

RESEARCH ARTICLE

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A systematic review of the prevalence of parental concerns measured by the *Parents' Evaluation of Developmental Status (PEDS)* indicating developmental risk

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Abstract

Background: Parental concerns about their children's development can be used as an indicator of developmental risk. We undertook a systematic review of the prevalence of parents' concerns as an indicator of developmental risk, measured by the *Parents' Evaluation of Developmental Status (PEDS)* and associated risk factors.

Methods: Electronic databases, bibliographies and websites were searched and experts contacted. Studies were screened for eligibility and study characteristics were extracted independently by two authors. A summary estimate for prevalence was derived. Meta-regression examined the impact of study characteristics and quality. Meta-analysis was used to derive pooled estimates of the impact of biological and psychosocial risk factors on the odds of parental concerns indicating high developmental risk.

Results: Thirty seven studies were identified with a total of 210,242 subjects. Overall 13.8% (95% CI 10.9 -16.8%) of parents had concerns indicating their child was at high developmental risk and 19.8% (95% CI 16.7-22.9%) had concerns indicating their child was at moderate developmental risk. Male gender, low birth weight, poor/fair child health rating, poor maternal mental health, lower socioeconomic status (SES), minority ethnicity, not being read to, a lack of access to health care and not having health insurance were significantly associated with parental concerns indicating a high developmental risk.

Conclusions: The prevalence of parental concerns measured with the *PEDS* indicating developmental risk is substantial. There is increased prevalence associated with biological and psychosocial adversity.

Trial registration: PROSPERO Registration: CRD42012003215.

Keywords: Prevalence, Parental concerns, Parents Evaluation of Developmental Status (PEDS), Risk factors, Developmental risk, Child health

Background

Children at developmental risk, are those who have significant problems in at least one area of their development (e.g., motor, language, self-help, social, cognitive, behavioural) [1]. They include children who may be at risk of having a developmental disorder, or children who

are functioning on the lower end of normal who may go on to struggle with the literacy, numeracy and socio-emotional demands of school and life [1]. Adverse childhood experiences including socioeconomic disadvantage, poor parental mental health, lack of stimulating early childhood experiences, and lack of access to services can contribute to developmental risk [2-6].

In order to develop a comprehensive public health response to optimise early childhood development, it is helpful if we are able to quantify the state of child development from a population perspective. Although not a comprehensive developmental assessment, measuring parental

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concerns about their children's development can be done in a quick, standardised, systematic manner and has been used to estimate level of developmental risk in the general population and to identify high risk subpopulations [7,8]. In addition, eliciting and addressing parental concern is a key component in the family centred practice of detecting individual children at developmental risk in well child health care so that they may have timely referral on for assessment and early intervention prior to starting school [9-12]. The *Parents' Evaluation of Developmental Status (PEDS)* is a 10 – item parent completed standardised questionnaire, which has been used to elicit parental concerns around child development for children aged less than 8 years in populations, communities and clinical samples. The *PEDS* open ended questions cover expressive and receptive language, fine motor, gross motor, behaviour, socialisation, self care, and learning [13]. An estimate of developmental risk as high, moderate, low or no risk is derived from the parental concerns recorded and a clinical pathway is recommended. The *PEDS* has a sensitivity of 91-97% and specificity of 73-86% in recent validation studies from the USA for the accuracy of parental concerns in detecting children at high and/or moderate developmental risk [14]. The *PEDS* has been found to be useful in vulnerable disadvantaged populations, high, middle and low income countries, and has been translated in multiple languages [14,15]. There is also a modified version of the *PEDS*, the *Survey PEDS* which has 12 close-ended questions that does not allow for further discussion of parental concerns and clinical decision making around these. It is less well validated than the clinical form of the *PEDS* but is used in telephone population surveys [7,14,16-18].

In order to better understand the current worldwide prevalence of parental concern measured by the *PEDS* that indicate developmental risk and associated risk factors, we undertook a systematic review to synthesize the available international evidence.

Methods

Search strategy

A protocol was developed and registered with the University of York Centre for Reviews and Dissemination (PROSPERO) on 6/11/2012 and updated on the 13/02/2014, registration number CRD42012003215 (<http://www.crd.york.ac.uk/PROSPERO/index.asp>).

A systematic search of the literature was undertaken using the following inclusion criteria: primary observational studies (cohort study, cross-sectional studies) in geographically defined population or a community sample (including samples from primary health care services) of children aged under 8 years using the *PEDS* [15] with available prevalence data (Additional file 1). Studies using the modified “*Survey PEDS*” were also included in this review [14]. Electronic databases searched

were Web of Science and Google Scholar, PubMed (Nov 2012), EMBASE (Nov 2012), Medline (Nov 2012), Psycinfo (Nov 2012), Global Health (Nov 2012) CINAHL (Nov 2012), the Cochrane Library (Nov 2012), LILACS (Nov 2012), ERIC (Nov 2012), and Proquest (Nov 2012). Secondary searches of citations in review articles, requests to experts in the field and additional searches of the USA based *PEDS*test and RCH *PEDS* website for key studies were undertaken. Advice from the Cochrane Child Development, Psychosocial and Learning Groups was sought regarding search terms which were specific for early child development, developmental risk and the *PEDS*. There were no language limitations. Studies using specific clinical samples, for example, neonatal intensive care graduates or with participants who had a known developmental disorder were excluded.

The study titles, abstracts and full papers of “potentially relevant articles” were reviewed independently by two authors (SW&VE). Disagreements about inclusion were resolved through consensus and discussion with a third author (KW). Study characteristics, prevalence, and risk factors, were extracted independently by SW and VE on a data extraction form that was piloted and modified prior to use. Where insufficient data were reported, study authors were contacted. If no reply was forthcoming or full data not made available, data were included in analysis where possible. Methodological quality was assessed independently by SW and VE based on a validity of the study methods (design, sampling frame, sample size, outcome measures, measurement and response rate), interpretation of the results and applicability of the findings [19], a score of 6 or greater was rated by the reviewers as high quality.

Statistical analysis

Prevalence

Estimates of the prevalence of parental concerns on the *PEDS* indicating moderate or high risk with corresponding 95% confidence intervals were extracted from each study. If the confidence intervals were not provided, these were calculated using the Agresti and Coull method [20]. For longitudinal studies, cross-sectional estimates of prevalence were used to extract prevalence data at the first time point. We used an exact likelihood approach to obtain pooled estimates of prevalence. We used metaregression, a regression method that allows the examination of study-level factors on prevalence with the following pre-specified variables on prevalence: sample type; type of *PEDS*; study purpose; study quality; study age group, publication type and country income [21].

Risk factor analysis

We conducted a meta-analysis for risk factors for having parental concerns on the *PEDS* indicating high versus

low/no developmental risk. We extracted odds ratios and 95% confidence intervals from each study. If odds ratio (OR) with a 95% confidence interval was not provided, we calculated the odds ratio and 95% confidence interval. We extracted adjusted odds ratios when possible, but we were unable to calculate these for studies in which they were not provided. We obtained pooled estimates of unadjusted odds ratios (uOR) using meta-analysis with random effects. Where studies presented adjusted odds ratios (aOR) for similar child and family variables these were combined in a separate meta-analysis.

Investigation of heterogeneity

For all meta-analyses and meta-regressions of prevalence, we modelled within-study variability using the binomial distribution [21]. We then examined heterogeneity through meta-regression models, as described in previous systematic reviews of prevalence [22]. We quantified the reduction in the between study variance from the inclusion of the study characteristics compared to the 'base' model (i.e., the model of prevalence without any covariates). This provides an estimate of the proportion of heterogeneity that is explained by that characteristic. For our meta-analysis of risk factors, the degree of heterogeneity was investigated by estimating the I^2 statistic (which describes variation in the summary effect due to genuine variation rather than a sampling error as a percentage, a low I^2 indicates low heterogeneity and high I^2 indicates significant between study variability) and visual inspection of forest plots [22].

Results

Studies identified

The search strategy identified 17,272 titles (excluding duplicates). Seventy-eight articles underwent a text screen and 41 of these were excluded (Figure 1) [23].

Included studies

The prevalence estimates of the 37 included studies are listed in Table 1 [7,13-18,24-56]. Twenty three studies were published in peer review journals, and the remainder were government/university reports, unpublished abstracts available on the *PEDStest* website, online population survey data and data from the *PEDS* Standardisation Manual (2013). There was one longitudinal cohort with data available on samples at two time points three years apart [39,40,57]. All other studies were cross sectional.

Fifteen studies used the *PEDS* as a research tool to measure prevalence of developmental risk of which 12 were population surveys in high income countries and three were community samples. The remaining studies used the *PEDS* as a developmental surveillance tool in primary health care and early childhood education/early primary school settings [14,24-28,31-33,35,38,41-46,51,53,

58,59]. Eight of the studies were conducted in low and middle income countries [24,42,44-46,51,53,59] and two studies were in socioeconomically disadvantaged communities in the USA [33].

Study sample sizes ranged from 20 to 54602 (median = 467). There were 210,242 subjects in total. Ages ranged from less than 1 month to 7 years and 11 months consistent with the age range for administration of the *PEDS*. Twenty seven of the studies used translated versions of the *PEDS* for at least part of their sample.

Study quality

Quality scores varied between studies (Table 2). Only 13 studies met 6 or more criteria and thus were deemed of high quality [7,14,16,18,29,34,47-50,52,54,56]. Key areas of potential bias were lack of random selection of the sample (22/37), a biased sampling frame (20/37), less than 300 participants (11/37), less than 70% response rate and refusers not described (11/37); confidence intervals not given for prevalence results and lack of subgroup analysis (31/37).

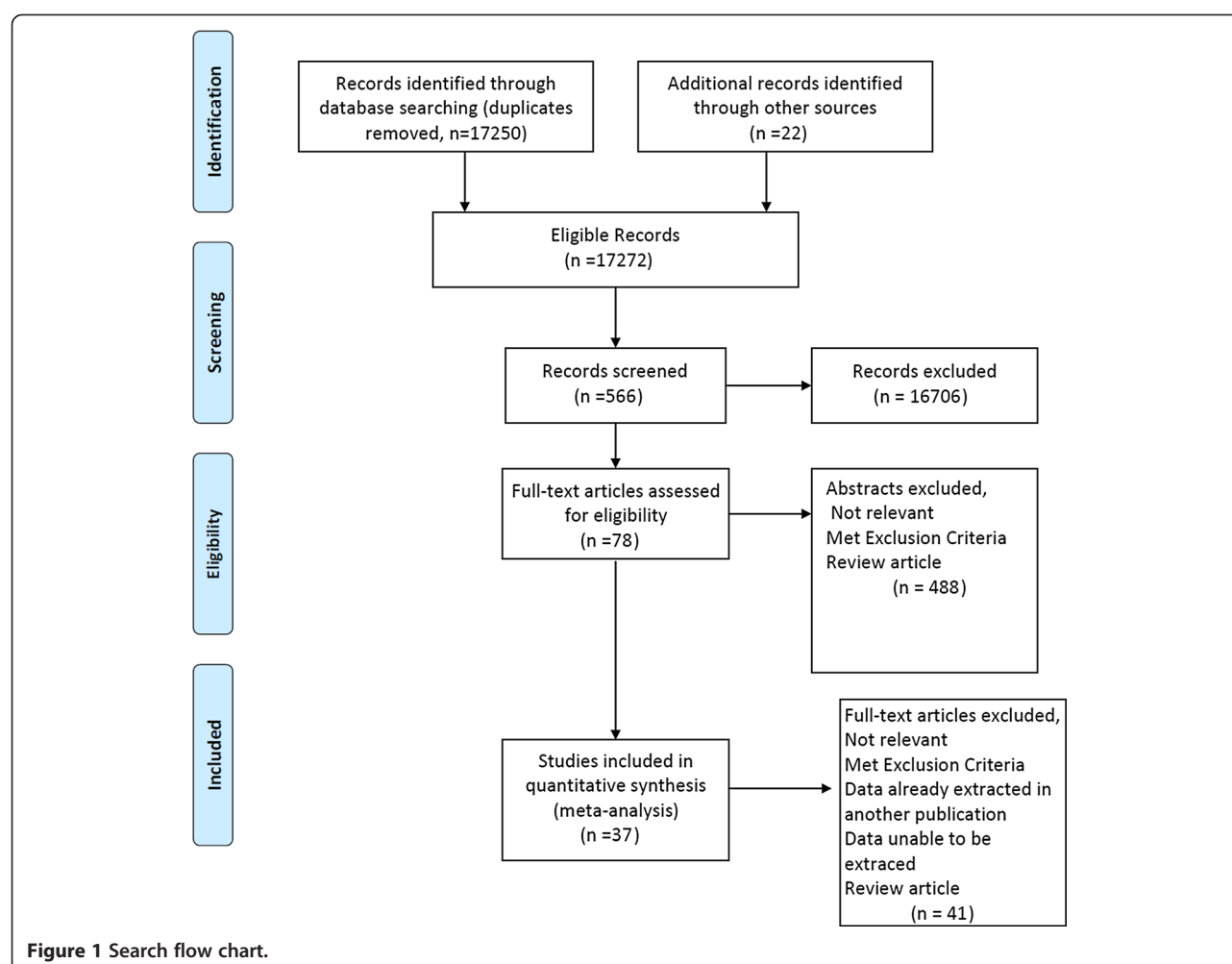
Prevalence of developmental risk

The pooled estimate of the prevalence of parental concern on the *PEDS* indicating high developmental risk was 13.8% (95% CI 10.9-16.8%), meaning that almost 14% of parents raised concerns associated with a high risk for developmental problems (Figure 2). The pooled estimate of for moderate developmental risk was 19.8% (95% CI 16.7-22.9%). The pooled estimate for high or moderate developmental risk was 31.5% (95% CI 27.0-36.0%), meaning that more than 31% raised concerns associated with either high or moderate risk of developmental problems.

Meta-regression was conducted for study characteristics (Table 3). Peer reviewed publications had a significantly lower level of parental concerns indicating high developmental risk on the *PEDS* than unpublished sources (abstracts, reports and population survey data available on the internet). This variable contributed to 19% of the overall variance between studies. For the report of parental concerns on the *PEDS* indicating moderate developmental risk, studies done in high income countries reported a significantly higher rate than those done in low and middle income countries. This variable contributed to 29% of the overall variance between studies. All other variability in study characteristics did not have an impact.

Pooled estimates for biological and psychosocial risk factors

As shown in Table 4, child sociodemographic variables predictive of parental concerns on the *PEDS* indicating high developmental risk included male gender [14,16,17, 27,28,30,37,40,47-50,52,54], age 3 years and above [14,27,28,47-50], low birth weight [17,37], poor/fair



child health [40,47-50] or special health care needs [16,30]. Family sociodemographic variables predictive of parental concerns on the *PEDS* indicating high developmental risk included poor maternal mental health [7,37,40], low family SES [7,16,30,40,47-50], being of African American [7,14,17,30,47-50], Hispanic [7,16,17,30,47-50], First Nations and Australian Aboriginal ethnicity [14,47-50,54], being from a Non English speaking household [30,47-50]. Service level variables predictive of parental concerns on the *PEDS* indicating high developmental risk included not having a usual source of health care/medical home [16,30,37,40,47,49,50]; or having public/no health insurance [7,16,30,37,47-50]. Parents not completing high school [16,27,28,30,40,50] and single parenthood [16,40,47-50,54] were significant using unadjusted OR, however not significant as adjusted OR [17,37]. Children not being read to daily was significant in the unadjusted analysis [40,47-49], however this did not appear to be significant in the one study that included it in a multivariate analysis ($p = 0.93$) [40]. Family size (more than 6 people in household) was not significant [47-50]. Parents of children who did not

attend formal childcare were less likely to have concerns on the *PEDS* that indicated high developmental risk [40,47-49], however findings from multivariate analysis of NSCH 2007 data $aOR = 1.05$ (CI 0.84,1.33) found a non-significant effect of childcare and that receiving more than 10 hours a week of care at another family's home was a risk factor ($aOR = 1.71$, $p < 0.05$) [17].

Narrative summary of single studies, cumulative risk and life course analysis

A wide range of additional child, family, and service level factors were noted in single studies [36,37,39,40,56]. Child level factors were ear infections prior to age 2 ($p < 0.001$) [40], history of hospital admissions aOR 1.80 (95% CI 1.35-2.40) [37] and being underweight aOR 2.66 (95% CI 1.68-4.24) [37]. Family level factors were low scores on contentment/relaxation during pregnancy aOR 2.5 (95% CI 1.4-4.2) [39], poor parenting morale when the child was 3 years old aOR 3.9 (95% CI 2.1-7.3) [39], maternal history of domestic violence at pregnancy aOR 2.2 (95% CI 1.3-3.7) [39,40], household

Table 1 Included studies characteristics and prevalence rates*

First author	Country	Age (months)	Sample size	Quality score/8	High risk% (95% CI)	Moderate risk% (95% CI)	High and moderate risk% (95% CI)	Low/no risk% (95% CI)
Armstrong [15]	Australia	0-95	246	3	11.4 (8.0-16.0)	21.9 (17.2-27.6)	33.3 (27.7-39.5)	66.7 (60.5-72.3)
Bethell [29]	USA	10-71	22883	8	9.6(9.2-10.0)	15.9 (15.5-16.4)	25.5 (25.0-26.1)	74.5 (73.9-75.0)
CHIS [50]	USA	4-60	2884	7	25.6 (23.6-27.5)	17.4 (15.6-19.2)	43.0 (41.2-44.8)	57.0 (55.2-58.8)
CHIS [49]	USA	4-60	3029	7	19.9 (18.3-21.5)	18.0 (16.4-19.6)	37.9 (36.2-39.2)	62.2 (60.4-63.9)
CHIS [48]	USA	4-60	3058	7	26.3 (24.5-28.2)	18.3(16.7-19.9)	44.7 (72.9-46.4)	55.3 (53.6-57.1)
CHIS [47]	USA	4 to 60	3096	7	20.1 (17.6-22.5)	19.7 (17.4-22.0)	39.8 (38.1-41.5)	60.2 (58.5-61.9)
Chuan [24]	Malaysia	12-72	86	2	26 (17.5-35.8)	NA	NA	17.0 (10.8-27.0)
Coghlan [28]	Australia	18-69	262	3	9.2 (6.2-13.3)	18.7 (14.4-23.9)	27.9 (22.8-33.6)	72.1 (66.4-77.2)
Davies [25]	UK	0-24	76	5	2.6 (0.2-9.8)	13.2 (7.2-22.8)	15.8 (9.2-25.8)	84.2 (74.2-90.8)
Glascoe [32]	USA	24-84	408	5	NA	NA	34.6 (30.1-39.3)	65.4 (60.7-69.9)
Glascoe [58]	USA	3-93 (mean 46.5 SD 21.8)	771	5	11.0 (9-13.4)	26.0 (23.0-29.2)	37.0 (33.6-40.4)	63.0 (59.6-66.4)
Glascoe [33]	USA	mean 36	257	4	41.0 (35.0-47.0)	40.0 (34.3-46.2)	81.0 (75.6-85.3)	19.0 (14.7-24.4)
Glascoe [33]	USA	mean 36	744	4	23.0 (20.1-26.2)	26.0 (22.9-29.2)	49.0 (45.4-52.5)	51.0 (47.5-54.7)
Glascoe [14]	USA	0.3-95 (mean 26 SD 20.6)	47531	6	4.5 (4.3-4.7)	13.7 (13.4-14.0)	18.2 (17.9-18.6)	81.8 (81.5-82.1)
Gustawan [59]	Indonesia	3-12	170	3	NA	NA	31.0 (24.2-37.9)	69.0 (62.1-75.8)
Ibironke [56]	USA	6-71 (mean 38.5 SD 18.4)	2381	7	NA	NA	21.4 (19.8-23.1)	78.6 (76.9-80.2)
Kiing [41]	Singapore	1-83	1806	3	7.5 (6.4-8.8)	26.0 (24.1-28.1)	33.5 (31.4-35.7)	66.0 (64.3-68.6)
Kosht-Fedyshin [42]	Tanzania	0-60	20	4	35.0 (18.1-56.9)	0.0	35.0 (18.1-56.9)	65.0 (43.1-81.9)
Limbos [43]	Canada	12-60	331	5	13.9 (10.6-18.1)	39.6 (34.5-45.0)	53.5 (48.1-58.8)	46.5 (41.2-51.9)
Malhi [44]	India	24-60	79	2	NA	NA	39.2 (29.2-50.3)	60.8 (49.7-70.8)
Matibag [45]	Philippines	24-60 (mean 53.6)	283	2	15.0 (11.2-19.5)	NA	NA	NA
McGookin [35]	USA	9-24	385	3	5.2(3.4-8.0)	17.4 (13.9-21.5)	22.6 (18.7-27.1)	77.4 (73.0-81.3)
Ng [18]	Canada	0-83 (mean 46.1)	419	6	9.3 (6.9-12.5)	18.9 (15.4-22.9)	28.2 (24.1-32.7)	72.0 (67.3-75.9)
NSCH (2011/2012) [16]	USA	4-60	28540	8	77.0 (10.1-11.9)	15.2 (14.3-16.1)	26.2(25.7-26.7)	73.8 (72.7-75.0)
Oreto [46]	Philippines	0-84 (means 53)	318	4	15.1 (11.6-19.5)	17.0 (13.3-21.5)	32.1 (27.2-37.4)	67.9 (62.6-72.8)
Palarca [51]	Philippines	0.5-96 (means 52.6)	421	3	9.0 (6.6-12.2)	5.0 (3.3-7.6)	14.0 (11.0-17.7)	86.0 (82.3-89.0)
Restall (2009) [52]	Canada	60	290	6	13.1 (9.7-17.5)	32.4 (27.3-38.0)	45.5 (39.9-51.3)	54.5 (48.7-60.1)
Rose-Jacobs [37]	USA	4-36	2010	5	13.8 (12.4-15.4)	NA	NA	NA
Roux [26]	USA	<60	2845	3	28.2 (26.6-29.9)	27.5 (25.9-29.2)	55.7 (53.9-57.5)	44.3 (42.5-46.1)
Sarmiento Campos [31]	Spain	6-42	1089	3	8.5 (7.0-10.4)	23.0 (20.7-25.7)	31.6 (28.9-34.4)	68.4 (65.6-71.1)
Sices [38]	USA	9-31 (means 17.6 SD 6.1)	60	2	26.7 (17.1-39.1)	10.0 (4.4-20.6)	36.7 (25.6-49.4)	63.3(50.6-74.4)
Stevens [7]	USA	4.35	2068	6	23.4 (21.6-25.3)	24.9 (23.1-26.8)	48.3 (46.2-50.5)	51.7 (49.5-53.9)

Table 1 Included studies characteristics and prevalence rates* (Continued)

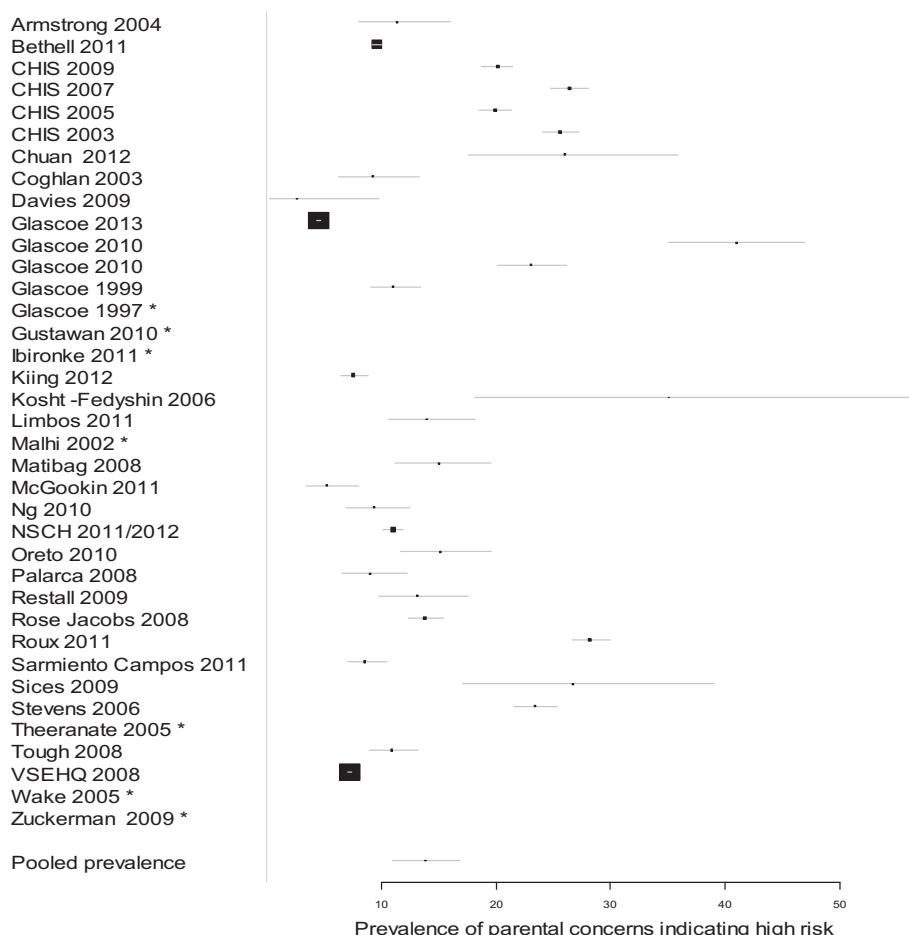
Theeranate [53]	Thailand	0-72	216	3	NA	NA	4.2 (2.1-7.9)	95.8 (92.1-97.9)
Tough [40]	Canada	Mean 38 (SD 8)	792	4	10.8 (8.9-13.2)	30.2 (27.1-33.5)	41.0 (37.7-44.5)	59.0 (55.5-62.3)
VSEHQ (2008) [54]	Australia	60-83	54602	6	7.2 (7.0-7.4)	16.5 (16.2-16.8)	23.7 (23.3-24.0)	76.3 (76.0-76.7)
Wake [55]	Australia	63.4-90	853	3	NA	NA	35.0 (31.9-38.3)	65.0 (61.7-68.1)
Zuckerman [34]	USA	<72	24933	7	NA	NA	22.4 (21.9-23.0)	77.6 (77.05-78.1)

*quality rating system as per quality rating tool developed by Public Health Agency in Canada [19].

Table 2 Quality assessment of included studies*

First author	Year	Random sample or whole population	Unbiased sampling frame (i.e. census data)	Adequate sample size (>300 subjects)	Measures were the standard	Outcomes measured by unbiased assessors	Adequate response rate (70%) and refusers described	Confidence intervals and subgroup analysis	Study subjects described	Quality risk rating/8
Bethell	2011	1	1	1	1	1	1	1	1	8
NSCH	2011/2012	1	1	1	1	1	1	1	1	8
CHIS	2003	1	1	1	1	1	1	0	1	7
CHIS	2005	1	1	1	1	1	1	0	1	7
CHIS	2009	1	1	1	1	1	1	0	1	7
CHIS	2007	1	1	1	1	1	1	0	1	7
Ibironke	2011	1	1	1	1	1	0	1	1	7
Zuckerman	2009	1	1	1	1	1	0	1	1	7
Glascoe	2013	1	1	1	1	1	0	0	1	6
Stevens	2006	1	1	1	0	1	0	1	1	6
Ng	2010	1	1	1	1	1	0	0	1	6
Restall	2009	1	1	0	1	1	0	1	1	6
VSEHQ	2008	1	1	1	1	1	0	0	1	6
Davies	2009	1	1	0	1	1	1	0	0	5
Glascoe	1999	0	1	1	1	1	0	0	1	5
Glascoe	1997	0	1	1	1	1	0	0	1	5
Rose Jacobs	2008	0	0	1	1	1	1	0	1	5
Glascoe	2010	0	0	1	1	1	0	0	1	4
Glascoe	2010	0	0	1	1	1	0	0	1	4
Kosht-Fedyshin	2006	1	0	0	1	1	0	0	1	4
Limbos	2011	0	0	1	1	1	1	0	1	5
Oreto	2010	0	0	1	1	1	0	0	1	4
Tough	2008	0	0	1	1	1	0	0	1	4
Armstrong	2008	0	1	0	1		0	0	1	3
Campos	2010	0	0	1	1	1	0	0	0	3
Coghlan	2003	0	0	0	1	1	0	0	1	3
Kiing	2012	0	0	1	1	1	0	0	0	3
McGookin	2011	0	0	1	1	1	0	0	0	3
Palarca	2008	0	0	1	1	1	0	0	1	3
Roux	2011	0	0	1	1	1	0	0	0	3
Theeranate	2005	0	0	0	1	1	0	0	1	3
Wake	2005	0	0	1	1	1	0	0	0	3
Gustawan	2010	0	0	0	1	1	0	0	1	3
Chuan	2012	0	0	0	1	1	0	0	0	2
Mahli	2002	0	0	0	1	1	0	0	0	2
Matibag	2008	0	0	0	1	1	0	0	0	2
Sices	2009	0	0	0	1	1	0	0	0	2

*Quality rating system as per quality rating tool developed by Public Health Agency in Canada [19].



*= no data available for high risk

Figure 2 Prevalence of parental concerns indicating high developmental risk.

food-insecurity (aOR 1.76 (95% CI 1.26 - 2.46) [37], severe energy insecurity aOR 1.82 (95% CI 1.38 -2.39) [36], geographic site differences in the USA ($p = 0.003$) [37] and poor overall social support ($p = 0.003$) [39]. Service level factors were referral to early intervention ($p < 0.001$), speech pathology ($p < 0.001$) or audiology ($p < 0.001$) [40], lack of care coordination aOR 0.33 (95% CI 0.24–0.46), referrals aOR 0.40 (95% CI 0.25–0.65), family-centred care aOR 0.47 (95% CI 0.36–0.62) [30] and parental difficulty understanding the doctor uOR 3.35 (95% CI 2.1–5.4) [48].

Two studies reported a dose–response relationship between the number of risk factors and the increased likelihood of parental concerns on the *PEDS* indicating high developmental risk [7,39,40]. In one study having one risk factor was associated with an aOR 1.7 (95% CI: 1.20–2.38); two risk factors aOR 3.28, (95% CI: 2.27–4.73), three risk factors aOR 4.69 (CI: 2.84–7.73), and four risk factors aOR 14.58 (95% CI: 4.98–42.64) compared to a child with

zero risk factors [7]. In addition, the greater the number of risk factors experienced by the child the more likely the child was to not receive comprehensive well child care [7].

The only longitudinal cohort in the review reported that at the second follow up when a child was 5 years of age male gender aOR 2.3 (1.3, 4.1), maternal history of abuse at pregnancy aOR 2.4 (1.3, 4.4) and poor parenting morale when the child was 3 years old aOR3.9 (2.1, 7.3) were predictors of parental concerns on the *PEDS* indicating high developmental risk [39].

Discussion

Prevalence and associated risk factors for parental concerns on the *PEDS* indicating developmental risk

This systematic review provides synthesised critically appraised evidence of the substantial global prevalence of parental concerns on the *PEDS* that indicate high and moderate developmental risk, which increases with biological and psychosocial adversity. This information is

Table 3 Metaregression of included studies

Study characteristics	Prevalence of high risk (%; 95% CI)	P value	Prevalence of moderate risk (%; 95% CI)	P value
All studies	13.8 (10.9,16.8)		19.9 (16.8,23.1)	
Sample type				
Population survey	13.5 (8.8,18.1)	0.86	18.7 (14.3,23.1)	0.47
Community sample	14.0 (10.2,17.8)		21.0 (16.7,25.2)	
Type of PEDS				
Survey PEDS	17.9 (10.9,24.9)	0.15	20.6 (16.9,24.3)	0.50
Clinical PEDS	12.6(9.6,15.7)		18.3 (12.9,23.7)	
Study purpose				
Population risk measure	14.5 (9.7,19.2)	0.71	20.1 (15.4,24.9)	0.92
Developmental surveillance tool	13.3 (9.6,17.1)		19.8 (15.6,24.0)	
Study quality				
High quality	13.5 (8.8,18.1)	0.86	18.7 (14.3,23.1)	0.47
Medium/low quality	14.0 (10.2,17.8)		21.0 (16.7,25.2)	
Study age group				
3 years and under	14.5(8.9,20.2)	0.76	22.9(16.7,29.1)	0.25
Includes over 3 years	13.5(10.1,16.9)		18.9 (15.4,22.3)	
Publication type				
Peer review/Government report	11(8.1,14.0)	0.013	21.1(16.9,24.4)	0.39
Abstracts/website/manuals	18.0(13.0,22.9)		18.4(14.1,22.8)	
Country income	High			
High	13.2(10.2,16.3)	0.38	21.5(18.6,24.5)	0.001
Middle/low	17.2(8.2,26.1)		8.4(3.7,13.1)	

useful for researchers, service providers and clinicians to quantify the level of parental concern and to estimate the risk of children having developmental problems in the general population and to identify vulnerable sub-populations. Gender, low birth weight, poor maternal mental health, low family SES, minority ethnicity, speaking a language other than English and a lack of stimulation, such as a child not being read to, are all associated with adverse impacts on development in the literature and this was supported by the synthesised evidence [1,60-63]. The increasing parental concerns with age of a child regardless of SES demonstrated in this review reflect the increasing developmental demands with age. The impact of child's poor general health on developmental risk may reflect a true increase as some chronic illnesses and syndromes are associated with adverse developmental outcomes. However concerns about their child's health may increase parental concerns generally [64,65].

This review demonstrated that lack of access to usual and comprehensive health care in the USA and Canada was associated with an increased prevalence of parental concerns on the *PEDS* indicating high developmental risk. Interestingly the evidence for access to services such as early childhood education which has been found to

particularly benefit children from disadvantaged backgrounds was not demonstrated [66-68].

Two studies demonstrated that parental concerns on the *PEDS* indicating high developmental risk increased with the number of risk factors a child was exposed to, consistent with our understanding of the burden of multiple risk factors on early childhood development [7,39,40,62]. In addition, the "inverse care law" applied in one USA study, with the greater the number of risk factors, the less access to comprehensive health care [7,69].

Comparison with other measures of developmental risk

The confidence intervals around the pooled prevalence estimates of high and moderate developmental risk using the *PEDS* (27.0-36.0%) is similar to rates using the *Denver Developmental Screening Test (DDST)* [70-72] but higher than those using the *Australian Early Development Index (AEDI)* [1], and *Ages and Stages Questionnaire (ASQ)* [38,43,52]. While the *PEDS* gives an estimate of high and moderate developmental risk based on parental concerns this is not synonymous with a comprehensive developmental assessment. The *PEDS* specificities of 73-86% for parental concerns indicating high and/or moderate developmental risk means that some children identified by parental concern will be false positives [14,17]. If parental

Table 4 Risk factors associated with parental concerns on *PEDS* indicating high developmental risk

Risk factor	N studies	Summary effect OR (95% CI)	P value	Heterogeneity (I ²)
Child level				
Male gender	11	1.68 (1.48,1.87)	<0.001	88.1%
Male gender (aOR)	3	2.01 (1.38, 2.94)	<0.001	91.6%
>3 years of age	7	1.83 (1.39,2.41)	<0.001	92.7%
Low birth weight	2	1.95 (1.53,2.49)	<0.001	0.0%
Poor/fair child health status	5	3.68 (2.66,5.08)	<0.001	68%
Special health care needs	2	4.86 (2.81,8.38)	<0.001	98%
Family level				
Poor maternal mental health (aOR)	3	1.61(1.31,1.99)	<0.001	0.0%
Low socioeconomic status	8	2.12(1.65,2.72)	<0.001	93.9%
Low socioeconomic status (aOR)	2	1.66 (1.08,2.53)	0.019	0.0%
Less than high school education	6	1.79 (1.14,2.79)	0.011	95.5%
Less than high school education (aOR)	3	1.94 (0.60,6.23)	0.26	98.8%
Being read to less than daily	4	1.47(1.28,1.67)	<0.001	30.6%
Family size (6 or more people in household)	4	1.18(0.83,1.68)	0.35	91.9%
Single parent	7	1.46 (1.16,1.84)	0.001	96.8%
Single parent (aOR)	2	0.94(0.75, 1.17)	0.57	0.0%
Ethnicity (vs White)				
African American	7	1.95 (1.43,2.66)	<0.001	90.5%
African American (aOR)	2	1.40 (1.10,1.78)	0.006	0.0%
Indigenous	6	1.98 (1.37,2.86)	<0.001	63.6%
Hispanic	4	2.24(1.83,2.72)	<0.001	88.9%
Hispanic (aOR)	2	1.54(1.16,2.04)	0.03	0.0%
Language spoken				
English as a second language (all)	5	1.61(1.12,2.33)	0.01	94.2%
English as a second language (Spanish)	5	1.48(0.87,2.53)	0.15	96.5%
Service Level				
No Usual Health Care/Medical Home(USA)	5	2.27(1.35,3.81)	0.002	84.3%
No or Public Health Insurance	4	1.85(1.45,2.37)	<0.001	95.2%
No Health Insurance (aOR)	2	2.01(1.01,4.02)	0.048	57.2%
Does not attend formal childcare	4	0.88(0.77,0.99)	0.040	0%

aOR = adjusted OR.

concerns indicating only high developmental risk are examined the specificity of the *PEDS* improves to 89%, reducing the number of false positives but the sensitivity drops substantially to less than 50% giving an unacceptable level of false negatives [38,43]. Thus, the true prevalence of actual developmental problems indicated by parental concerns is likely to lie somewhere between the values indicating high and moderate developmental risk [38,73]. This is reflected in how the *PEDS* is used in clinical practice with those children identified as at high developmental risk on parental concerns referred on for a comprehensive developmental assessments and those at moderate risk undergoing a secondary developmental screen with a tool such as the

ASQ and if they fail that then being referred on for a comprehensive developmental assessment [38,43,52]. Systematic reviews of the diagnostic test accuracy (DTA) of the tools that measure developmental risk such as the *PEDS* in relation to the reference-standard diagnostic batteries in nationally representative samples with an inclusive analysis of vulnerable subpopulations would be useful in understanding how useful developmental risk is as a way to estimate the burden of developmental problems in a population. This systematic review only included studies which had used the *PEDS*. Prevalence and DTA systematic reviews of other tools such as the *ASQ* and *AEDI* would also be useful for further comparison.

Limitations

There was considerable variation in quality of the individual studies included in this systematic review. The major sources of bias were an inadequate sampling method, sampling frame, sample size and response rate and a lack of information to aid interpretation and applicability of the results including reporting of confidence intervals and subgroups. It is suggested that future research focus on designing studies that address these issues. Where community samples were used, parents most concerned about their children may be over-represented and this could lead to an overestimation of prevalence. However meta-regression using quality of the study as a variable did not find significant differences in pooled prevalence estimates. There were significant differences in pooled prevalence estimates of developmental risk between studies when the subgroups of publication type and country income were examined. We did not have individual patient data to undertake our own multivariate analysis. Although covariates were similar between studies, how these were measured and the breadth of variables measured varied. This highlights the need for agreed tools on measurement of psychosocial risk in research.

The cross sectional nature of the majority of papers in the review means that only associations of prevalence with risk factors can be examined not causality. In an attempt to address the issue of misclassification bias due to false positives we only examined the relationship between risk factors and high versus low/no developmental risk. Thus any significant relationship is likely to be an underestimate of the true strength of association [17].

Conclusions

This systematic review found that the prevalence of parental concerns indicating developmental risk on the *PEDS* is substantial. As with most systematic reviews there were methodological issues with many of the primary studies with variable quality in sampling, representativeness and reporting. Nevertheless, the level of parental concerns that indicate developmental risk highlights the need to support families and promote early childhood development. At the individual level, parents, especially those in disadvantaged communities, should be asked systematically about their concerns and service providers should respond to these concerns through advice, support and facilitating further assessment and early intervention as required [11,74,75]. At the population level families should have access to universal high quality early childhood services that optimise child development. Given the prevalence of parental concerns increased with biological and psychosocial adversity, the service response needs to be one of proportionate universalism where the greater the disadvantage, the more services available [68].

Additional file

Additional file 1: Search strategy.

Abbreviations

PEDS: Parents Evaluation of Developmental Status.

Competing interests

"Financial Disclosure: The authors have no financial relationships relevant to this article to disclose".

"Potential Non- financial Competing Interests: The authors have no non-financial competing interests relevant to this article to disclose".

Authors' contributions

SW conceptualized and designed the study, systematically searched the literature, excluded and included papers; designed the data collection form, extracted and analysed the data from the papers, assessed quality of the papers; drafted the initial manuscript and revised all subsequent versions of the manuscript. VE independently excluded and included papers from the systematic literature search assessed their quality and extracted data and reviewed and revised the manuscript. KW provided consensus for SW and VE when difference around exclusion/inclusion of papers and quality scoring and critically reviewed and revised the manuscript. AH undertook the data analysis of the prevalence data and supported SW in the data analysis of the risk factor data, critically reviewed the manuscript. NS supported SW in the design of the systematic review and critically reviewed and revised the manuscript. LK provided content expertise, supervised SW project management and critically reviewed the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Acknowledgement

Many thanks to Professor Frances Glascoe and Associate Professor Sharon Goldfeld for consultation in regards to access to unpublished *PEDS* data.

What's known on this subject?

Children at developmental risk are more likely to have long term adverse educational and health outcomes. Parental concerns about their child's development measured by the *Parents' Evaluation of Developmental Status (PEDS)* has been used as an indicator of developmental risk.

What this study adds

The prevalence of parental concerns measured with the *PEDS* that indicate developmental risk is substantial. There is increased prevalence associated with biological and psychosocial adversity.

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Received: 4 April 2014 Accepted: 2 September 2014

Published: 13 September 2014

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doi:10.1186/1471-2431-14-231

Cite this article as: Woolfenden et al.: A systematic review of the prevalence of parental concerns measured by the *Parents' Evaluation of Developmental Status (PEDS)* indicating developmental risk. *BMC Pediatrics* 2014 **14**:231.

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