral by PYH[b]	
Extra healthcare visit in PYH[b]	1.55 (1.20-2.01)

	Children with only MHPs n= 811 Total person years 32,576 OR (95% CI)	Children with MHP and CAMH use n= 482 Total person years 32,247 OR (95% CI)
	0.83 (0.72-0.96)	0.67 (0.56-0.82)
		0.47 (0.35-0.63)
		1.75 (1.06-2.91)
		1.73 (1.42-2.11)
	2.32 (1.45-3.71)	NA
	1.36 (1.10-1.69)	1.36 (1.03-1.80)
	NA	
	1.24 (1.06-1.44)	
	1.45 (1.24-1.68)	1.43 (1.18-1.74)
		1.34 (1.08-1.66)
	1.37 (1.14-1.65)	
	1.25 (1.07-1.46)	1.51 (1.23-1.85)

Table 5. Continued

Characteristics	Children with only CAMH use n= 528 Total person years 32,293 OR (95% CI)
MHP related	
cMHP[b]	1.45 (1.18-1.79)
SDQ borderline[b]	
SDQ increased[b]	
KIVPA increased[b]	
Parent/family/environment	
Family history of MHP[b]	2.39 (1.38-4.14)
Risk factor parents[b]	0.73 (0.55-0.97)
Non-traditional family composition[b]	
Low Socioeconomic status	
Little confidence in parenting skills	
Environmental stressors[b]	

Only characteristics with significant associations with the outcome (i.e. OR doesn't contain 1) are presented, characteristics that were not included in the model with the specific outcome in this age group because of a prevalence <1% are presented with not applicable (NA)

Characteristics related to the parent, family or environment

Characteristics related to the parent, family or environment were not associated with MHPs and/or CAMH use in children aged 4-11 years. In adolescents aged 12-18 years, a family history of MHPs was positively associated with only CAMH use, while other adverse parental risk factors, such as unemployment or being abused in childhood, decreased the likelihood of CAMH use. These adverse parental risk factors and a family composition other than 2 biological parents increased the risk of GP registered MHPs without CAMH use.

	Children with only MHPs n= 811 Total person years 32,576 OR (95% CI)	Children with MHP and CAMH use n= 482 Total person years 32,247 OR (95% CI)
	1.26 (1.06-1.49)	1.47 (1.18-1.83)
	1.58 (1.25-2.00)	1.64 (1.22-2.21)
	1.24 (1.02-1.52)	
	1.52 (1.11-2.08)	

Discussion

In this population-based retrospective cohort study, we obtained further insight into the children who use child and adolescent mental healthcare (CAMH). Our study found that depending on age, 3 to 10% of the children had either a first GP-registered MHP and/or were recorded in CAMH. About 20 to 25% of these children were known both in the GP-registration and in the CAMH-registration. The 4–11-year-olds had a relatively large proportion of children with only GP registered MHPs. From the large number of characteristics we studied, only a minority appeared to be associated with children in the different subgroups: 1) only CAMH use, 2) only GP registered MHPs, and 3) both CAMH use and GP registered MHPs. In general, the children with GP registered MHPs more often had a history of medical conditions or consultations. The ones who were not yet recorded with CAMH use seemed to more often have typically age-specific registrations such as a difficult temperament and incontinence at primary school age or adverse parental and family factors in adolescence.

To our knowledge this is the first study that used a large population-based cohort with all available routine healthcare data from primary care that also linked this data on the individual patient level with data regarding CAMH use. This made it possible to obtain insight into the overlap between recorded MHPs in primary care and CAMH use, including the timeline between recorded MHPs by GPs and CAMH use.

We found that children with CAMH use without a GP recorded MHP in the same year were less likely to be overweight or to have a history of medical conditions such as somatic complaints, chronic diseases and medication or laboratory test results than with a GP recorded MHP. This might suggest that the children with only CAMH use could be less visible on the GP's radar, as registered somatic symptoms in children such as headache or abdominal pain have previously been described as risk factors for anxiety and depression based on GP records(37). In addition, primary school-aged children in the only CAMH use group also relatively had more registered school problems, which would suggest that referral to CAMH might have happened via schools. Their problems may reflect the psychosocial problems that a child encounters when entering the school setting. Preventive youth healthcare professionals often have a close link with the schools, to facilitate early recognition of problems in school(27).

In line with this, in this current study preventive youth healthcare concerns for MHPs in primary school-aged children, were more often found in the children with CAMH use but not in the group with GP recorded MHPs. Interestingly, the children with CAMH use without GP registered MHPs did not score particularly high on screening tools for MHPs,

and they less often had a lower secondary school level. It is known that adolescents with a higher educational level experience more stress. And this group of children with CAMH use without GP registered MHPs might concern these children who seek psychological counselling themselves. Or it might concern a group of children/parents that has been referred to as the 'worried-well', typically higher educated patients that fear symptoms or disease in the absence of pathology and who might have sought psychological counselling themselves(38, 39). It would be interesting to investigate further who the children with only CAMH use are and how and for what reasons these children were referred to CAMH. Future studies should therefore also aim to include data from the social domain, e.g. from social workers, as they might be involved in the care for these children.

We were also interested in whether certain characteristics would differentiate between children with GP registered MHPs who were or who were not also registered in CAMH. In primary school-aged children, having school problems or bullying/being bullied were risk factors for having both GP recorded MHPs and CAMH use, whereas these factors were not associated with only GP recorded MHPs. The presence of these characteristics could indicate more severe MHP symptoms, also affecting the daily social and academic functioning of the child and this could be a reason for a GP to refer a child to CAMH(40). These characteristics however were not associated with both GP recorded MHPs and CAMH use in secondary school-aged children. A possible explanation for this finding might be that in adolescence more girls are reported to have MHPs with relatively more internalizing problems, possibly resulting in somatic symptoms, as opposed to boys in primary school with a higher prevalence of externalizing problems.

In secondary school-aged children being overweight was protective for the outcome both GP recorded MHPs and CAMH use, while being underweight was a risk factor for this outcome. Being underweight might indicate problems with eating such as anorexia nervosa or bulimia. The incidence of eating disorders rises in adolescence and these kinds of problems are typically not being treated by GPs so that children with these problems would be referred for additional professional help(41).

A limitation of this study was the quality of the available data. As more extensively described elsewhere, over half of the characteristics based on information from preventive youth healthcare had more than 50% missing data and the prevalence of characteristics like family history of MHPs was lower than expected from the literature(42). Although electronic health records (EHRs) have the advantage of providing larger quantities of real-life clinical data than are available from scientific studies, the quality of this data raises important considerations(43). This is mainly the result of the

fact that these data were primarily used for providing healthcare, not scientific research. One of the major challenges of using EHR data for research is the presence of missing data, which are often missing not at random(35, 43, 44). As our aim was to identify characteristics of children who use CAMH based on available information from EHRs, we chose not to impute. However, missing data regarding determinants registered with data from preventive youth healthcare might have led to an underestimation of the found associations.

In addition, the general practice data regarding referrals/contact with other healthcare professionals and specifically CAMH was not very detailed in our extracted database. We could for instance see that there had been contact with certain health professionals, but for the majority of contacts we could not see whether the mail was inbound or outbound. We don't expect this to have affected our outcomes in a substantial way.

Due to governmental policy changes, data regarding CAMH use were only available for the period between 2009 and 2014 and we could not exclude children with CAMH use before 2009. We aimed to study children with a first episode of MHPs. As the majority of children with CAMH use also had MHPs registered by GPs, these children would have been excluded based on the presence of MHPs registered by GPs before 2009. However, the small group of children with only CAMH use before 2009 and no GP recorded MHPs might incorrectly not have been excluded from our study population. As it concerns a small group, we don't expect this to have altered our findings in a substantial manner. In addition, it is known from literature that not all children in need of CAMH receive CAMH(11, 12). Due to the nature of our data, we could not investigate these children.

This study showed that over six percent of children used CAMH without the GP having recorded MHPs and that these children in general less often had registered somatic or chronic diseases. Those children might be less visible in general practice and we would recommend future studies to investigate further who these children are and how they ended up using CAMH and for what reasons. In addition, we know from qualitative research that Dutch GPs currently have no structural interactions with preventive youth healthcare professionals other than occasional referral letters and that both professionals feel the need of better information exchange(45). As preventive youth healthcare concerns for MHPs were a risk factor for CAMH use and/or GP recorded MHPs, our study suggests that better information exchange between preventive youth healthcare and general practice could be useful in the identification of children who might need CAMH. It should be investigated whether this information is indeed what GPs need and how this structural information exchange practically can be executed.

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Supplementary Files

Supplement Table 1. Outcome definition

MHP based on the presence of ≥1 of the following:	Description
MHP ICPC code	P01 Feeling anxious P02 Acute stress reaction P03 Feeling depressed P04Feeling/behaving irritable P05 Senility, feeling/behaving old P06 Sleep disturbance P07 Sexual desire reduced P08 Sexual fulfilment reduced P09 Sexual preference concern P10 Stammering/stuttering/ tic P11 Eating problem in child P12 Bedwetting/enuresis P13 Encopresis/ bowel training problem P15 Chronic alcohol abuse P16 Acute alcohol abuse P17 Tobacco abuse P18 Medication abuse P19 Drug abuse P20 Memory disturbance P21 P22 Child behaviour symptom P23 Adolescent behaviour symptom P24 Specific learning problem P25 Phase of life problem adult P27 Fear of mental disorder P28 Limited function P29 Psychological symptom other P71 Organic psychosis other P72 Schizophrenia P73 Affective psychosis P74 Anxiety disorder/anxiety state P75 Somatization disorder P76 Depressive disorder P77 Suicide/suicide attempt P78 Neurasthenia/surmenage P79 Phobia/compulsive disorder P80 Personality disorder P81 Hyperkinetic disorder P82 post-traumatic stress disorder P85 Mental retardation P86 Anorexia nervosa/bulimia P98 Psychosis NOS/other P99 Psychological disorders, other T06 Anorexia/ bulimia
MHP ATC Code	N05A Antipsychotic drugs, N05B Anxiolytic drugs, N05C Hypnotics and sedative drugs, N06A Antidepressant drugs, N06BA02 dexamphetamine, N06BA04 methylphenidate N06BA09 atomoxetine N07BA drugs used in nicotine dependence or N07BB drugs used in alcohol dependence
MHP Referral to psychologist, psychiatry or psychotherapy	'eerste-lijnspsychologie' 'EERSTE-LIJPSYCHOLOGIE', 'GGZ-instelling', 'psychiatrie''PSYCHIATRIE' 'psychologische zorg' 'PSYCHOLOGISCHE ZORG' 'psychotherapie' 'PSYCHOTHERAPIE', 'ELP' 'ELP eerste-lijnspsyc' 'ggz' 'GGZ' 'PSL' 'PSL psychologische z' 'PSL Psycholoog' 'PST' 'PST' 'PSY' 'PSY psychiatrie' 'PSY' 'Psychiatrie' 'PTH' 'PTH psychotherapie'

MHP = mental health problem, ICPC = International Classification of Primary Care, ATC = Anatomical Therapeutic Chemical, a medication classification (29, 30)

Supplement Table 2. Definition of characteristics based on general practice data

Variable
Age
Gender
Medical condition
Congenital anomaly
Disabilities
Chronic Disease
Neoplasms

	Definition
	Age in years based on birth year
	Recorded as in EMR: male or female
	ICPC A90 Congenital anomaly OS/multiple, B78 Hereditary haemolytic anaemia, B79 Congenital anomaly Blood/lymph other, D81 Congenital anomaly digestive system, F81 Congenital anomaly eye other, H80 Congenital anomaly of ear, K73 Congenital anomaly cardiovascular, L82 Congenital anomaly musculoskeletal, N85 Congenital anomaly neurological, R89 Congenital anomaly respiratory, S81 Haemangioma/lymphangioma, S82 Naevus/mole, S83 Congenital skin anomaly other, T78 Thyroglossal duct/cyst, T80 Congenital anomaly endocrine/metabolic, U85 Congenital anomaly urinary tract, W76 Congenital anomaly complicate pregnancy, X83 Congenital anomaly genital female, Y82 Hypospadias, Y84 Congenital genital anomaly male other
	ICPC A28 Limited function/disability NOS; The remaining ICPC codes refer to the limited function/disability codes of the corresponding chapters B28, D28, F28, H28, K28, L28, N28, P28, R28, D28, T28, U28, X28, Y28, Z28,
	≥1 of the following: Asthma, Eczema, Psoriasis, Crohn, Inflammatory bowel disease IBD, Epilepsy, Diabetes Mellitus DM, Cystic Fibrosis CF, Rheumatoid Arthritis RA Asthma ICPC R96 ATC R03, Eczema/psoriasis ICPC S91 Psoriasis, IBD ICPC D94, S86 Dermatitis seborrhoeic S87 Dermatitis/atopic eczema S88 Dermatitis contact/allergic ATC D07 Dermatological corticosteroids, Epilepsy ICPC N88 ATC N03 anti-epileptics, DM ICPC T89 T90 ATC A10 drugs used in diabetes, CF T99.10, RA L88
	ICPC B75 Benign/unspecified neoplasm blood, D78 Neoplasm digest. benign/uncertain, F74 Neoplasm of eye/adnexa, H75 Neoplasm of ear, K72 Neoplasm cardiovascular, L71 Malignant neoplasm musculoskeletal N75 Benign neoplasm nervous system N76 Neoplasm nervous system unspecified, R86 Benign neoplasm respiratory, S78 Lipoma, S79 Neoplasm skin/benign/unspecified, S80 Solar keratosis/sunburn, T72 Benign neoplasm thyroid, T73 Neoplasm endocrine other/unspecified, U78 Benign neoplasm urinary tract, U79 Neoplasm urinary tract NOS, W73 Benign/unspecified. Neoplasm/pregnancy, X78 Fibromyoma uterus, X79 Benign neoplasm breast female, X80 benign neoplasm female genital, X81 genital neoplasm other/unspecified Y79 Benign/unspecified. Neoplasm gen. male, Y85 Benign prostatic hypertrophy, A79 Malignancy NOS, B72 Hodgkin's disease/lymphoma, B73 Leukaemia, B74 Malignant neoplasm blood other, B75 Benign/unspecified neoplasm blood, D74 Malignant neoplasm stomach, D75 Malignant neoplasm colon/rectum, D76 Malignant neoplasm pancreas, D77 Malignant neoplasm digest other/NOS, N74 Malignant neoplasm nervous system, R84 Malignant neoplasm bronchus/lunch, R85 Malignant neoplasm respiratory, other, S77 Malignant neoplasm skin, T71 Malignant neoplasm thyroid, U75 Malignant neoplasm of kidney, U76 Malignant neoplasm of bladder, U77 Malignant neoplasm urinary other, W72 Malignant neoplasm relate to pregnancy, X75 Malignant neoplasm cervix, X76 Malignant neoplasm breast female, X77 Malignant neoplasm genital other female, Y77 Malignant neoplasm prostate, Y78 Malignant neoplasm male genital other

Supplement Table 2. Continued

Variable
Prematurity/other perinatal morbidity
Lower socioeconomic status
Life events in past year
Academic problems
Difficult temperament
Developmental problem
Chronic somatic disorder parent
Somatic complaints

Healthcare use
Number of primary care visits in past year
Number of laboratory tests in past year
Number of medication prescripts in past year
Number of referrals/correspondences with other healthcare professionals (non-mental health)

MHP = mental health problem, ICPC = International Classification of Primary Care, ATC = Anatomical, Therapeutic Chemical, a medication classification(29, 30)

	Definition
	ICPC A93 Premature newborn, A94 Perinatal morbidity other
	Postcode marked as lower socioeconomic area: 0-20th percentile of Socioeconomic status (SES) score(46)
	ICPC Z15 Loss/death of partner problem, Z22 Illness problem parent/family, Z23 Loss/death parent/family problem, Z25 Assault/harmful event problem
	ICPC Z07 Education problem
	ICPC A14 Infantile colics, A15 Excessive crying infant, A16 Irritable Infant, T04 Feeding problem of infant/child
	ICPC T10 Growth delay, N19 Speech disorder
	No specific ICPC code, partly part of 'life event' with ICPC code Z22 Illness problem parent/family
	≥1 of the following: Tension headache, Migraine, Abdominal pain, Constipation, Tiredness, Irritable bowel syndrome IBS, Musculoskeletal symptoms, Dizziness, Nausea, Hyperventilation syndrome, Palpitations, Fainting. Tension headache ICPC N01 Headache N02 Tension headache, Migraine ICPC N89 ATC N02C, Abdominal pain ICPC D01 Abdominal pain/cramps general D06 Abdominal pain localized other, Constipation ICPC D12, ATC 06 Drugs for constipation, Tiredness ICPC A04 Weakness/ tiredness general. IBS ICPC D93, IBS ATC A03A Drugs for functional gastrointestinal disorders A03F Propulsives, Musculoskeletal symptoms ICPC symptom/complaint of: L01 Neck L02 Back L03 Lower back L08 L20 Joint, Dizziness ICPC H82 Vertiginous syndrome N17 Vertigo/ dizziness, Nausea ICPC D09 Nausea, Hyperventilation syndrome ICPC R98 Hyperventilation syndrome ICPC R86, Palpitations ICPC K04 palpitations K05 irregular heartbeat other, Fainting ICPC A06 Fainting/syncope

	Count per year
	Count per year
	Count per year
	Count per year

Supplement Table 3. Definition of characteristics based on preventive youth healthcare data

Variable	Definition[a]	Timing: first or last recorded measurement ≤T0
Concerns for MHPs (cMHPs)	-≥1 referral to a mental health specialist with indication mental health -≥1 consultation with a mental health specialist with indication mental health - Extra healthcare use in PYH between standard visits with indication mental health -≥1 intervention for mental health: -Triple P level 3 or higher and tip sheets (fears in children, stealing, dealing with fear or depression)(47) -Atypical mental health functioning (single examination in PYH) -≥1 abnormal specific mental health functioning recorded	First
Premature	Pregnancy duration <37 weeks or 259 days	First
Ethnicity	Immigrant/refugee Country of birth of ≥1 parent is other than the Netherlands or West-Europe (e.g. Suriname Dutch Antilles, Turkey, Morocco, Eastern Europe, other non-Western countries)	First
Nonspontaneous birth	Caesarean section, vaginal birth with forceps or vacuum extraction	First
Developmental problems	General developmental delay and/or speech and language delay at age 7 years and older	First
Incontinence	Incontinent for urine or faeces at age 4 years and older	Last
Sleeping problems	Sleeping problems	Last
Eating problem	Eating Problem	Last
Overweight	BMI classified as overweight or obese according to international age and gender specific standards(48, 49)	T0
Underweight	BMI classified as underweight according to international age and gender specific standards(48, 49)	T0
Negative weight perception	Negative perception of own weight (too light or too heavy)	T0

Supplement Table 3. Continued

Variable	Definition[a]	Timing: first or last recorded measurement ≤To
School problem	Any reported problems in school e.g. dyslexia, difficulty focusing, motivation problems, absenteeism or declining school performance	First
Secondary school level	Secondary school education level divided into 4 categories according to the Dutch school system: -low: VMBO or lower -middle: HAVO (reference category) -high: VWO -Other: in case of special education/no education; HAVO is reference category. When combined education levels were recorded, the lowest level was chosen, e.g. HAVO for HAVO/VWO	Last
Bullying/being bullied	Bullying or being bullied	First
Bad relationship with at least one parent	Bad relationship with at least one parent	Last
Low self-confidence/ resilience	Low self-confidence/ resilience	Last
Self-harm	Self-mutilation or suicidal thoughts	First
Female genital mutilation	Female genital mutilation	First
Unemployment or financial distress of the child	Unemployment or financial distress of the child	Last
Member of hobby of music club	Member of a hobby or music club	Last
Insufficient physical exercise	Less than one hour of exercise a day and/or not enough physical exercise according to the EMOVO[b] questionnaire: cycling or walking to school or an internship less than 1 day a week	Last

Supplement Table 3. Continued

Variable	Definition[a]	Timing: first or last recorded measurement ≤T0
Substance use	Alcohol use: at least once a week an alcoholic consumption	Last
	Drugs use: using or ever used hard drugs or soft drugs	Last
	Smoking: smoking or ever smoked	Last
	Water pipe use, at least once a week	Last
	Substance abuse/addiction (sum of the use of alcohol, drugs, smoking, waterpipe) and additional element	Last
Excessive Energy drink consumption	Energy drink abuse/addiction, consumes more than 1 energy drink a day	Last
High technology use	Gaming: more than 3 days a week	Last
	Social media use more than 3 days a week	Last
	Screen use on average daily over 2 hours of television or computer use	Last
SDQ borderline[c]	SDQ total score between normal and increased limits (borderline) -total score 3 years: 9-11 -total score 4-7 years: 11-14 -total score 8-14 years: 11-13 -total score 15-19 years: 13-15	Last
SDQ increased[c]	Increased SDQ total score -total score 3 years: 12-40 -total score 4-7 years: 15-40 -total score 8-14 years: 14-40 -total score 15-19 years:16-40	Last
KIVPA increased[d]	Increased KIVPA score ≥6 is an indication for consultation with PYHP. Maximum is 25 points	Last
Under treatment other than PYH	Already perceiving any form of treatment not in PYH	Last
Medical referral	Medical referral	until T0
Paramedical referral	Referral to speech therapist, dietician or physical therapist	until T0
Other referral	All referrals except medical or paramedical referrals, e.g. parenting support, home counselling, program for overweight children	until T0

Supplement Table 3. Continued

Variable	Definition[a]	Timing: first or last recorded measurement ≤To
Total referral by PYH	Sum of all above referrals	
Extra healthcare visit in PYH	Extra healthcare visit in preventive youth healthcare on top of standard visits, excluding visits for MHP and vaccinations	Until To
Life events	Looked after children (children who are (temporarily) in a foster family, living in an institution only when parents cannot take care of the child or custody by other person than family member	First
	Conflicts within household/hostile atmosphere	First
	Death of parent(s), sibling or another significant person.	First
	Victim of violence/abuse	First
	Divorce parent(s) or abandonment by parent	First
	Adoption	First
	Immigrant/refugee	First
Family history of MHP	Parents with any mental health problem	First
	Siblings with any mental health problem	First
Chronic illness parent	Parent with chronic illness	First
Risk factor parents	Parent victim of abuse in youth	Last
	Start of parenting support program "Stevig ouderschap", which helps parent(s) with a difficult start, for example due to the medical history of the parent or child, personal problems, insufficient supportive environment	Last
	Little support from social network parents	Last
	Unemployment or financial distress parents	Last
	Both parents with low level of completed education according to the International Standard Classification of Education(50): no, primary or lower secondary education	Last

Supplement Table 3. Continued

Variable	Definition[a]	Timing: first or last recorded measurement ≤T0
Prenatal risk factors	Substance abuse (smoking, alcohol or drugs) of the mother during pregnancy	First
	Young parenthood: 1 or more parent <20 years old at birth	First
	Complications during pregnancy (IVF/ICSI, blood loss in 1st or 2nd trimester, hypertension, diabetes)	First
	Medication use during pregnancy (all prescribed oral medication to mother during pregnancy)	First
Non-traditional family composition	All non-two parent family compositions, e.g. co-parent family composition, stepparent family composition	Last
Negative balance	Based on the model of Bakker(51) which combines different protective factors and risk factors for a child's healthy development on micro- meso- and macro level	Last
Little confidence parenting skills	Little confidence in parenting skills and/or parents with problems with parenting according to triple P multilevel program with level 3 or higher	First
Environmental stressors	Long hospital admittance child	Last
	Long hospital admittance sibling	Last
	Expansion in the family by sister, brother or stepparent, stepbrother or stepsister	Last
	Move/migration	Last
	Conflict outside of household	Last

[a]All definitions of the determinants are binary (yes/no). Information regarding developmental delay, incontinence, school problems including bullying, substance use, mental health problem (MHP) screening tools Strengths and difficulties questionnaire (SDQ) and short indicative questionnaire for psychosocial problems among adolescents (KIVPA), life events, family MHPs and parental educational level was available from the period 2005-2015. Information regarding the other predictors was available from the period 2010-2015. [b]EMOVO = a digital questionnaire of Dutch preventive youth healthcare (PYH) to monitor the health and well-being of second and fourth graders of secondary school(52). [s]Strengths and difficulties questionnaire (SDQ) = short screening questionnaire to screen for MHPs in children 2-17 years old(53). [d]KIVPA = a short indicative questionnaire for psychosocial problems among adolescents(54).

Chapter 7

Collaboration between general practitioners and preventive youth health physicians: room for improvement

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Abstract

Background: General practitioners (GPs) and preventive youth healthcare physicians (PYHPs) each have specific roles and expertise within Dutch primary child healthcare. GPs are responsible for curative care, whereas PYHPs perform regular check-ups to monitor a child's healthy development. Better interprofessional collaboration would improve the identification and treatment of health problems.

Aim: To investigate how GPs and PYHPs experience their collaboration and to analyse the factors involved.

Methods: Fourteen GPs and eleven PYHPs were interviewed in a semi-structured manner. Important themes related to collaboration were identified using thematic analysis within the 'Framework method'.

Results: The frequency of contacts between GPs and PYHPs varied from weekly to biannually. Most participants failed to meet important conditions for good collaboration that are known from literature. Not all GPs were aware of the tasks and competencies of PYHPs, and GPs were less likely to have joint agreements/guidelines than PYHPs. Both parties experienced little support for collaboration from their own organizations or municipalities. Exchange of information mainly took place in case of a medical emergency or on request, and both reported inconsistent accessibility of the other party. Better exchange of information was considered essential to improving interprofessional collaboration.

Discussion: Current collaboration between GPs and PYHPs is suboptimal. Key improvements include knowledge of respective tasks and competencies, building trust, information exchange and organizational/municipal support. These insights should help to formalize and improve interprofessional collaboration in Dutch primary healthcare for children but can also be valuable to improve quality of care in other settings.

Introduction

In the Netherlands, general practitioners (GPs) and preventive youth healthcare physicians (PYHPs) are the key professional groups involved in primary healthcare for children. GPs and PYHPs each have their own specific knowledge and tasks within the Dutch healthcare system. They each have different information on the health and illnesses of children and their families and gather this information at different times and for different reasons. This means that their roles are potentially complementary(1).

A GP mainly sees children with specific health complaints, and most children and adolescents visit their GP once a year on average. GPs often have a longstanding relationship with their patients. They generally provide care to the child, parents and other family members, and therefore have a good overview of the child and its environment(2, 3). In the Netherlands, a PYHP sees 80-90% of all children aged 0 to 19 during periodical preventive health check-ups(4, 5). The goal of these check-ups is to prevent disease, promote health and allow early detection of health risks, disease, and developmental problems in the physical, psychological, social and cognitive domains(6).

In recent years, recommendations were made by several professional associations, including the Dutch College of GPs (NHG), the National General Practice Association (LHV) and Dutch Preventive Youth Health Care Physicians (AJN), to promote mutual collaboration between GPs and PYHPs. One of these recommendations was to plan an annual or biannual meeting to discuss working arrangements and to evaluate collaboration(1, 7).

Additionally, national primary care collaboration agreement documents (LESA's), based on existing NHG and AJN guidelines, were developed for specific topics such as cardiac defects and child abuse(8, 9). Municipalities, GPs and PYHPs also participated in local meetings to develop collaborative agreements in the context of the Youth Healthcare Transition 2015 (Transitie Jeugdzorg) and changes in legislation regarding direct referral from preventive youth healthcare to secondary care(10, 11). During the Youth Healthcare Transition in 2015, the responsibility for providing youth healthcare was transferred from the government to the municipalities.

In this study we investigated how the collaboration between GPs and PYHPs progressed since the Youth Healthcare Transition and which factors affected this collaboration. We also made an inventory of physician's needs regarding collaboration and where they see room for improvement.

Methods

Research design

Within this qualitative study using semi-structured interviews, we investigated the collaboration between GPs and PYHPs and how each party experienced the collaboration. Collaboration was defined as any form of mutual contact. We applied the 'consolidated criteria for reporting qualitative research' (COREQ; Supplement Table 1)(12).

Participants

GPs from the Leiden and The Hague regions in the Netherlands were invited to participate by mail, followed by a telephone call. PYHPs from the organizations 'Jong Florence' The Hague (preventive youth healthcare 0-4 years), Community Health Service (GGD) 'Haaglanden' (preventive youth healthcare 4-19 years, The Hague area) and 'GGD Hollands Midden' (preventive youth healthcare 0-19 years, Leiden area) were approached by key figures within these organizations. We also placed an advert explaining the study in the in-house magazine of the 'GGD Hollands Midden'. Using 'purposive sampling', a heterogeneous group of physicians was selected based on age, sex, practice type, practice location and type of neighbourhood. Data saturation (when interviews no longer yielded new relevant information) determined the sample size.

Data collection

The interview topic list was based on determinants derived from literature, that are known to influence (interprofessional) collaboration(13, 14). The topic list was tested beforehand during a test interview. Prior to the interviews, the main topics were e-mailed to the participants in order to increase the interview yield. The interviews were conducted between June and October 2015 and each lasted approximately one hour. There were two interviewers per interview, one of whom mainly observed. Audio recordings of the interviews were made with the permission of the participants.

Data Analysis

The audio recordings of the interviews were transcribed verbatim and thereafter coded by two different members of the project group. We coded deductively, based on the determinants of collaboration known from literature. New codes were inductively obtained when the existing codes did not fit. Ambiguities were discussed in the project group until agreement was reached. Using the 'Framework method'(15), a thematic analysis technique, the most important themes concerning the collaboration were identified from the data and discussed in the project group. Interviewing and analysis took place simultaneously and iteratively. Atlas.Ti version 6.2 was used for the analyses.

Ethical considerations

All participating physicians received written information regarding the study and they all provided written or verbal agreement to participate in this study.

Results

A total of 14 GPs and 11 PYHPs were interviewed. Eight GPs and four PYHPs were based in the Leiden area, other participants were based in or around The Hague (Table 1, Supplement Table 2). 'Lack of time' and 'no collaborations' were given as reasons for non-participation by GPs.

Both the GPs and the PYHPs showed initiative in seeking mutual contact. Most participating GPs commented that their contact with PYHPs was non-existent or only sporadic, ranging from a couple of times a year to once every two to three months. GPs sought contact with PYHPs in case of developmental problems, school problems, difficult family situations or nutritional problems. Most PYHPs reported having contact with a GP once or twice a month. Reasons for contact were a request for information about a child or family regarding both somatic and psychosocial complaints, school absenteeism and referral to specialized care.

PYHPs mentioned that they mostly initiated contact, using a variety of methods (referral letter/e-mail/telephone/face-to-face contact). GPs typically only used a referral letter. In this study, the physicians from smaller municipalities generally seemed to know each other personally and they reported to keep contact with each other. This was not the case in the larger municipalities.

The below themes were indicated as important to collaboration according to the participating physicians. Table 2 shows the reported barriers and facilitators for collaboration. Supplement Table 3 contains statements characterizing the various themes found in the data.

Low educational level and multi-problem families

Certain patient characteristics such as socioeconomic status (SES), ethnicity and the nature of a patient's complaint were alternately cited as affecting or not affecting the collaboration. However, it was regularly indicated that patients with a lower educational level and multi-problem families had more difficulties formulating their needs, resulting in a more pro-active role for the physician, also in terms of collaborations. A patient's opinion regarding collaboration also affected the collaboration.

Table 1. Characteristics of participating physicians per group: general practitioners and preventive youth healthcare physicians

Characteristics physicians		Preventive youth healthcare physician n = 11	General practitioner n = 14
Gender	Male	0	5
	Female	11	9
Age	30-40 years	2	3
	41-50 years	5	6
	51-60 years	3	4
	61-70 years	1	1
Work experience	1-10 years	3	5
	11-20 years	5	6
	21-30 years	1	1
	>30 years	2	2
Location practice	City	8	10
	Village	3	4
Area with low SES	Yes	5	6
	No	3	5
	Mixed	3	3
Type of family practice *	1 GP	Not applicable	8
	2 GPs	Not applicable	4
	Group practice	Not applicable	2
Age of patient	0-4 years old	4	Not applicable
population PYHP	0-12 years old	2	Not applicable
	4-19 years old	5	Not applicable

*According to the definition of the Netherlands Institute for Health Services Research (NIVEL)(16). GP = general practitioner, PYHP = preventive youth healthcare physician, SES = socioeconomic status

Trust, personal acquaintance, and understanding of competencies and shared goals

Trust, personal acquaintance and understanding of respective competencies were all important for the interaction between GPs and PYHPs. GPs did not always have full confidence in the PYHPs and reported to have insufficient knowledge of all PYHP competencies. This was confirmed by the PYHPs. Some GPs expressed doubts about whether PYHPs took adequate action in case of concerns regarding a child. GPs also frequently mentioned that they were uncertain about PYHPs' tasks regarding school-aged children and psychosocial problems. GPs were generally unfamiliar with the LESA's and PYHP guidelines. PYHPs all knew one or more GPs and felt they had a good

understanding of GPs' tasks. However, it was not always clear to them how the GP's knowledge and experience regarding health and developmental problems in children was, or whether a general practice physician-assistant for mental health (POH-GGZ) was available in a practice. PYHPs generally expressed their trust in GPs and that this trust, in addition to mutual respect, was important for the collaboration. Negative feedback or a rejected referral could result in damage to this trust. Most PYHPs and GPs indicated that although shared goals were not often explicitly expressed, they did feel reasonably in agreement regarding the shared goals. Better exchange of information was frequently cited as being important and of added value.

Accessibility

Participating physicians had differing experiences in terms of accessibility, and both groups of physicians regularly experienced problems with each other's availability by phone. Only a few physicians who happened to work in the same building reported frequent face-to-face contact, which was felt to facilitate collaboration. E-mail was barely used for consultations, partly because PYHPs were unable to send e-mail messages securely. GPs also frequently mentioned that they had insufficient knowledge of which PYHP was assigned to a specific patient. One physician mentioned a shared patient record system as a possible solution.

Exchange of information

The exchange of information with the aim of 'creating a complete picture' together was considered important and was generally considered a goal of the collaboration. However, it was striking that in practice little information was exchanged and that most contacts were (short) referral letters. Physicians consulted each other regarding individual children in case of a (medical) emergency. Regarding psychosocial problems, GPs rarely collaborated with preventive youth healthcare when these problems were suspected. PYHPs sometimes exchanged information with a GP when psychosocial problems were first identified, but they also often collaborated with schoolteachers or social workers in these instances.

Table 2. Summary of the most important determinants that influence collaboration between GPs and PHYPs, including themes often mentioned by participants

Factor	**Influence**		
	Facilitator	**Barrier**	**Neutral***
Interaction			
Trust	Equivalence Mutual respect Knowledge of respective expertise/ experience	Complaints by patients Negative experiences in communication (referral, feedback) Concerns regarding an adequate approach Lack of expertise/ experience	
Mutual acquaintanceship	Accessibility Work location in proximity Stable team Mutual activities	Unfamiliarity with each other Overlap in catchment areas	
Understand respective competencies	Information exchange Mutual projects	Unfamiliarity with each other's competencies, in general and regarding specific subjects	
Joint activities	Joint project	Lack of time and money	
Shared goals	Feeling aligned Better information exchange important		Shared goals tentatively expressed
Organization			
Accessibility	Work location in proximity Linking patient records	Lack of consultation facilities Seeking contact at unfavourable times (e.g. during outpatient clinics) Unknown which physician takes care of which patient	

Table 2. Continued

Factor	**Influence**		
	Facilitator	**Barrier**	**Neutral***
Leadership	Professional is initiator of a contact regarding an individual child. CJG coordinators and staff PYHPs are sometimes leaders of collaborations. External support that initiates joint meetings	Lack of mutual agreements	
Organizational support	External support that initiates joint meetings	Lack of time and money Lack of policy	
Agreements and guidelines	Familiarity and contact with each other	Unfamiliarity with guidelines	
Structural connectivity	External support Joint meetings Active approach		
System			
Policy of the municipality or government		Lack of municipal policy Low priority for municipality Lack of practice orientation	Changes in governmental policies
Support from government of municipality	External support	Lack of money Lack of support	
Mutual training		No mutual training for interprofessional collaboration	Existing training in an overarching subject

* 'Neutral' also means sometimes regarded as either facilitator or barrier

*Requirement only mentioned by GP, ** Requirement only mentioned by PYHP; CJG = Centre for Youth and Families

Leadership, commitment and organizational support

Both the GPs and the PYHPs indicated that collaboration was primarily instigated by a prior contact with a child or its family. Organizational connectivity and professional leadership that stimulated collaboration within the organization would be supportive, but both were lacking according to many physicians. For example, one GP referred to 'two separate worlds'. GPs experienced little organizational support for collaboration, even the overarching GP organizations offered little support. GPs reported lack of time and reimbursement as factors impeding collaboration in the form of joint activities to strengthen cooperation regarding individual patients. PYHPs indicated that their contract allowed them to dedicate a few hours to collaboration but that this was insufficient. Several times, they mentioned that attending physicians ('stafartsen') and coordinators of the Youth and Family Centre (CJG) were important for their collaboration.

Collaborative agreements and joint activities

In practice, there were few clearly structured collaborative agreements between most GPs and PYHPs. One doctor felt little need for (too many) rules 'from above'. Agreements that were developed during a one-off project were experienced positively, as were joint meetings. Many PYHPs mentioned that they had occasionally participated in a joint meeting. This resulted in closer acquaintance and familiarity with each other's way of working, and therefore in a better collaboration. Physicians from The Hague mentioned the positive influence of 'Lijn 1', a regional organization supporting primary care, which for example organizes joint meetings to improve collaboration.

Municipal and governmental policy and support

Physicians experienced little or no support from the municipality, for example, in the form of time and money for joint meetings. Likewise, many doctors were of the opinion that the policy of municipalities regarding collaboration was not suitable for daily practice. At the time of the interviews, a collaborative agreement regarding youth in The Hague was signed by, among others, GPs and PYHPs. The operationalization of this agreement had yet to take place, but the agreement was experienced positively by physicians in The Hague. The effect of budget cuts associated with the 'Youth Healthcare Transition' (Transitie Jeugdzorg) were mentioned negatively.

Table 3. GP and PYHP needs in the interprofessional collaboration

Suggestions for improvement
Interaction
Improve knowledge regarding competencies of the PYHP
To get to know each other personally
Organization
More active approach for collaboration from PYHP*/GP†
More information exchange
Structural meetings/discussions of patients
Secure e-mail
(Partly) linked patient records
Support: time and money
Work agreements regarding when information exchange/consultation need to take place
To have an overview of all people involved and their contact details
To use multidisciplinary guidelines†
CJG as initiator of collaboration†
Electronic referrals*
Knowing which PYHP takes care of which child
A dedicated GP telephone number for colleagues†
CJG coordinator as leader† or single contact person*

	Citation
	GP12: 'I think that knowing each other personally and knowing what the other person does is very important.'
	PYHP1: 'GPs in general rarely seek direct contact with us.' GP8: 'I don't know any PYHP, you never see them. And they never call.'
	GP2 re psychosocial problems: 'We see the top of the iceberg during consultations. To really have a good view I think it is important to collaborate, to complete the picture together [...] I think in the end you will need other healthcare professionals and the school to complete the picture.' PYHP1: 'In my opinion we don't think about it often enough. Eh, you really need to have it in your system: always call a GP in case of psychosocial things to get info regarding the family.'
	GP13: 'I would really like to have a regular meeting to discuss things.'
	PYHP1: 'So parts of the patient files could be linked or only shared on indication. I don't think everything, because not everything is relevant for a GP.'
	GP1: 'So that there is some alignment between us. I think it would be really great if specific established information is exchanged. And definitely not too much, for instance regarding (a decrease in) school performance, that we are aware of.'
	GP11: 'To have a list with all email addresses of PYHPs and GPs and everybody involved in youth healthcare; email addresses and telephone numbers, that already was a huge improvement.'
	GP10: 'We sometimes receive a note with a request to refer a child to an ophthalmologist. That is a little note [...] A sloppy piece of paper. Whereas we do have the possibility to refer electronically, I can show you.'
	GP1: 'We don't need a whole list of people, a whole structure. Just give us one person.'

Table 3. Contintued

Suggestions for improvement
System
Improve the visibility of preventive youth healthcare
More information re preventive youth healthcare in the GP training program
Support from municipality/government/..
Joint trainings
Policy focused on daily practice
Smaller family practices*

CJG = Centrum for Youth and Families, GP = general practitioner, PYH = preventive youth healthcare, PYHP = preventive youth healthcare physician, * Requirement only reported by general practitioners, ǂ Requirement only reported by preventive youth healthcare physician

Requirements and starting points for collaboration

Most GPs and PYHPs reported a need for more collaboration, including better exchange of information and more mutual contact. The indicated starting points for improvement followed logically from the various factors that influenced the collaboration (Table 3). Most often mentioned by both disciplines was improved exchange of information, for example through adequate working agreements on when physicians should involve each other in specific cases, when feedback should be given. Structured, planned contact moments were also mentioned. PYHPs also wished that GPs had better knowledge about their tasks and competencies, a sentiment shared by most GPs. Better accessibility was also mentioned, and possible solutions included secure e-mail and a shared overview of relevant e-mail addresses and telephone numbers. Furthermore, both groups frequently mentioned the importance of more support for collaboration from the organization and municipality/government, for instance in the form of time and money.

	Citation
	GP9: 'What does a PYHP do? Where do I see him/her? Does he/she work at school? There is way too little information. They are not visible enough. I honestly wouldn't know what they do.'
	GP7 re competencies/task/guidelines preventive youth healthcare: 'That is nice for in the GP vocational training program.'
	GP6: 'We do not have a pot of money for that, no. If I must join a meeting during my clinic, I won't make any money, it costs me money since I can't see any patients. It is not too bad if it is only occasionally, but you have so many meetings, e.g. with the pharmacy and practice assistants. So no, there is not much room.'
	GP5: 'I recently had a meeting with the Ministry of Health, but it is so focused towards civil servants. Problem this, create a protocol that. Daily practice doesn't work like that. That is a problem we face. They have really nice protocols, but those don't always work in daily practice.'
	GP2: 'It is a shame to always talk about money, but my own practice is not growing at all. But my workload is becoming heavier and heavier. In my opinion we need smaller practices because you can't do everything that is expected of you anymore.'

Discussion

This study shows that important factors and conditions for collaboration between general practitioners (GPs) and preventive youth healthcare physicians (PYHPs) are suboptimal for the majority of participants. Most GPs and PYHPs recognize a need for better collaboration and especially an improved exchange of information. The collaboration between GPs and PYHPs seemed better when physicians had more frequent joint meetings or projects, knew each other and each other's competencies better and had more frequent contact.

This study provides in-depth insight into how these two groups of medical specialists experience collaboration. By using a semi-structured approach based on literature-derived factors that influence collaboration, the broadest possible view of the collaboration between GPs and PYHPs was presented. The method of selection of participants may have led to the inclusion of participants with greater affinity for and more experience of collaboration. Unfortunately, no comparison was possible with the non-respondents. Compared with the national GP registry, this study involved more women, more middle-aged GPs and fewer GPs aged 60 years or over. As is typical of the GP population in the Leiden and The Hague regions, participating GPs more often worked alone in their own practice, compared to working in a group practice. The participating GPs also worked relatively more frequently within a low social economic status population(16).

Despite recommendations from professional associations urging improved collaboration (2008), collaboration does not appear optimal and still largely depends on individual initiatives. Given the complementary roles of GPs and PYHPs, collaboration is important for the continuity of care for children and their families(1). The issues in need of improvement mentioned in our study, such as a better exchange of information, greater mutual familiarity and a better understanding of respective competencies, are in line with the barriers and facilitators of interprofessional collaboration found in earlier international research(17, 18).

Important facilitating factors for collaboration were frequent consultation, further information exchange and improved understanding amongst GPs regarding the role of PYHPs in the care for 4–19-year-olds. Given the need for improvement highlighted by this study, existing recommendations such as a (semi-) annual consultation regarding working agreements and evaluation of collaboration(1) appear insufficient. The improvement of collaboration calls for a more proactive approach at all levels: among physicians, organizations and at the municipal level.

In this study, most contacts between GPs and PYHPs was with (short) referral letters. In case of a medical emergency regarding individual children, both groups reported that in those cases personal (telephone) contact was not a problem. In order to make optimal use of the knowledge and expertise of both professions, information exchange on a structural basis would be desirable, for example by sharing elements from the respective patient records, instead of ad hoc in case of emergency. However, solutions will also have to be developed to tackle commonly mentioned barriers such as lack of time, money and organizational support. Initiatives developed by local authoritative figures are known to promote interprofessional collaboration(13). In addition, we are aware that not every situation or every patient is comparable, as our study illustrates that collaborations are more likely in the case of vulnerable families. The wishes of an individual patient regarding cooperation also influence a possible collaboration.

This study took place during the first year of the youth care transformation. The community meetings for care providers, including GPs and PYHPs, that were organized in this context were received positively. The frequently mentioned need for better insight into each other's way of working and the need for working agreements on accessibility and information exchange were discussed during these meetings. As the transformation may have had positive consequences for the collaboration between GPs and PYHPs, this study should be repeated in the future.

In conclusion, this study provided insight regarding possible starting points for improvements in the collaboration between GPs and PYHPs. Information exchange was seen as the main goal of collaboration by both professions. Improved information exchange, better personal acquaintance, a better understanding of respective competencies and additional organizational support are important aspects in this light.

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Supplementary Files

Supplement Table 1. Consolidated criteria for reporting qualitative studies (COREQ)(15)

1.	Interviewer: we used two trained interviewers per interview (LS-NK, LS-MK of MK-NK), of whom one mainly observed.
2.	Credentials: please see title page.
3.	Occupation: at the time of the study LS and MK were master students in medicine at Leiden University Medical Centre (LUMC). They conducted this study as part of a scientific internship. NK was a family practice trainee and PhD candidate at the LUMC. MC and FB were senior researchers at the Department of Public Health and Primary Care of the LUMC. MN was general practitioner and head of the Department of Public Health and Primary Care of the LUMC. JW was preventive youth healthcare physician and senior researcher at the Department of Public Health and Primary Care of the LUMC.
4.	Gender: LS, MK, NK, FL and MC are female; JW and MN are male.
5.	Experience and training: MC and FB are experienced qualitative researchers. NK, MK and LS were trained by MC; interviewing is part of the medical training program.
6.	Relationship established: prior to study commencement, there was no relationship between the interviewers and the participants. LS, MK and NK only had contact with the participants when making appointments and during the interview itself.
7.	The participants were aware of the aim of this study. They were also aware of the background of the interviewers: title and affiliation. Regarding NK, they knew that she was a PhD candidate and studied the identification of psychosocial problems in children.
8.	Interviewer characteristics: see 2 and 7, no additional characteristics were reported.
9.	Methodological orientation and theory: using the 'Framework method' , a thematic analysis technique, we identified the main themes in the data(15).
10.	Sampling: we used a 'purposive sampling' approach, please see method section of the article.
11.	Method of approach: please see method section of the article.
12.	Sample size: 25 physicians (14 GPs and 11 PYHPs) participated in this study.
13.	Non-participation: We invited 65 GPs to participate in this study via mail. Of the 20 respondents, 11 were willing to participate. We telephoned 34 of the non-responders, after which another three GPs were willing to participate. The PYHPs were approached via key figures in the organization; there were no non-responders. As reasons not to participate GPs mentioned lack of time, no collaborations and recent practice takeover (professional network not yet established).
14.	Setting: the interviews took place at the offices of the participants in all but two cases where participants preferred to be interviewed at the LUMC.
15.	Presence of non-participants: during the interviews only the participant and the two interviewers were present.
16.	Description of the sample: see result section of the article and table 1 and supplement 2.

Supplement Table 1. Continued

17.	Interview guide: we used a topic list based on the framework for interprofessional collaboration mentioned in the article. Before the interview, we emailed the main topics of the interview to the participants in order to increase the output. We had one test interview. Since this interview was of good quality, we included this interview in our analysis.
18.	Repeat interviews: no interviews were repeated.
19.	Audio/visual recordings: we made an audio recording of each interview with permission of the participants.
20.	Field notes: in some cases relevant field notes were made during the interviews.
21.	Duration: the interviews approximately lasted one hour.
22.	Data saturation: data saturation was established and determined the sample size.
23.	Transcripts returned: the transcripts of the interviews were not returned to the participants for comments or corrections.
24.	Number of data coders: half of the interviews were coded by both LS and NK/MK or by MK and NK. The other half of the interviews were coded by LS or MK, and these codings were checked by NK or MC.
25.	Description of the coding tree: see result section of the article. In case of interest one can send a request to the authors.
26.	Derivation of themes: the main themes were derived from the data by NK and MC and discussed in the project group.
27.	Software: we used Atlas.Ti version 6.2 to manage the data.
28.	Participant checking: the participants had the possibility to give feedback on the manuscript.
29.	Quotations: relevant quotations were presented in the tables of the article, together with the participant number.
30.	Consistency data and findings: there was consistency between the presented data and the findings.
31.	And 32. Clarity of the major and minor themes: the major and minor themes are presented in the article as determinants and themes. They are reported in the text and depicted in table 3 and figure 1. We presented typical quotations as well as contrasting quotations.

Supplement Table 2. Characteristics of participating physicians

Participant	Gender	Age (years)	Work experience (year)	Practice location	Area with low SES population (yes/no/mixed population)	Type of family practice/ age of patient population PYHP
GP 1	F	41-50	1-10	City	Yes	Practice with 2 GPs
GP 2	F	51-60	11-20	City	Yes	Practice with 1 GP
GP 3	F	31-40	1-10	City	Mixed	Practice with 1 GP
GP 4	M	51-60	21-30	City	Yes	Group practice
GP 5	F	31-40	1-10	City	Yes	Practice with 1 GP
GP 6	F	41-50	11-20	City	Yes	Practice with 1 GP
GP 7	F	41-50	11-20	City	Mixed	Practice with 2 GPs
GP 8	M	51-60	>30	City	Yes	Practice with 2 GPs
GP 9	M	41-50	1-10	City	Mixed	Practice with 1 GP
GP 10	M	51-60	11-20	City	No	Practice with 1 GP
GP 11	F	31-40	1-10	Village	No	Practice with 2 GPs
GP 12	F	41-50	11-20	Village	No	Practice with 1 GP
GP 13	F	41-50	11-20	Village	No	Group practice
GP 14	M	>60	>30	Village	No	Practice with 1 GP
PYHP 1	F	51-60	1-10	City	Yes	0-4 years old
PYHP 2	F	31-40	11-20	City	Yes	4-19 years old
PYHP 3	F	>60	>30	City	Mixed	0-4 years old
PYHP 4	F	31-40	11-20	City	Yes	4-19 years old
PYHP 5	F	41-50	1-10	City	Mixed	4-19 years old
PYHP 6	F	51-60	>30	City	Mixed	0-4 years old
PYHP 7	F	41-50	11-20	City	Yes	4-19 years old
PYHP 8	F	51-60	11-20	Village	No	0-12 years old
PYHP 9	F	41-50	11-20	City	Yes	4-19 years old
PYHP 10	F	41-50	21-30	Village	No	0-12 years old
PYHP 11	F	41-50	1-10	Village	No	0-4 years old

GP = General practitioner, PYHP = preventive youth healthcare physicians

Supplement Table 3. Summary of the most important determinants influencing collaboration between GPs and PYHPs, with the most often reported themes

Determinant	Theme	Physician*	Description
Determinants related to the interaction			
Trust	Equality/ mutual respect	PYHP	Mutual respect important for collaboration
	Expertise/ experience	B	-Trust in each other's expertise/ experience present
		GP	-GP has no trust in PYHP
	Familiarity	B	More familiarity, more trust
	Patient complaints	GP	Negative patient experiences regarding a doctor influences trust and way of working
	Negative experience: referrals/ feedback	B	Negative experience harms trust. Feedback is missing.
	Concerns as to adequate approach	GP	Some GPs have concerns as to whether PYHPs approach things adequately
Personal acquaintance	Accessibility	B	Contact details and personal acquaintance are facilitators.
	Unfamiliarity with each other	B	Unfamiliarity with each other and each other's competencies are barriers
	Work location in the proximity	B	Working in the same building is facilitating
	Permanent team	B	Permanent team, knowing each other well, is facilitating
	Non-overlapping catchment area	GP	Discrepancy catchment area GP and PYHP, e.g. different neighborhoods resulting in less familiarity
	Joint activities	B	If there are joint meetings/projects, they are experienced positively.
Knowledge of respective competencies	Unfamiliarity expertise	B	Unfamiliarity of GPs regarding the expertise of PYHPs
	Unfamiliarity expertise specific subject	GP	-Unfamiliarity regarding the expertise of re psychosocial problems, school-aged children
		PYHP	-Unfamiliarity whether GP has expertise with children or mental health

	Quotation
	PYHP10: 'That you appreciate each other; what the other person does and is able to do. That is important, it is a prerequisite.'
	GP2: 'I have a lot of trust in the doctors; they've been here much longer than me. So they know the neighborhood and are very experienced.' GP9: 'Yes, in my opinion, in all honesty, I don't consider them to be of high quality.'
	GP13: 'There are people that say: I don't ever want to go back there. You'll take note of that. If you hear that from 2 different people, you'll take that into account and you'll filter those people out, absolutely.'
	PYHP10: 'Of course it is a shame that you receive a referral letter corrected in red because is 'so-called' wrong. That doesn't affect your relationship in a good way. It makes you hesitant about referring to that person again or to even consult that person. You will just not bother.'
	GP1: 'You may wonder how something will turn out. It doesn't always go well and then you notice that sometimes the urgency is not felt by some doctors.'
	PYHP6: 'I think it's always an advantage to have a familiar face together with an email address and telephone number, so that you always have them available for possible use.'
	PYHP1: 'The bottleneck is not so much trust, but unfamiliarity with each other and each other's way of working, and yes indeed someone's face.'
	GP2: '..that we can just walk over to each other to quickly discuss something, that is much easier.'
	GP3: 'It is always difficult, with multiple neighborhoods and schools, to know every PYHP in a town; that is not always possible.'
	PYHP8: 'Together with the CJG, JFTs and GPs, we have set up an ADHD pilot; from that moment collaboration went really well.'
	GP10: 'For children aged 4-19 years, to me it is unclear what PYHPs have to offer. The purpose of well-baby clinics is clear to me.' PYHP1: 'Maybe I underestimate their competencies regarding children. ...and what I don't really know is whether they have a practice assistant for mental health who can also do something for my patients. That's something I currently miss.'

Supplement Table 3. Continued

Determinant	Theme	Physician*	Description
	Joint activities	B	Both have more insight regarding each other's competencies
	Information exchange	B	Better information exchange is important for better care
Joint activities	Lack of time and money	GP	No time/money for joint meetings is a barrier to joint meetings
	Joint project	B	A joint project facilitates personal familiarity and collaboration
Determinants of the organization:			
Accessibility	Lack of meeting facilities	PYHP	When meeting facilities are lacking (e.g. special telephone number for colleagues)
		GP	GP is less easily accessible
		B	Dedicated point of contact works well Overview of contact details works well
	Work location in proximity	B	Shared work location: easier to pop in to each other's office
	Linking patient files	GP	Facilitates collaboration
	Time of contact	B	Often seeking contact during inconvenient hours (during patient visits/ day off)
	Unknown which PHYP is responsible for care of a child	GP	Unclear which PYHP you need to contact regarding a specific child is a barrier
Leadership	In individual patient contact	B	-Professional is lead contact regarding a specific child
	Present in organization	B	-CJG coordinator mentioned as initiator of meetings
		PYHP	-Staff PYHP mentioned as bridge to other professionals
		B	-Sometime there is a leading GP
		PYHP	-Lack of agreement, PYHP needs to figure it out herself
	Present in municipality	B	'Lijn 1' supports and organizes joint meetings

	Quotation
	PYHP10: 'GPs I spoke to were very surprised that I do this and that; that they can refer children to me for this and that.'
	GP4:'What I find very important is that we can complement each other's knowledge. I think that that is a real advantage.'
	H10: 'When you are invited to a meeting, it takes an hour; that is too much, we don't have time for that. We are too busy.'
	GP2: '.. we've just done a project, then you really hear what they do. You get to know each other pretty well and that makes it easier to consult each other.'
	PYHP7: 'Yes, it would be easier if you, for instance, had a dedicated telephone line after 4pm for colleagues.' GP5: 'We've received an overview of PYHPs, with their catchment areas and telephone numbers. Now we pick up the phone to consult each other more easily.'
	GP10: 'You notice that it is difficult when people who work on different islands have to contact each other. One of the big problems is that we have so much data and we don't share that data. Whereas there are easy solutions, e.g. web-based sharing of information regarding a child.'
	PYHP4: 'The assistant says: 'he is seeing patients at the moment, he will call you back' that happens often, and they never call you back. Or they call back when you are out of office.'
	GP5: '..I call for a specific patient, they then need to look the specific doctor up in the system, they really have to look and then they don't know where to find that doctor. That's really inconvenient.'
	GP3: 'The manager of the CJG takes an active position and organizes meetings.'
	GP3: 'I think mainly my colleague (name) is a leading figure.'

Supplement Table 3. Continued

Determinant	Theme	Physician*	Description
Organizational support	Lack of time and money	B	PYHPs mentioned a few hours available for collaboration but this is not enough. GPs mention lack of support
	Lack of policy	B PYHP	No policy that facilitates collaboration; budget cuts are barriers
	External support	B	'Lijn 1' organizes joint meetings
Agreements/ guidelines	Familiarity/ contact	B	-Facilitates collaboration -Specific agreements or project worked well
	Unfamiliarity with guidelines	B	GPs are more often not aware of joint guidelines
Structural connectivity	External support	B	Support by the convenant and 'Lijn 1' are positive
	Joint meetings	B	Stimulate connectivity, to meet each other is important
	Active approach	PYHP	Active role of CJG (in organizing meetings) coordinator is stimulating
Determinants related to the system:			
Policy government/ municipal	Lack of municipal policy	B	Lack of a clear policy from municipalities
	Low priority for municipal	PYHP	It seems that collaboration is not important to municipalities
	Lack of practice orientation	B	Lack of a practice-oriented policy is a barrier
	Changes to government policies	B PYHP	Budget cuts have a negative effect. PYHP has a more active role in the new law; this is expected to facilitate collaboration
Support government/ municipal	Lack of money	B GP B	Lack of money mainly reported as barrier. Also reported as not the main problem. GPs are not reimbursed for meetings. Budget cuts are a barrier
	Lack of support	B	Lack of support from municipality is an often-reported barrier
	External support	B	'Lijn 1' supports and organizes meetings

Quotation
GP3: 'No, we don't get money for meetings, it is charity and that is strange.'
PYHP10: 'The organization has no real policy on collaboration.'
GP4: 'We made agreements regarding overweight children that work really well. We should continue this really.'
PYHP4: 'Yes, the positivity is there. How the initiative works out, well, we need to see. But the first steps are there and that is positive.'
GP1: 'First you need to grow towards each other.'
GP2: 'In my opinion, there is no policy. I haven't noticed anything. I've never heard something about it from the municipality. Yes, I received some emails regarding institutions they collaborated with, but that doesn't work for me.'
GP11: 'The municipality really has an impossible task. They now need to manage all youth and mental healthcare for half the money without any experience. They don't have expertise.. that is impossible, of course.'
PYHP5: 'New law…many services are coordinated from the CJG. We are more for prevention and guidance towards appropriate care. I think this improves collaboration.'
GP13: 'I think that the money isn't the biggest problem, but the time and motivation, those are the key problems.'
GP5: 'Financial resources .. 'Lijn 1' also takes care of that.'

Supplement Table 3. Continued

Determinant	Theme	Physician*	Description
Joint training	Lack: subject collaboration	B	Specific training regarding collaboration does not exist
	Existing: training in an overarching subject	B	There are subject training courses both professions could attend

B = both GPs and PYHPs YFT = Youth Family Team, CJG= Center for Youth and Family, ADHD = attention deficit and hyperactivity disorder, Lijn 1 = independent organization that supports primary care

Quotation
PYHP10: 'You meet each other there accidentally, talking about a specific case for instance. But those training courses are not aimed at collaboration.'

Chapter 8

General discussion

General discussion

The main objective of this thesis and the Pippi-study was to improve the early identification of child mental health problems (MHPs) by developing a prediction model for child MHPs, with readily available information from electronic health records from general practice. In addition, we investigated whether combining electronic health record information from general practice and preventive youth healthcare (PYH) would result in better prediction of adverse mental health events in children.

In the current chapter, we first describe the main findings of this thesis by relating them to the case of Tess, who was introduced in chapter 1. Considerations regarding the used data, the methodological approach and developments in current research regarding prediction models will be discussed thereafter. We will then elaborate on considerations regarding the early identification of child MHPs and the clinical implications of this thesis. Finally, we will give recommendations for further research, before presenting our conclusion.

Main findings related to the case of Tess

To illustrate the dilemmas general practitioners (GPs) can face when identifying child MHPs, the case of Tess was presented in chapter 1

Tess, 14 years old
Tess visited her GP Julia, because of depressive feelings and a declining school performance. A lot appeared to have happened in Tess's family situation in the previous years, which might have influenced Tess's current situation. Other than occasional visits for common complaints, Tess's medical history mentioned several visits for constipation. Julia referred Tess to secondary mental healthcare for further treatment but wondered whether she could have seen Tess's mental health problems coming earlier.

As all GPs in the Netherlands do, Tess's GP uses an electronic information system to store the medical records from her patients. With these readily available data, we built a prediction model for child MHPs, which could be applied to Tess's electronic medical record (EHR). The goal of the model was to automatically calculate Tess's risk

of developing an MHP based on the available data in her EHR. At the time Tess visited Julia or one of her colleagues for constipation, it would have been possible for them to use the model to see Tess's risk of developing an MHP. The GP might have taken the opportunity to approach the constipation differently, with more attention to the context.

The prediction models we developed in chapter 3, however, were not able to give a clear indication of whether Tess was at risk of developing MHPs. In their current form, the models need further improvement before they can safely be used in daily practice. Nonetheless, individual characteristics from EHRs such as somatic complaints (including constipation and headache) and factors related to a higher healthcare use appeared to be age-independent risk factors for child MHPs. Awareness of the presence of (a combination of) these risk factors can inform GPs about the vulnerability of a child to develop MHPs. The GP seeing Tess regarding her constipation could already have been alerted to her vulnerability and the GP might have taken the opportunity to explore Tess's mental wellbeing and context further.

In addition, we found that some information regarding already known predictors for child MHPs that involve the child's family and environment, could not be extracted from the data due to incomplete registration. Whether the GP would suspect psychosocial factors to play a role and how she would explore the child's context depends on the GP. We found that such inter-professional variation played a role in the identification of child MHPs by primary care professionals, which is described in chapter 2. In this systematic review we showed that the prevalence rates of MHPs identified by primary care professionals varied substantially. Primary care professionals identified between twenty-six and sixty percent of the children with an increased risk of MHPs as indicated by MHP assessment tools. Factors related to the child or the visit that made identification of MHPs by primary care professionals more likely were a family composition other than married parents, severe mental health symptoms, prior MHPs, male gender in elementary school, preventive well-child visits or visits to primary care professionals related to psychosocial concerns. In the case of Tess, information regarding her family situation (e.g. her parents' divorce and MHPs of her father) could have been relevant to assess her complaints. In addition, we found that professionals who self-identified as being less burdened treating MHPs and professionals who were recently trained in child MHPs were more likely to identify MHPs. Those professionals were also more likely to recognize MHPs in children with an increased score on MHP assessment tools. Our findings suggest that professionals who are trained and feel less burdened managing MHPs would have approached a child like Tess, presenting with constipation, differently than colleagues who are not trained and feel more burdened would have.

The second aim of this thesis was to explore whether combining EHR information from general practice and PYH would result in better prediction of adverse mental health events in children. The results of the study presented in chapter 5 indicate that the models that incorporated information from PYH did not perform better compared to the models based on general practice data alone. Nevertheless, several individual characteristics measured in PYH were predictors for MHPs in general practice. These characteristics include PYH concerns for MHPs, borderline or increased scores on mental health screening tools, exposure to life events, a recorded family history of MHPs in PYH data, and an extra visit to PYH. Information regarding these characteristics could still be useful for GPs in daily practice to have access to, in order to improve the early identification of child MHPs.

Relating these findings to the case of Tess, Tess would have been seen for routine appointments in a PYH setting twice in primary school and once in secondary school in the years prior to the current consultation for her depressive feelings. During these visits, mental health screening tools would have been used, and enquiries would have been made regarding Tess's development, school performance and psychosocial situation. Leaving aside potential outcomes of the mental health screening instruments, PYH might have had access to information about Tess's family situation and problems at school at an earlier stage. If this information had been shared with general practice, this might have influenced the approach that was taken during Tess's general practice visits for constipation. In addition, the study performed in chapter 6 found that the presence of PYH concerns for MHPs was also a risk factor for child and adolescent mental healthcare (CAMH) use, next to the characteristics school problems, a child being bullied/bullying or being underweight, all of which are registered in PYH.

In the qualitative study presented in chapter 7, we investigated the current collaboration between GPs and preventive youth healthcare professionals (PYHPs). We found that the current collaboration between GPs and PYHPs is suboptimal, and that structural collaboration and information exchange was often not present. With the case of Tess in mind, we explored how likely it would be that the GP who assessed Tess for constipation would have reached out to PYH for further information? Our study suggested that most professionals did not have any structural contact and contact was mostly sought in urgent cases. Therefore, we do not think PYH would have been contacted at this point: a potential missed opportunity.

Considerations regarding the data and methodology used in this thesis

Before we are able to address the implications of the findings presented in this thesis, it is important to place the data and methodology used in this thesis into perspective.

Strengths of the Pippi-study

To our knowledge, the Pippi-study is the first study to combine routine healthcare data from different sources on such a large scale for the purpose of improving child MHP recognition. In this way, the Pippi-study provided unique complementary information from the different healthcare professionals involved in the primary care for Dutch children. In recent decades, the availability of clinical data extracted from EHRs has generated new opportunities for research. Although generally gathered for the purpose of providing healthcare, the use of routine healthcare data for scientific research has several important advantages. It provides a low-cost and time-efficient way of accessing rich, real life, longitudinal data on large populations, which can be linked to data from other sources or people(1).

Other reported advantages of EHR data are, for instance, fewer systematic errors (bias) such as selective nonresponse, response bias (systematic error caused by social desirability or leading questions), and recall bias (systematic error caused by differences in the precision or completeness of the recollections of events or experiences from the past)(2).

Linkage of the different datasets

In chapters 5 and 6 of this thesis we linked the datasets from general practice to data from PYH and to data regarding CAMH use on an individual patient level. Our original cohort of general practice data from the period between 2007 and 2017 included 70,000 children, and for 91% of those children, data from Statistics Netherlands regarding CAMH use was available. For approximately 70% of the children included in the original general practice cohort, data extracted from PYH could be individually linked to the general practice data. All children with both general practice and PYH data could be linked to data from Statistics Netherlands.

Data from general practice could not be individually linked to data from PYH of Statistics Netherlands when either no unique Dutch citizen service number (burgerservicenummer, BSN) or a wrong BSN was present in the databases. In the early years of the general practice cohort, it was not yet legally required to register a child at a general practice with a BSN(3). In addition to a missing or incorrect BSN number, the fact that children can go to secondary schools outside their PYH region, meaning they are monitored by

a different regional PYH, was another reason why data from GPs and PYH could not be linked for some individual patients. There were, however, no major differences in the characteristics of the children with and without PYH data. Therefore, we do not expect that a successful linkage between data from GPs and PYH for 70% of the children has altered our findings.

Generalizability of the Pippi-study

Most Dutch inhabitants are registered with a general practice. We therefore expect our cohort to be a fair reflection of the general Dutch population, including minority populations (either ethnic or socio-economically defined) that are known to be underrepresented in studies that actively recruit patients(4).

In addition, Dutch GPs are the gatekeepers to secondary healthcare. We assume the findings related to the general practice data to be fairly generalizable to countries with a similar, gatekeeper healthcare system, such as the United Kingdom(2). In general, when transporting a developed prediction model to another setting, one should look at factors that are related to the transportability of a prediction model, for example changes in patient characteristics, changes in administered treatments and changes in predictor measurement procedures(5). External validation of developed prediction models is therefore recommended(6).

We are aware that the PYH data we used in this study is specific to the Dutch healthcare system and the registration used in this particular region. That said, many countries do have a form of preventive youth healthcare or well-child clinic that monitor a child's healthy development(7-9), and validated mental health screening instruments are widely used(10). We think our findings can therefore still serve as a starting point for research regarding the use of EHR data for the early identification of child MHPs, when the approach is adapted to the local healthcare system and digital registrations used. The same holds true for the data regarding CAMH use.

Model development

The available EHR data contained an abundance of information and many potential predictors that could be included in a prediction model. Popular strategies to reduce a set of potential predictors during model development include stepwise selection methods, such as a backward selection of predictors based on a certain p-value(11, 12). These statistical selection methods do have disadvantages and it is advised to consider literature and clinical knowledge when selecting predictors for model development, rather than solely rely on statistical selection methods(6, 11, 12). Much is already known regarding the multiple risk factors for developing child MHPs. Given the above, we

developed models that incorporated the existing subject matter knowledge, including the results of our systematic review, and perspectives from various professionals working with children in clinical practice by means of an expert panel(13).

Limitations related to the use of EHR data for research purposes

Data primarily recorded to facilitate patient care

The information stored in EHRs is generally not collected in a standardized way, as it is primarily recorded to document and facilitate the care of individual patients rather than for scientific purposes. Regarding the data from general practice, registration of information depends on both the patient and the GP. The patient first has to decide to visit the GP and mention specific complaints, and it then depends on the GP which information is recorded and how this information is registered or coded in the EHR. These factors might affect the completeness and accuracy of EHR data. In the Netherlands, the International Classification of Primary Care (ICPC) coding system, which facilitates consistent recording, is built into EHR systems together with a guideline describing what should be recorded in an EHR system and when(2, 14, 15). Over the years the quality of the general practice EHR data has therefore improved(16).

The data from PYH differed from the general practice data since it concerned data from scheduled, standardized visits in which certain aspects of a child's healthy development should be monitored. However, it is known from the field that professionals have a lot to register during consultations, and that it again depends on both the professionals and the child which information is being recorded. There is no standardised coding system available yet and PYHPs can record a lot of information as free text. As with the GP data, we expect that PYH data quality will improve over time. At present, PYH in the Leiden area has implemented a new EHR information system in daily clinical practice and emphasis is being placed on the importance of correct recording of clinical information, also for research purposes. Furthermore, research is being conducted regarding the development of a national uniform basic set of diverse indicators or items regarding a child's healthy development.

Missing data

Missing data is one of the major challenges of using EHR data for research(17, 18). Missing general practice data is often missing not at random, i.e. the probability that an observation is missing depends on information that is not observed in the data(19). It is common practice to assume that a determinant or disease is not present when data is missing(18, 19). In line with this, we chose to not use multiple imputation techniques when developing the prediction models with general practice data.

One of the aims of this thesis was to explore which specific information from PYH (reflecting the structured, routine PYH visits) could be useful to exchange with GPs to enhance MHP identification. In this quest, we did not expect to find that a large number of determinants had quite some missing data, which was the case for over 80% of the children. Although a small percentage of the missing determinants could be explained by the fact that they concerned information from extra healthcare visits in PYH for a specific reason (e.g. visual problems) and not a regular visit in which standard items should be checked, this did not fully explain the magnitude of the absence. One hypothesis for the absence of this data could be that as a result of currently unknown technical issues, information from prior consultations which should be visible during later consultations in practice was not present in our extracted data. In addition, during the early years of our study period, data was transferred from paper to electronic files. All important information should have been transferred, but this migration will still have caused some gaps in the data.
As some missing PYH data could be predictive (e.g. missing results of mental health screening tools), we included a "missing" category for some determinants in chapter 4. Missingness turned out to have no predictive value.
As with the general practice data, we chose to not use multiple imputation techniques for the missing data from PYH. Imputing data missing from our extracted PYH data, eventually potentially used to share with GPs for clinical practice purposes, did not seem justifiable.

Misclassification
In the Pippi-study, we aimed to define the determinants and outcomes we investigated as specifically as possible by supplementing coded diagnoses with other information (e.g. medication prescriptions) when feasible. This was in order to increase the validity of the determinants and outcomes and to prevent misclassification(20). For the definition of the determinants based on general practice data, this was not always possible, and we found that information regarding known social risk factors for child MHPs (e.g. regarding the child's family and environment) was not available since due to incomplete registration (chapter 3). We expect that the absence of extractable information regarding these important risk factors for child MHPs will have affected the performance of the developed prediction models.

We assume some misclassification bias, i.e. when a person is assigned to a different category than the one they should be(21, 22), to play a role when looking at specific determinants, such as the presence of chronic diseases based on general practice data, we looked at in chapter 3. We expect the misclassification regarding the general practice data to be mainly related to some of the determinants (e.g. chronic disease) we investigated, and we expect

this misclassification to be non-differential, i.e. not depending on the outcome status of the patient, leading to potential dilution of the found effects(21). Regarding PYH data, the number of PYH concerns for MHPs varied greatly between different ages, meaning that misclassification regarding the outcome could not be ruled out.

In chapter 6, we investigated which children had healthcare costs in child and adolescent mental healthcare (CAMH) based on data from Statistics Netherlands. We defined the presence of CAMH costs as the first calendar year with any costs made regarding CAMH for a child. Misclassification could have happened in several instances. As we looked at any costs present, this could in theory also involve children who were only seen once in CAMH and who did not undergo treatment. We feel however, that this would concern a very small group of children and the fact that a child has been referred to CAMH already indicates more severe problems.

In addition, by calculating a timeline between a first MHP registered by the GP and the first registered CAMH use per calendar year some misclassification will have occurred. The two scenarios to note would be: 1. a child being referred to CAMH in late December of one year and first being seen in CAMH in early January of the next year, this being counted as one year difference; and 2. a child being registered in general practice with MHPs in January of one calendar year and being seen in CAMH in December of that same year, counted as the same year. In addition, it could happen that a child would have GP registered MHPs but registration of CAMH use would be outside our time-window, or vice versa. We expect that these effects will have balanced over the whole cohort and that the data from the period 2009-2015 would give a fair indication of registered MHPs in general practice and CAMH use.

One should, however, bear in mind that the waiting time between a GP's referral and the child being seen in CAMH is also included in this timeframe and that this waiting time could vary in time and between the different CAMH professionals/institutes. Our data was not specific enough to enable us to look into this further.

What is a good prediction model?

Numerous prediction models have been developed over the past few years, but only a small number are implemented in daily clinical practice. A sufficient discriminative ability (i.e. the ability of the model to distinguish between children with MHPs and those without MHPs), is the primary requirement if one wants to use the model to identify a high-risk group, as we aimed to do in this thesis(6). A model's discriminative ability,

however, is not sufficient to indicate the clinical usefulness of a prediction model. Or in other words, whether a prediction model is useful to support medical decision-making(6). Nevertheless, a lower discriminative ability makes it unlikely that a model will be clinically useful(6).

The prediction models we developed in this thesis showed a moderate performance. We are of the opinion that our models need further improvement before they can safely be used in daily clinical practice. One of the explanations for this moderate performance of the models based on general practice data is the absence of extractable information regarding some known risk factors for child MHPs in the general practice data (chapter 3).

Our hypothesis was that combining information from PYH and general practice would result in better performing prediction models for MHPs compared to models based on general practice data alone. Unfortunately, this was not the case (chapter 5). The structured registration of potential MHP predictors in PYH was less good than expected and this is most likely one of the reasons for the limited added value of combining PYH and general practice data into one decision supporting algorithm. It is difficult, therefore, to conclude that combining data from PYH and GPs to improve prediction models for child MHP identification would not be worthwhile.

Developments in current research regarding prediction models - what role can machine learning techniques play?

Applying machine learning techniques to the data might result in better performing prediction models. Machine learning (ML), techniques that focus on models that directly and automatically learn from data, have gained enormous popularity over the past few years(23). ML is claimed to have better performance over traditional statistical modelling and to better handle a larger number of potential predictors(23). With the increasing availability of large datasets, for instance from EHRs, the expectations of ML in medicine are high(24).

As previously described, the development of the prediction models presented in this thesis was approached more traditionally. Data preparation and coding of potential predictors was done manually, which was quite time-consuming. ML would provide a more efficient approach. An exploration of ML techniques in the general practice dataset resulted in prediction models with c-statistics up to 0.79(25). Some found predictors

seemed to make sense from a clinical point of view (e.g. number of visits), while others (e.g. a performed worm egg test or sex hormone medication) seemed to make less sense. Research on ML for primary care is at an early stage of maturity for practice applications(26). Attention should also be paid to the physician's point of few regarding the explainability of models incorporating ML that are potentially implemented in daily care.

However, there is evidence that ML based prediction models do not automatically lead to improved performance over traditional methods(23, 27). So how can ML support the early identification of children like Tess? A study investigating the use of primary care EHR data for identification of depression in adults showed better performing models when both structured (coded) and unstructured (free text) EHR data was used(28).

Natural language processing

As we feel that one of the explanations for the moderate performance of the developed models in this thesis is the absence of extractable information regarding some known risk factors for child MHPs, natural language processing (NLP) may be of particular interest for future research(29). NLP is a special field in ML which parses unstructured text (free text or narrative data) into structured, quantifiable variables(30). With NLP, the free text of EHRs, in which potential useful information regarding important social/contextual risk factors for child MHPs are written down, could be assessed. These free text notes in which physicians describe the patient's subjective story and symptoms were not part of the available data in the current Pippi-study. We would strongly recommend future studies to investigate free text analysis in order to improve prediction models for early identification of child MHPs.

Considerations regarding the early identification of child MHPs

Recognition of MHPs differs from the recognition of somatic diseases

Identifying child MHPs is different compared to the recognition of somatic diseases (e.g. Diabetes Mellitus), as there are no direct quantitative biomedical tests such as blood tests for mental health issues(29). Instead, physicians are dependent on signs and symptoms that children or parents report, and on observations during consultations(29). It is known that a substantial number of children with MHPs is not being recognised as such. US paediatric primary care providers' sensitivities and specificities for identification of child MHPs, for example, ranged from 14% to 54% and from 69% to 100% respectively(31).

Furthermore, mental health-related stigma plays a role in the identification and help-seeking process of MHPs(32), and this might also be of influence on the diagnostics and management of experienced mental health related symptoms or problems. Especially as children with MHPs are known to visit their GP more often for physical than psychological reasons prior to MHP diagnosis(33). In addition, children who experience somatic complaints that can be related to MHPs (e.g. headache and abdominal pain) are frequently referred to paediatricians working in secondary care to rule out somatic causes of the experienced complaints.

Can highly discriminating models that predict child MHPs be developed?

The question also is whether it is actually possible to develop a highly discriminating model that predicts child MHPs in the future. MHPs and symptoms are known to fluctuate over time, and this differs per MHP type. The widely used mental health screening instrument Strengths and Difficulties Questionnaire (SDQ) has a good concurrent discriminative ability, with a reported c-statistic of around 0.80(34). The long-term predictive value of the SDQ, however, is lower. The reported sensitivity of the SDQ sore in preschool children predicting MHPs 5 year later for instance was 35% for any MHP, with lower numbers for emotional problems and higher numbers for behavioural problems(35).

The SDQ is a specific mental health screening instrument incorporating information regarding mental health symptoms. In this light, the moderate discriminative ability of our models to predict child MHPs one year later based on general practice data, including biomedical and healthcare use information, could be valuable for the GP's decision-making process. Similar discriminative abilities of prediction models for anxiety and depression were found in a US study among undergraduate students using ML techniques(36). This study also used EHR information, and only included biomedical and demographic information, on purpose excluding any psychiatric information(36).

However, it also means that such a prediction model cannot be used with a cut-off value above which children are labelled to have problems. The models should be seen more as a tool to give insight in the factors that are found to be predictive for MHPs. Given the above, it is advocated that early identification of MHPs with screening tools or predictive algorithms cannot stand alone and that emphasis should be placed on research regarding the ability of screening instruments to improve clinical decision-making(37).

Automatic pop-up indicating a child's vulnerability to developing MHPs

We believe that a prediction model could aid physicians in daily clinical practice to identify children like Tess at risk of developing MHPs. Such a model could be translated into an automatic pop-up in a child's EHR to alert the GP when the child comes in for

a visit. The pop-up would show the vulnerability of a child to develop MHPs in, for instance, the next year. The GP could then take this vulnerability into account during the consultation. We see the pop-up as a tool to support GPs, which should always be used next to the clinical judgement of the physician, and the wishes of both the child and the parents. Especially as the recognition of child MHPs differs from the recognition of somatic diseases, as outlined above.
A similar concept can be found in geriatrics, where electronic frailty indexes based on primary care EHR information are currently being evaluated(38).

The aim of an automatic pop-up in the child's EHR could be viewed in the same way: early identification of children at risk of developing MHPs to improve informed, shared decision-making, allowing physicians to tailor interventions to their patients' individual needs and prevent adverse outcomes in later life(39). Ideally, the pop-up would already be based on combined information from general practice and PYH. But when the pop-up would only be based on information from the general practice EHR, the GP could actively assess information from PYH (e.g. regarding mental health screening tools) in case the pop-up would indicate a child being vulnerable and incorporate this knowledge in the clinical decision-making process.

How do our findings improve the early identification of child MHPs?

This thesis provides further evidence that there is a substantial inter-professional variation in the identification of child MHPs in primary care. Although the prediction models we developed did not perform well enough yet to support GPs in daily practice, the results of this thesis can still help professionals to improve the early identification of child MHPs.

First, knowledge about (a combination of) the individual risk factors for child MHPs based on general practice data could support GPs in the identification of child MHPs. These risk factors include amongst others somatic complaints and healthcare use-related risk factors. In addition, this thesis shows that information from PYH regarding results from mental health screening tools, concerns for MHPs, exposure to life events, family history of MHPs and an extra visit in PYH could be relevant to share with general practice. Especially as some of these characteristics were also predictive for the group of children that was registered as having used child and adolescent mental healthcare (CAMH), but that was not registered as having MHPs according to GPs (chapter 6).

Although the scenario of an automated pop-up is still a long way off – as described earlier, there are still barriers to resolve further – this thesis shows what could be done in the meantime to help children like Tess in an earlier stage: namely, improving collaboration and information exchange between general practice and PYH.

We believe that a structured exchange between PYH and general practice of some of these relevant key elements would support GPs in the early identification of child MHPs and in treating children like Tess. Better information exchange between PYH and general practice was also mentioned as the most important point for improvement of the collaboration in general by the participating GPs and PYHPs in our qualitative study. We feel that exploring the structural exchange of some characteristics registered in PYH that are relatively easy to obtain, exchange and interpret, such as scores of mental health screening tools, PYH concerns for MHPs and school problems, might be a good starting point for improving collaboration, and, more importantly, improving the early identification of child MHPs.

Proactive, integrative care for children at high risk

Structural information exchange between GPs and PYHPs could improve the early identification of child MHPs. Early identification is important in order to provide adequate treatment strategies and enable prevention of adverse outcomes in later life(40). The scenario of an automatic pop-up that indicates the vulnerability of a child to develop MHPs, or in an earlier stage structural information exchange of some relevant information between general practice an PYH, would provide an efficient solution to support GPs. This is particularly interesting since the majority of GPs nowadays work part time and fewer GPs want to become practice owners(41), potentially resulting in the loss of important knowledge regarding the context of patients and less continuity of care. These factors can hamper MHP identification.

In addition, the duties of GPs have changed over the years. An increased burden of administrative duties, growing possibilities for diagnostics and management, system changes such as in the care for youth ('Transitie Jeugdzorg'), elderly and in mental healthcare, and substitution of care from secondary to primary care all result in more complex problems GPs have to face(41). In light of this, the main tasks and values of general practice were redefined in 2019. Next to providing general medical care, emergency care and terminal palliative care, prevention and coordination were defined as core tasks of Dutch general practice(41). Not only are GPs responsible for the care provided by their own team, they are often also the

connecting factor between and the first point of contact for other care providers who have medical questions about their patients(41). Adequate information exchange between healthcare providers therefore is essential.

The GP core tasks coordination and prevention also fit in with a panel management approach, which is a form of population health management, and the increasing political attention for prevention in healthcare. In panel management, a set of tools and processes for population care are applied systematically on populations at a defined risk with physicians directing proactive care for those high-risk patients(39). This is to enable adequate, efficient, patient-centred care and to minimize care waste. The early identification of children like Tess who are at high risk of developing MHPs can be seen as the first step of panel management. Multidisciplinary collaboration and information exchange between general practice and PYH would have beneficial effects for the proactive identification and management of these children.

Additional recommendations for future research

In addition to previously mentioned recommendations for future research, we have outlined several other recommendations below. First, the work presented in this thesis suggests that better information exchange between general practice and PYH is both desirable and useful. Exploring the structural exchange of some characteristics registered in PYH that are relatively easy to obtain, exchange and interpret, such as scores of mental health screening tools, PYH concerns for MHPs and school problems, can be a good starting point. We recommend future studies to investigate whether this information exchange is indeed desired and how structural information exchange can be executed in a practical manner. Factors such as privacy and patients' consent for information exchange should be taken into consideration.

We found that a small group of children was registered as having used CAMH, but was not registered as having MHPs according to GPs. We would recommend further investigation into these children: who are they and how did they end up in CAMH? What can we learn from their non-standard entry to the CAMH system? Data from CAMH referral letters or information from the social domain including 'jeugdteams' or 'wijkteams' might be helpful.

When a better performing prediction model to aid child MHP identification can be developed, it should be investigated whether such model improves the identification of the right children, i.e. children who actually have MHPs. In addition, one should

pay attention to children who never visit a GP. These children are less likely to have information registered in their EHR and so less likely to be identified as at high risk of developing MHPs.

We also found that registered somatic complaints (e.g. headache or constipation) were a predictor for MHPs registered by GPs. We would suggest a closer look is taken at children with somatic complaints. Factors like the course of the somatic symptoms, including accompanying diagnoses, number of visits and referrals to secondary care should be explored. A long-term follow-up of these children into adulthood would be also very interesting. Is there a relationship between a patient having registered medically unexplained physical symptoms in adulthood or being a frequent healthcare user? And from a family perspective, how is the healthcare use and occurrence of MHP diagnoses and potential medically unexplained physical symptoms in the parents of these children?

Conclusion

MHPs are common in children and adolescents. This thesis provides further evidence that the prevalence rates of MHPs identified by primary care professionals varied substantially and that many of the children with an increased risk of MHPs are not identified as such. This thesis shows that GPs can be supported in their early recognition and referral decisions concerning MHPs in children with the results of thorough analysis of routine healthcare data. In addition, further improvement of registration and data-reusability would enable further improvement of primary healthcare for children with MHPs. This thesis also reveals that it is useful to share information between general practice and PYH, and that there is a wish for improved information exchange and collaboration between general practice and PYH. Based on the findings of this thesis we believe that the information exchange between PYH and general practice should be strengthened.

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Chapter 9

Summary

Summary

Mental health problems are generally characterized by some combination of specific thoughts, emotions, behaviour and relationships with others. With a worldwide prevalence of 14%, mental health problems (MHPs) are common in children and adolescents. MHPs do not only impact the daily life and wellbeing of children and their families, but are also related to long-term effects such as adverse health, academic, work and social outcomes. About 30% of adults experience one or more MHPs across their lifetime and the majority of these originate in childhood and adolescence. Early identification of child MHPs is therefore important to be able to provide adequate treatment strategies and enable prevention of adverse outcomes later in life.

General practitioners (GPs) and preventive youth healthcare professionals (PYHPs) are the key professional groups involved in the Dutch primary healthcare for children. Almost every Dutch citizen is registered with a general practice. General practice is the formal point of entry into secondary healthcare. PYHPs provide regularly scheduled check-ups to children and adolescents during which all aspects of a child's healthy development are monitored. With both GPs and PYHPs regularly seeing a child during childhood and adolescence, one would expect that MHPs are adequately identified. However, a substantial number of children with MHPs is not being recognised as such.

The main objective of this thesis and the Pippi-study was to improve the early identification of child MHPs, by developing a prediction model for child MHPs based on readily available information from electronic health records from general practice. In addition, we investigated whether combining electronic health record information from general practice and preventive youth healthcare (PYH) would result in better prediction of adverse mental health events in children.

Main findings of this thesis

As a starting point for the development of a prediction model for child MHPs, we made an overview of the literature regarding factors that were associated with child MHP identification in primary care, including general practice and PYH (chapter 2). We found that prevalence rates of child MHPs according to primary care professionals varied substantially and ranged between 7 and 30%. In addition, only 26-60% of the children with an increased risk of MHPs as indicated by MHP screening tools were identified with MHPs by primary care professionals. Factors that made identification of child MHPs more likely were a family composition other than married parents, having worse mental health symptoms, prior MHPs, male gender in primary school-aged children, well-child visits or visits related to psychosocial concerns. In addition, professionals who felt less burdened treating MHPs and professionals who were recently trained in child MHPs were more likely to identify MHPs. Those professionals were also more likely to recognize MHPs in children with an increased score on MHP screening tools.

The prediction models for child MHPs based on routine healthcare data from GPs we developed in chapter 3 were a first promising step towards improving child MHP identification. Our algorithms showed a moderate performance in recognising children at risk, with 'c-statistics' of 0.62-0.63. The algorithms in their current form need further improvement before they can safely be used in daily practice. In addition, some information regarding already known predictors for child MHPs that involve the child's family and environment, could not be extracted from the data due to incomplete registration. We did find several characteristics such as somatic complaints (e.g. abdominal pain or headache) and characteristics related to a higher healthcare use (e.g. more than two GP visits or a laboratory test in the previous year) to be age-independent predictors for MHPs. Awareness of (a combination of) these characteristics might already help GPs in the early recognition of MHPs.

In chapter 4, we investigated the usefulness of routine healthcare data from PYH in relation to MHP identification. Unfortunately, structured registration in this domain was worse than expected: the continuity of the data was low and a large number of the characteristics we aimed to extract showed missing data for over 80% of the included children. In addition, the number of 'PYH concerns for MHPs' varied greatly in the different age groups. Consequently, the prediction models we developed based on PYH data showed poor performance., with 'c-statistics of 0.60 or lower'. Nevertheless, routine electronic health records from PYH showed characteristics that can be helpful to improve child MHP identification (such as registered life events), especially when registration quality and reuse of the data could be improved.

To investigate whether combining information from preventive youth healthcare professionals (PYHPs) and GPs into one decision supporting algorithm would improve MHP recognition, we combined information from PYHPs' and GPs' electronic health records in chapter 5. The models based on the combined information, however, did not perform better than the models based on general practice data alone. Nevertheless, several individual characteristics measured in PYH were predictors for MHPs in general practice. These characteristics were 'concerns for MHPs from PHYPs', borderline or increased scores on mental health screening tools, exposure to life events, family history of MHPs and an extra visit in PYH. Knowledge regarding these characteristics can be useful for GPs in daily practice to improve the early identification of child MHPs.

In chapter 6 we aimed to gain more insight into which children used child and adolescent mental healthcare (CAMH) with information from the electronic health records from GPs and PYHPs. We found that over 10% of the 48,915 children who had data available regarding both CAMH use and general practice, had both GP recorded MHPs and registered CAMH use between 2009 and 2014. Twenty-three percent of the included children had GP recorded MHPs. In addition, we found that a small group of children (6.3% of the included children) used CAMH, but that this group was not registered in the GP records as having MHPs. These children seemed to be less visible in primary care, as they were less likely to have registered somatic complaints, chronic diseases, medication prescriptions, laboratory tests, or high scores on MHP screening tools.

Information regarding some of the characteristics registered in PYH was found to predict CAMH. The presence of 'PYH concerns for MHPs' was a risk factor for CAMH use and/or GP recorded MHPs. Risk factors for having both GP recorded MHPs and CAMH use were being bullied/bullying themselves, school problems (in primary school-aged children), and being underweight (in secondary school-aged children), which are all registered in PYH.

Although the roles of GPs and PYHPs are potentially complementary, and collaboration and information exchange are promoted, these are still not part of usual practice of both domains. We therefore investigated the current collaboration between GPs and PYHPs in a qualitative study that was presented in chapter 7. We found that structural collaboration and information exchange were often not present. Contact was mostly sought in urgent cases and most participating GPs and PYHPs felt the need for better information exchange. Key improvements regarding collaboration according to the professionals included knowledge of respective tasks and competencies, building trust, improved information exchange and organizational/municipal support.

Conclusion

This thesis provides further evidence that primary care professionals vary substantially in their identification of child MHPs and that many of the children with an increased risk of MHPs are not being identified as such. We conclude that GPs can be supported in their early recognition and referral decisions concerning MHPs in children with the results of thorough analysis of routine healthcare data. However, further improvement of registration and data-reusability would enable further improvement of primary healthcare for children with MHPs. Based on the findings of this thesis, we recommend that the information exchange between PYHPs and GPs should be strengthened.

Appendix

Nederlandse samenvatting

Psychosociale problemen hebben te maken met bepaalde gedachten, gevoelens en/of problemen in het contact met anderen. Met een wereldwijde prevalentie van 14% komen psychosociale problemen (PsP) veel voor bij kinderen en adolescenten. Naast invloed op het dagelijks leven en het welzijn van kinderen en hun gezinnen, kunnen PsP ook nadelige gevolgen hebben op de lange termijn. Zo zijn PsP gerelateerd aan slechtere uitkomsten wat betreft opleiding, werk en op sociaal vlak. Ongeveer 30% van de volwassenen krijgt tijdens hun leven te maken met een of meer PsP. Het merendeel deel van deze problemen ontstaat tijdens de kinderleeftijd en adolescentie. Vroege herkenning van PsP bij kinderen is daarom belangrijk om adequate behandeling te kunnen bieden en nadelige gevolgen op latere leeftijd te voorkomen.

Huisartsen en professionals van de jeugdgezondheidszorg (JGZ) zijn de belangrijkste beroepsgroepen die betrokken zijn bij de Nederlandse eerstelijnsgezondheidszorg voor kinderen. Vrijwel iedere Nederlander staat ingeschreven bij een huisartsenpraktijk. De huisartsenpraktijk is de formele toegangspoort tot de tweede lijn. De JGZ biedt regelmatig geplande controles aan kinderen en adolescenten, waarbij alle aspecten van de gezonde ontwikkeling worden gecontroleerd. Aangezien zowel huisartsen als JGZ professionals een kind regelmatig zien, zou men verwachten dat PsP adequaat worden herkend. Een aanzienlijk aantal kinderen met PsP wordt echter niet als zodanig herkend.

Het hoofddoel van dit proefschrift en de Pippi-studie was het verbeteren van de vroege herkenning van PsP bij kinderen, door het ontwikkelen van een voorspellend model voor PsP bij kinderen op basis van direct beschikbare informatie uit elektronische patiëntendossiers uit de huisartsenpraktijk. Daarnaast hebben we onderzocht of het combineren van gegevens uit de elektronische dossiers uit de huisartspraktijk en van de JGZ zou leiden tot een betere voorspelling van PsP bij kinderen.

Belangrijkste bevindingen van dit proefschrift

Als startpunt voor de ontwikkeling van een voorspellend model voor PsP bij kinderen hebben we een overzicht gemaakt van de literatuur over factoren die samenhangen met de herkenning van PsP bij kinderen in de eerste lijn, bestaand uit de huisartsenpraktijk en JGZ (hoofdstuk 2). We ontdekten dat de prevalenties van PsP bij kinderen volgens eerstelijnszorgprofessionals aanzienlijk varieerden: tussen 7 en 30%. Bovendien werd slechts 26-60% van de kinderen met een verhoogd risico op PsP, zoals aangegeven door screeningsinstrumenten voor PsP, door professionals in de eerste lijn herkend met PsP. Factoren die de herkenning van PsP bij kinderen meer waarschijnlijk maakten, waren een gezinssamenstelling anders dan gehuwde ouders, het hebben van symptomen passend bij een slechtere psychische gezondheid, eerdere PsP, het mannelijk geslacht bij kinderen in de basisschoolleeftijd en bezoeken aan de JGZ in het algemeen of bezoeken aan de huisarts voor PsP. Professionals die zich minder belast voelden door het behandelen van PsP en professionals die recentelijk waren getraind in PsP, hadden een grotere kans om de PsP te herkennen. Deze professionals hadden ook meer kans om PsP te herkennen bij kinderen met een hogere score op screeningtools voor PsP.

De voorspellende modellen voor PsP bij kinderen, gebaseerd op de gegevens uit de elektronische patiëntendossiers van huisartsen die we in hoofdstuk 3 hebben ontwikkeld, waren een eerste veelbelovende stap in het verbeteren van de herkenning van PsP bij kinderen. Onze algoritmen presteerden matig in het herkennen van kinderen met een verhoogd risico, met 'c-statistics' van 0.62-0.63. De algoritmen in hun huidige vorm moeten nog verder worden verbeterd, voordat ze veilig in de dagelijkse praktijk kunnen worden gebruikt. Belangrijk hierbij is dat sommige informatie over reeds bekende voorspellers voor PsP bij kinderen die gerelateerd zijn aan het gezin en de omgeving van het kind, niet uit de beschikbare gegevens kon worden gehaald vanwege onvolledige registratie. Er zijn wel een aantal relevante voorspellende kenmerken geïdentificeerd: kenmerken als lichamelijke klachten (bijvoorbeeld buikpijn of hoofdpijn) en kenmerken gerelateerd aan een hoger zorggebruik (bijvoorbeeld meer dan twee huisartsenbezoeken of een laboratoriumonderzoek in het voorgaande jaar) waren leeftijdsonafhankelijke voorspellers voor PsP. Bewustwording van (een combinatie van) deze kenmerken kan huisartsen helpen bij het vroegtijdig herkennen van PsP.

In hoofdstuk 4 onderzochten we de bruikbaarheid van de elektronische patiëntengegevens van de JGZ bij de herkenning van PsP. Helaas was de gestructureerde registratie in dit domein slechter dan verwacht: de continuïteit van de gegevens was laag en bij een groot aantal van de kenmerken die we wilden extraheren ontbraken gegevens voor meer dan 80% van de geïncludeerde kinderen. Bovendien varieerde het aantal 'zorgen van JGZ-

professionals over PsP' sterk in de verschillende leeftijdsgroepen. De voorspellende modellen die we ontwikkelden op basis van de JGZ-gegevens presteerden dan ook slecht, met 'c-statistics' van 0.60 of lager. Desalniettemin waren er bepaalde kenmerken uit de elektronische dossiers van de JGZ die nuttig kunnen zijn bij de herkenning van kinderen met PsP (bijvoorbeeld geregistreerde life-events), vooral wanneer de kwaliteit van de registratie en het hergebruik van de gegevens kunnen worden verbeterd.

Om te onderzoeken of het samenvoegen van informatie van de JGZ en huisartsen in één algoritme de herkenning van PsP kan verbeteren, hebben we in hoofdstuk 5 informatie uit de elektronische dossiers van de JGZ en huisartsen gecombineerd. De modellen op basis van de gecombineerde gegevens, echter, presteerden niet beter dan de modellen op basis van alleen huisartsgegevens.

Verschillende individuele kenmerken gemeten in de JGZ bleken wel voorspellers te zijn voor PSP in de huisartsenpraktijk. Deze kenmerken waren 'zorgen van JGZ-professionals over PsP', twijfelachtige of verhoogde scores op screeningsinstrumenten voor PsP, life events, familiegeschiedenis van PsP en een extra bezoek aan de JGZ. Kennis over deze kenmerken kan huisartsen in de dagelijkse praktijk helpen bij het verbeteren van de vroegtijdige signalering van kinderen met PsP.

In hoofdstuk 6 wilden we meer inzicht krijgen in welke kinderen gebruik maakten van de Geestelijke Gezondheidszorg (GGZ) met informatie uit de elektronische dossiers van huisartsen en de JGZ. Van 48,915 kinderen hadden we gegevens over zowel GGZ-gebruik als gegevens uit de huisartspraktijk. We ontdekten dat meer dan 10% van deze 48.915 kinderen bekend was in de GGZ én een PsP geregistreerd had in het dossier van de huisarts tussen 2009 en 2014. Drieëntwintig procent van de geïncludeerde kinderen had door de huisarts geregistreerde PsP. Daarnaast vonden we dat een kleine groep kinderen (6.3% van de geïncludeerde kinderen) bekend was in de GGZ, maar dat deze groep geen geregistreerde PsP had in hun huisartsendossiers. Deze kinderen leken minder zichtbaar in de eerste lijn, omdat ze minder vaak geregistreerde lichamelijke klachten, chronische ziekten, medicatievoorschriften, laboratoriumtesten of hoge scores op screeningtools voor PsP hadden in hun dossiers. Enkele van de in de JGZ geregistreerde kenmerken voorspelden ook het gebruik van de GGZ. De aanwezigheid van 'zorgen van JGZ-professionals over PsP' was een risicofactor voor GGZ-gebruik en/of door huisartsen geregistreerde PsP. Risicofactoren voor het hebben van zowel door huisartsen geregistreerde PsP als GGZ-gebruik waren zelf pesten/gepest worden, schoolproblemen (bij kinderen in de basisschoolleeftijd) en ondergewicht (bij kinderen in de middelbare school), kenmerken die allemaal worden geregistreerd in de JGZ.

Hoewel de rollen van huisartsen en JGZ-professionals complementair zijn en samenwerking en informatie-uitwisseling tussen de domeinen worden aanbevolen, behoren deze nog steeds niet tot de gebruikelijke praktijk. We onderzochten daarom de huidige samenwerking tussen huisartsen en jeugdartsen in een kwalitatieve studie in hoofdstuk 7. We vonden dat structurele samenwerking en informatie-uitwisseling vaak niet aanwezig waren. Het contact werd vooral gezocht in dringende gevallen en de meeste deelnemende huisartsen en jeugdartsen hadden behoefte aan een betere informatie-uitwisseling. Belangrijke punten voor verbetering met betrekking tot samenwerking volgens de professionals waren kennis van elkaars taken en competenties, het krijgen van vertrouwen, een verbeterde informatie-uitwisseling, en ondersteuning vanuit de eigen organisatie en gemeente.

Conclusie

Dit proefschrift levert verder bewijs dat eerstelijnszorgprofessionals aanzienlijk verschillen in hun herkenning van PsP bij kinderen, en dat veel van de kinderen met een verhoogd risico op PsP niet als zodanig worden herkend. We concluderen dat huisartsen kunnen worden ondersteund bij de vroege herkenning en verwijzingsbeslissingen met betrekking tot kinderen met PsP, met de resultaten van een grondige analyse van gegevens uit de elektronische patiëntendossiers. Een verbetering van de registratie en de herbruikbaarheid van deze gegevens zou een verdere verbetering van de eerstelijnsgezondheidszorg voor kinderen met PsP mogelijk kunnen maken. Op basis van de bevindingen uit dit proefschrift bevelen wij aan om de informatie-uitwisseling tussen de JGZ en huisartsen te versterken.

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Curriculum Vitae

Nynke Rixt Koning was born on April 19, 1988 in Leidschendam, the Netherlands. She grew up in Boskoop and in 2006, she obtained her VWO Gymnasium diploma at the 'Groene Hart Lyceum' in Alphen aan den Rijn. Thereafter, she moved to Utrecht to study Medicine. During her studies she undertook several (extracurricular) internships in Malaysia, Tanzania and the United Kingdom. After her graduation in January 2014, she started working as a junior researcher at the Julius Center for Health Sciences and Primary Care at the University Medical Center Utrecht. In the summer of 2014, she moved to Sydney, Australia, with her now-husband Max and worked there as a clinical research associate at the St. Vincent's Centre for Applied Medical Research. In March 2015 she returned to the Netherlands to combine the training to become a general practitioner with a PhD trajectory at the department of Public Health and Primary Care of the Leiden University Medical Center. Under supervision of Prof. dr. M.E. Numans, dr. M.R. Crone and dr. F.L. Büchner, she investigated the identification of child mental health problems in primary care, using an interdisciplinary approach. The results of the PhD trajectory are described in this thesis and presented at several (inter)national conferences. During this time, she followed several courses as part of the 'Opleiding tot Epidemioloog B'. She also was an active member of the scientific committee of the 'Landelijke Organisatie Van Aspirant Huisartsen' (LOVAH). Nynke is currently working at 'Gezondheidscentrum Robijnstraat' in Leiden, as part of the final year of her training to become a general practitioner.