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
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 synthesise 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), Psychinfo (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 I² statistic (which describes variation in the summary effect due to genuine variation rather than a sampling error as a percentage, a low I² indicates low heterogeneity and high I² 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 PEDS test 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

Figure 1 Search flow chart.
| First author | Country      | Age (months) | Sample size | Quality score | High risk% (95% CI) | Moderate risk% (95% CI) | High and moderate risk% (95% CI) | Low/no risk% (95% CI) |
|--------------|--------------|--------------|-------------|---------------|---------------------|------------------------|-------------------------------|-------------------|
| Armstrong    | 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      | USA          | 10-71        | 2283        | 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)   |
| Coghlan      | 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       | 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      | USA          | 24-84        | 408         | 5             | NA                  | NA                     | 34.6 (30.1-39.3)             | 65.4 (60.7-69.9)   |
| Glascoe      | 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      | 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      | 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)   |
| Gustawan     | Indonesia    | 3-12         | 170         | 3             | NA                  | NA                     | 31.0 (24.2-37.9)             | 69.0 (62.1-75.8)   |
| Iborone      | USA          | 6-71 (mean 38.5 SD 18.4) | 2381 | 7 | NA | 21.4 (19.8-23.1) | 78.6 (76.9-80.2) |
| Kiing        | 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 | 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       | 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        | India        | 24-60        | 79          | 2             | NA                  | NA                     | 39.2 (29.2-50.3)             | 60.8 (49.7-70.8)   |
| Matibag      | Philippines  | 24-60 (mean 53.6) | 283 | 2 | 15.0 (11.2-19.5) | NA | NA | NA |
| McGookin     | 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           | 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        | 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      | 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      | 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  | USA          | 4-36         | 2010        | 5             | 13.8 (12.4-15.4)    | NA                     | NA                           | NA               |
| Roux         | 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 | 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        | 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      | USA          | 435          | 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)   |
| Study          | Country     | Age       | Sample Size | Duration | Prevalence Rates | Quality Rating |
|---------------|-------------|-----------|-------------|----------|------------------|----------------|
| Theeranate [53] | Thailand    | 0-72      | 216         | 3        | 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)  | 41.0 (37.7-44.5)  |
| VSEHQ (2008) [54] | Australia  | 60-83     | 54602       | 6        | 7.2 (7.0-7.4)    | 23.7 (23.3-24.0)  |
| Wake [55]      | Australia   | 63.4-90   | 853         | 3        | NA               | 35.0 (31.9-38.3)  |
| Zuckerman [34] | USA         | <72       | 24933       | 7        | 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].
| 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                                         | 8                        |          |
| NSCH         | 2011/12 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 1                                             | 1                                         | 8                        |          |
| CHIS         | 2003 | 1                                | 1                                         | 1                                    | 1                        | 0                                      | 1                                             | 7                                         |            |
| CHIS         | 2005 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 1                                         | 7                        |          |
| CHIS         | 2009 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 1                                             | 7                                         |            |
| CHIS         | 2007 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 1                                         | 7                        |          |
| Ibronke      | 2011 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 1                                         | 7                        |          |
| Zuckerman    | 2009 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 1                                         | 7                        |          |
| Glascoe      | 2013 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 1                                         | 6                        |          |
| Stevens      | 2006 | 1                                | 1                                         | 1                                    | 0                        | 1                                      | 0                                             | 1                                         | 6                        |          |
| Ng           | 2010 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 1                                         | 6                        |          |
| Restall      | 2009 | 1                                | 1                                         | 1                                    | 0                        | 1                                      | 0                                             | 1                                         | 6                        |          |
| VSEHQ        | 2008 | 1                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 1                                         | 6                        |          |
| Davies       | 2009 | 1                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 5                        |          |
| Glascoe      | 1999 | 0                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 1                        |          |
| Glascoe      | 1997 | 0                                | 1                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 1                        |          |
| Rose Jacobs  | 2008 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 1                                             | 0                                         | 1                        |          |
| Glascoe      | 2010 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 1                        |          |
| Glascoe      | 2010 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 1                        |          |
| Kosht-Fedyshin| 2006 | 1                                | 0                                         | 0                                    | 1                        | 1                                      | 0                                             | 1                                         | 4                        |          |
| Limbos       | 2011 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 1                                             | 0                                         | 1                        |          |
| Oreto        | 2010 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 1                        |          |
| Tough        | 2008 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 1                        |          |
| Armstrong    | 2008 | 0                                | 1                                         | 0                                    | 1                        | 1                                      | 0                                             | 0                                         | 1                        |          |
| Campos       | 2010 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 0                        |          |
| Coghlan      | 2003 | 0                                | 0                                         | 0                                    | 1                        | 1                                      | 1                                             | 0                                         | 1                        |          |
| Kiing        | 2012 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 0                        |          |
| McGookin     | 2011 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 0                        |          |
| Palarca      | 2008 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 1                        |          |
| Roux         | 2011 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 0                        |          |
| Theeranate   | 2005 | 0                                | 0                                         | 0                                    | 1                        | 1                                      | 1                                             | 0                                         | 0                        |          |
| Wake         | 2005 | 0                                | 0                                         | 1                                    | 1                        | 1                                      | 0                                             | 0                                         | 0                        |          |
| Gustawan     | 2010 | 0                                | 0                                         | 0                                    | 1                        | 1                                      | 1                                             | 0                                         | 0                        |          |
| Chuan        | 2012 | 0                                | 0                                         | 0                                    | 1                        | 1                                      | 1                                             | 0                                         | 0                        |          |
| Mahli        | 2002 | 0                                | 0                                         | 0                                    | 1                        | 1                                      | 1                                             | 0                                         | 0                        |          |
| Matibag      | 2008 | 0                                | 0                                         | 0                                    | 1                        | 1                                      | 1                                             | 0                                         | 0                        |          |
| Sices        | 2009 | 0                                | 0                                         | 0                                    | 1                        | 1                                      | 1                                             | 0                                         | 0                        |          |

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

| 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                  | 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)                         |         |

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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.

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 (I²) |
|-------------------------------------------|-----------|---------------------------|---------|-------------------|
| **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 healthcare 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.
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
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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.

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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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