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REVIEW ARTICLE

INCREASING PREVALENCE OF CEREBRAL PALSY AMONG CHILDREN AND ADOLESCENTS IN CHINA 1988–2020: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Objectives: **To investigate the pooled prevalence of cerebral palsy in China, analyse the differences between different subgroups, and explore the trend over the 32-year period from 1988 to 2020.**
Methods: **All potential studies related to the prevalence of cerebral palsy among children and adolescents in China were identified from 3 English-language databases and 4 Chinese-language databases. Pooled prevalence was calculated to estimate the prevalence of cerebral palsy among 0-18 years old and different geographical regions in China, using a random-effects meta-analysis model. Continuous fractional polynomial regression modelling was used to estimate the trend in prevalence of cerebral palsy over time. Subgroup analysis and meta-regression were conducted to investigate heterogeneity. Funnel plots and Egger's test were used to explore potential publication bias.**
Results: **The pooled prevalence of cerebral palsy over the study period among 0–18 years old and different geographical regions in China was 2.07‰ (95% confidence interval (95% CI) 1.66–2.47‰), and the prevalence of cerebral palsy was higher in males compared with females (2.25‰ vs 1.59‰), and in rural residents compared with urban residents (2.75‰ vs 1.90‰), respectively. The prevalence of cerebral palsy varied significantly between different geographical regions. In subjects with birthweights < 2.5 and > 4 kg, the prevalence of cerebral palsy was significantly higher than in subjects with birthweights between 2.5 and 4 kg. The trend in pooled prevalence of cerebral palsy increased continuously over the period studied, and could be divided into 3 stages; the mean annual increase in prevalence from 1988 to 1996 and from 2008 to 2019 was more rapid. Multivariate meta-regression found that the year of study was one of the sources of heterogeneity among overall prevalence. (*p*-value = 0.006).**
Conclusion: **The pooled prevalence of cerebral palsy over the 32-year period from 1988 to 2020 was 2.07‰. There was an increasing trend in prevalence of cerebral palsy among children and adolescents in China over this period.**

Key words: cerebral palsy; children; prevalence; meta-analysis; China.

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LAY ABSTRACT

There are few reports regarding trends in childhood cerebral palsy in China over the past 30 years. This study searched and statistically analysed all potentially relevant studies regarding cerebral palsy. The trend in childhood cerebral palsy in China increased continuously over the period studied, and could be subdivided into 3 stages. From 1988 to 1996, and from 2008 to 2019, the mean annual increase in prevalence was more rapid than for the other years studied. Counter-measures, such as health monitoring and management of infants and young children, are recommended to reduce the prevalence of childhood cerebral palsy in China.

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Cerebral palsy (CP) is a group of heterogeneous non-progressive neurodevelopmental conditions that affect the developing foetal or infant brain (1); it is one of the most common risk factors for motor impairment (2) and limitation in manual ability, which is strongly related to limitations in daily activities (3). In line with the global trend, CP places a heavy burden of disease on children, families and society in both developed and developing countries. In Norway, the prevalence of CP decreased from 2.62 per 1,000 live births in 1999 to 1.89 per 1,000 live births in 2010 (4). A register-based cohort study in Denmark reported that the prevalence of CP was 2.2/1,000 in children of Danish-born mothers in 2018 (5). Furthermore, 2 population-based studies, from Uganda and Bangladesh, on the prevalence of CP reported prevalences of 2.9 per 1,000 children in 2017 and 3.4 per 1,000 children in 2016 (6, 7), respectively. According to a systematic review published in 2013, the global prevalence of CP was 2.11 per 1,000 live births (8).

In China, a "birth deficient registration system" has been in operation since the 1980s, but it lacks a specific registration system for CP. Lv (9) reported the prevalence of childhood CP in 1988 in China as 1.20 per 1,000

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children. With the acceleration of China's economic development and the rapid population growth in the past 30 years, CP is one of the leading diseases with a heavy burden of disease among Chinese children (10). It has been reported that the lifetime total economic loss due to all new cases of CP in 2003 in China amounted to US$ 2–4 billion (11). Based on data from multiple provinces in China, the prevalence of CP among Chinese children has been reported to range from 1.92 to 2.46‰ in 1998 and 2013 (12, 13), respectively. A systematic review published in 2015 (14) reported the prevalence of CP among children as 1.80‰, including 21 studies published from 2000 to 2014, based on data from PubMed and 4 Chinese databases. However, there have been few reports on the trend in childhood CP in China in the past 30 years.

In addition, some updated original data published in recent years, has combined data from diverse populations, types of area and geographical regions. Hence, the aims of this study are to provide a comprehensive update on the trend in prevalence of CP in China, from 1988 to 2020, and to systematically analyse childhood CP by urban or rural area, five geographical regions, age group and birthweight.

METHODS

This systematic review and meta-analysis adhered to the 2009 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (15).

Search strategy

Three English-language databases (PubMed, Embase and Web of Science) and 4 Chinese-language databases (China National Knowledge Infrastructure (CNKI), Wanfang, Weipu, and China Biology Medicine disc (CBMdisc)) were searched to identify all potential studies related to the prevalence of CP among children and adolescents in China published from database inception to 5 February 2021. The following search terms were used: cerebral palsy, mixed cerebral palsy, athetoid cerebral palsy, spastic diplegia, prevalence, morbidity, epidemiology, China, Chinese, children, and adolescent. The specific search strategies for each database are shown in Table SI[1]. The language of publication was restricted to English and Chinese. The reference lists of included articles and previous reviews were retrieved to identify potential studies as comprehensively as possible. Two authors, working independently, carried out the searches (SY Y and JY X).

Inclusion and exclusion criteria

The inclusion criteria were: (*i*) population-based studies; (*ii*) original investigations reporting data among children (under 12 years old) and adolescents (12–18 years old) in China; (*iii*) data from cross-sectional studies or baseline investigations from prospective studies and randomized controlled trials (RCTs); (*iv*) the diagnostic criteria followed Chinese clinical guidelines on diagnosis of CP (16); (*v*) samples obtained from the province, city or county of residence by a probability sampling method; (*vi*) directly and/or indirectly providing prevalence of CP; (*vii*) details of the research plan, regarding design, research approach and research process, are clear.

The exclusion criteria were: (*i*) original investigations reporting data are adults (over 18 years old) or not Chinese; (*ii*) not related to CP; (*iii*) the diagnostic criteria for CP were not clear or not mentioned; (*iv*) did not report the prevalence of CP or information inadequate to evaluate the prevalence; (*v*) research plan, regarding design, research approach and research process, not clear; (*vi*) reviews, duplicate publications, randomized controlled trials (RCTs) and case-control studies.

Data extraction

Two researchers (SY Y and JY X) independently abstracted the following information from each article: author, year of publication, medium year of data collection, geographical location of the study, sampling method, case definition, sample size, number of cases of CP, and prevalence of CP.

Subgroup information for number of cases and number of populations, including sex (male, female), age group (0–1, 1–3, 3–6 years), geographical location (East China, Central China, South China, Southwest China, Northwest China, North China, Northeast China), regions (urban or rural), birthweight (under 2.5 kg, 2.5–4 kg, over 4 kg), gestation (under 37 weeks, 37–42 weeks, over 42 weeks) and classification of CP, were collected.

The study authors were contacted for additional data or clarification, if necessary. Disagreements were resolved by consensus after discussion.

Quality assessment

Two researchers assessed the quality of each included study using the quality assessment criteria for observational studies recommended by the Agency of Healthcare Research and Quality (AHRQ) (17). These assessment criteria included 11 criteria with 3 potential responses: yes, no and unclear. Briefly, "yes"=1 point, "no or unclear"=0 points, and a maximum score of 11 was possible for each study. The total score for each study was calculated. Studies with a score <3 points were considered low quality, 4–7 points medium quality, and 8–11 points high quality.

Statistical analysis

Pooled prevalence and 95% CI of children with CP were calculated. A χ^2-based Q test and the I^2 test were performed to evaluate the heterogeneity of the studies. A random-effects meta-analysis model was used when the heterogeneity was statistically significant (I^2>50, p-value <0.05) (18). Furthermore, subgroup analysis was performed to evaluate the levels of prevalence of CP according to different subgroups. In addition, a continuous fractional polynomial regression model at the midpoint of each study period was used to estimate the trend in prevalence over time. Egger's test was performed to explore potential publication bias. To explore the sources of heterogeneity, sensitivity analysis, univariate and multivariable meta-regression analysis were performed including the following variables: year of publication, year of study, geographical location, male/total, mean age, quality scores, sample size, and research type. p-value <0.05 was considered

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statistically significant. EndNote X9 (Thomson Corporation, American) was used for reference management, Excel 2008 for data arrangement, Stata 15.0 for data analysis, and Origin 2019b for graphs (Origin Lab, American).

RESULTS

Selection of studies

The search strategy yielded a total of 839 abstracts: 121 from PubMed, 178 from Embase, 38 from Web of Science, 174 from CNKI, 162 from Wanfang, 106 from CBM, and 60 from Weipu. A manual search of the references cited in an available systematic review of CP prevalence yielded an additional 6 abstracts. After removal of duplicates, 450 studies remained. After title and abstract screening, 112 full-texts were assessed for eligibility based on the inclusion and exclusion criteria, and 57 studies were excluded, as follows: 8 review articles, 4 studies based on non-Chinese populations, 2 studies that used recruitment from schools, 7 studies conducted in populations other than children and adolescents, 19 studies that lacked data on population, 18 studies with no diagnostic criteria for CP, and 11 studies that used data from the same study populations. A final total of 43 studies were included in the quantitative synthesis. The study selection process is shown in Fig. 1.

Characteristics of studies

The 43 studies included in this systematic review were published during the years 1993 to 2020, among which, the data were collected between 1988 and 2019. The geographical locations included were East China (15 studies), Central China (8 studies), South China (5 studies), Southwest China (6 studies), Northwest China (4 studies), North China (1 studies), and Northeast China (2 studies). The age of children mostly ranged from 0 to 6 years, and almost 85.70% of the population were live births. The sample sizes of the included studies ranged from 1,712 to 12,902,002, with a total of 17,723,942 people. Quality scores for the studies ranged from 5 to 10. A detailed description of the studies is shown in Table I.

Pooled prevalence of CP

As shown in Fig. 2, the pooled prevalence of CP was 2.07 per 1,000 persons (95% CI 1.66–2.47‰), ranging from 1.02 to 7.59 per 1,000 persons. Significant heterogeneity was found among studies (I^2=99.4%, p-value<0.001).

Subgroup analysis

Prevalence of CP by sex and age. The pooled prevalence of CP among children per 1,000 live births was calculated by sex. The prevalence of CP was significantly higher (p-value <0.001) among males (2.25‰, 95% CI 1.65–2.85‰) compared with females (1.59‰, 95% CI 1.35–1.82‰), and heterogeneity was found among the different subgroups (I^2 for males=99.8%, p-value<0.001; I^2 for females=95.9%, p-value<0.001). Regarding the age subgroups (Fig. 3), the pooled prevalence of CP was different among the different age groups, and the highest level was found in the 0–1 year group (1.95‰, 95% CI 1.44–2.46‰) (Fig. 3).

Prevalence of CP by geographical location and region. The prevalence of CP varied significantly between different geographical regions. The pooled prevalence of CP was highest in Southwest China (2.80‰, 95% CI 1.91–3.70‰), followed by Northwest China (2.55‰,

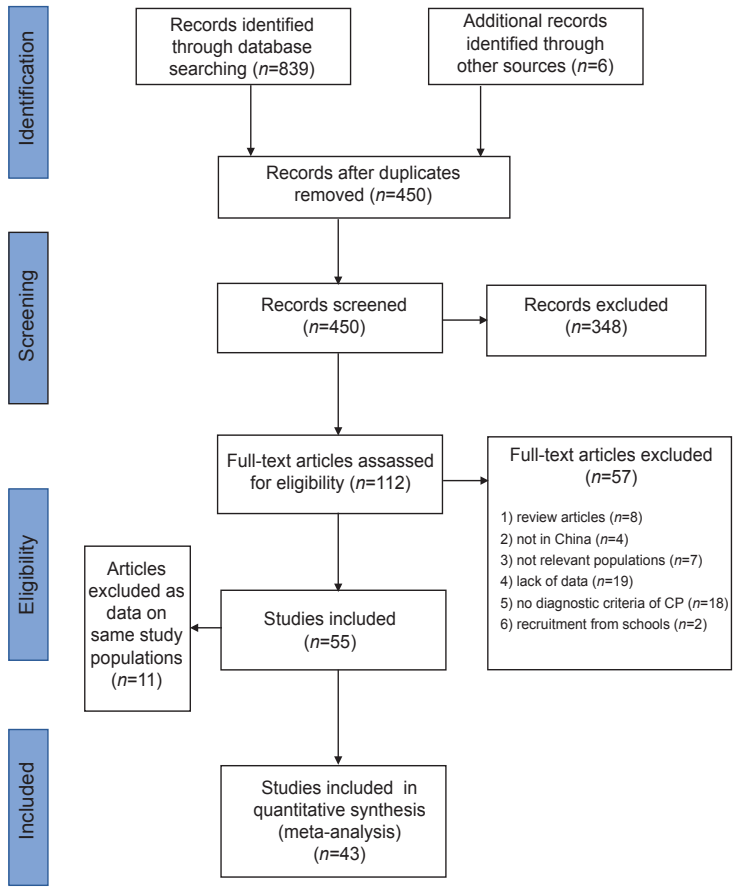

Fig. 1. Flow diagram of study selection process. CP: cerebral palsy.

Table I. Characteristics of studies on the prevalence of cerebral palsy (CP)

Reference	Publication year	Study year	Province/s	Geographical location	Range of birth time	Age range, years	Cases with CP, *n*	Sample size, n	Denominator	Prevalence (‰)	Quality scores*
Lv et al. (9)	1993	1988	Sichuan	Southwest China	1974–1988	0–14	15	12,489	Children < 14 years	1.20	6
Ma et al. (40)	1996	1995	Yinchuan, Ningxia	Northwest China	1982–1995	0–12	31	16,872	Children < 13 years	1.84	8
Li et al. (41)	1996	1996	Jiaxing, Zhejiang	East China	1988–1995	0–6	98	69,852	Live births	1.40	8
Song et al. (42)	2002	1997	Suzhou, Jiangsu	East China	1990–1997	0–6	92	56,231	Live births	1.64	10
Li et al. (43)	2003	1997	Jiangsu	East China	1991–1997	1–6	484	305,263	Live births	1.59	9
Li et al. (44)	2000	1997	Jilin	Northeast China	1991–1997	0–6	56	30,876	Live births	1.81	8
Liu et al. (45)	2000	1997	Jiangsu	East China	1990–1996	0–6	622	388,192	Children < 7 years	1.60	7
Xie et al. (46)	2005	1997	Leshan, Sichuan	Southwest China	1991–1997	0–6	50	22,180	Live births	2.25	8
Wang et al. (47)	2002	1997	Suzhou, Jiangsu	East China	1990–1997	0–6	108	63,102	Live births	1.71	9
Zhang et al. (48)	2000	1998	Wujin, Jiangsu	East China	1991–1997	0–6	63	62,003	Live births	1.02	10
Li et al. (49)	2000	1998	Nanning, Guangxi	South China	1991–1997	1–6	39	30,485	Live births	1.28	8
Zhao et al. (50)	2002	1998	Zhejiang	East China	1992–1997	1–6	92	62,949	Live births	1.46	10
Liang et al. (51)	2002	1998	Guangxi	South China	1991–1997	1–6	193	150,806	Live births	1.28	9
Tao et al. (52)	1999	1998	Anhui	East China	1990–1998	1–8	105	50,714	Live births	2.07	7
Lin et al. (12)	2001	1998	6 provinces in China	–	1991–1997	1–6	2009	1,047,327	Children 1–6 years	1.92	7
Zhong et al. (53)	2002	1998	Chengdu, Sichuan	Southwest China	1992–1998	1–6	348	148,723	Live births	2.07	9
Guo et al. (54)	2003	1998	Gansu	Northwest China	1991–1997	1–6	395	152,463	Live births	2.59	7
Chen et al. (55)	2000	1998	Hefei, Anhui	East China	1985–1996	2–13	11	7,388	Live births	1.49	10
Yan et al. (56)	2002	1999	Guangxi	South China	1991–1997	1–6	100	61,912	Live births	1.62	7
Xing et al. (57)	1999	1999	Heilongjiang	Northeast China	1991–1997	1–6	25	13,755	Live births	1.82	10
Sun et al. (58)	2001	2000	Rizhao, Shandong	East China	1993–1999	0–7	81	62,989	Live births	1.29	8
Tao (59)	2001	2000	Anhui	East China	1992–2000	1–8	193	104,120	Children 1–8 years	1.85	8
Shi et al. (60)	2004	2000	Hebei	North China	1993–1999	1–6	171	96,435	Live births	1.77	8
Tao et al. (61)	2002	2000	Anhui	East China	1992–2000	0–8	88	53,406	Live births	1.65	10
Gao et al. (62)	2003	2001	Henan	Central China	1995–2000	0–6	582	434,920	Live births	1.34	8
Yuan et al. (63)	2005	2002	Xiangtan, Hunan	Central China	1995–2002	0–7	385	179,895	Live births	2.14	9
Wang et al. (64)	2005	2002	Fujian	East China	1985–2001	1–16	298	179,393	Live births	1.49	9
Tseng et al. (65)	2018	2005	Taiwan, China	East China	2002–2008	0–6	49521	1,290,2002	Children < 7 years	3.84	8
Li (66)	2010	2009	Chongqing	Southwest China	2002–2009	0–6	13	1,712	Live births	7.59	5
Tan et al. (67)	2011	2009	Chongqing	Southwest China	2002–2009	0–6	17	3,360	Live births	5.06	7
Hu et al. (68)	2016	2012	Hunan	Central China	2005–2010	0–6	55	20,003	Live births	2.75	9
Ma et al. (69)	2014	2012	Henan	Central China	2005–2010	0–6	120	51,108	Live births	2.35	8
Song (70)	2014	2012	Henan	Central China	2005–2010	1–6	69	24,500	Live births	2.82	10
Li (71)	2012	2012	Shandong	East China	2005–2010	1–6	36	20,077	Live births	1.79	10
Li et al. (72)	2017	2012	Qinghai	Northwest China	2005–2010	1–6	54	10,000	Live births	5.40	9
Yuan et al. (73)	2019	2012	Henan	Central China	2005–2010	0–6	120	50,596	Children < 7 years	2.37	9
Peng et al. (74)	2016	2013	Xiamen, Fujian	East China	2010–2014	0–5	32	20,915	Live births	1.53	8
Li et al. (13)	2018	2013	12 provinces in China	–	2005–2010	1–6	797	323,858	Live births	2.46	10
Lin et al. (75)	2015	2014	Kazak Autonomous prefecture of Ili-Xinjiang	Northwest China	2006–2012	1–6	515	288,368	Live births	1.79	10
Wang et al. (76)	2016	2015	Ezhou, Hubei	Central China	2007–2014	0–6	106	71,310	Live births	1.49	10
Zhang et al. (77)	2016	2015	Foshan, Guangdong	South China	2008–2013	0–6	60	28,704	Live births	2.09	6
Li et al. (78)	2018	2016	Hainan	South China	2008–2014	0–6	80	37,862	Live births	2.11	8
Luo et al. (79)	2020	2019	Xizang	Southwest China	2009–2018	0–10	29	4,827	Live births	5.80	9

*The quality of each included study was assessed by using the quality assessment criteria for observational studies recommended by the Agency of Healthcare Research and Quality (AHRQ) (17).

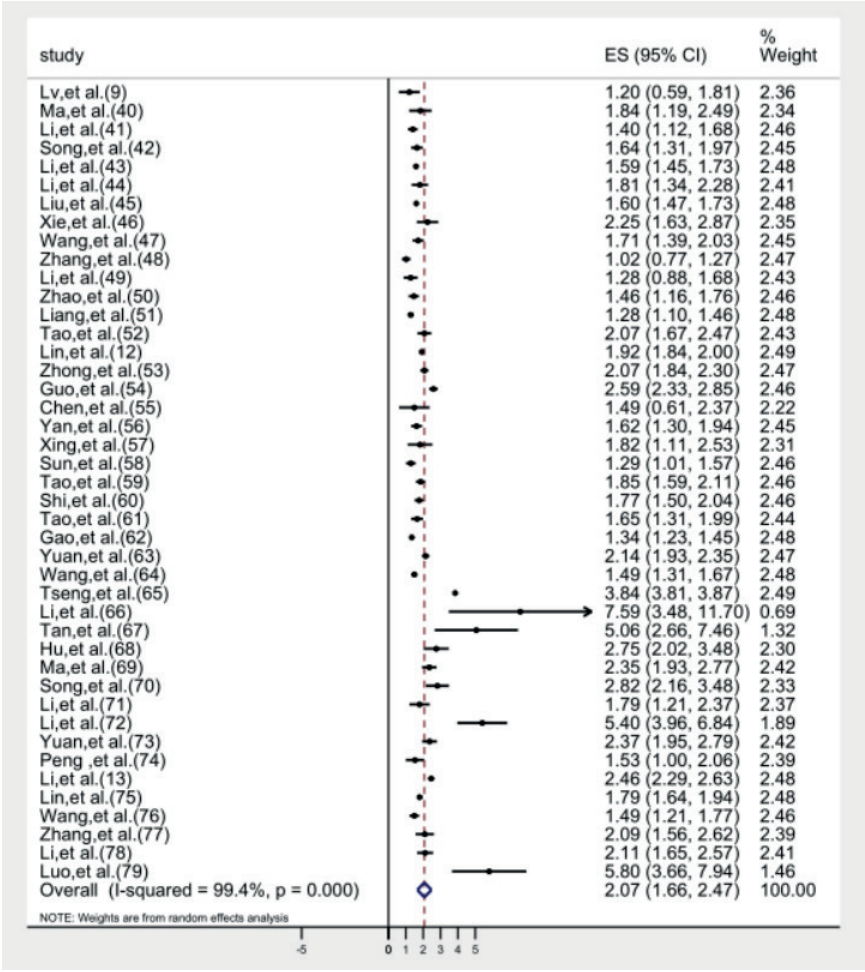

Fig. 2. Forest plot of prevalence of cerebral palsy (CP) in Chinese children and adolescents in the random-effects model (‰). NO.: number; 95% CI: 95% confidence interval; ES: estimated statistics.

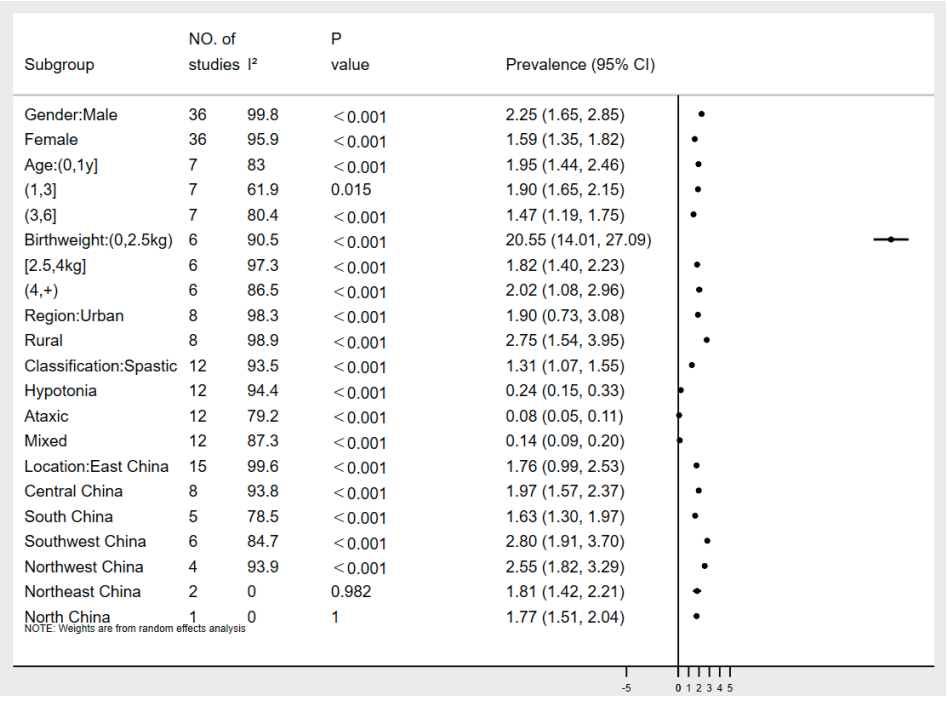

Fig. 3. Prevalence of cerebral palsy (CP) in children and adolescents in China (‰): subgroup meta-analysis and analysis of heterogeneity. 95% CI: 95% confidence interval; NO.: number; y: years.

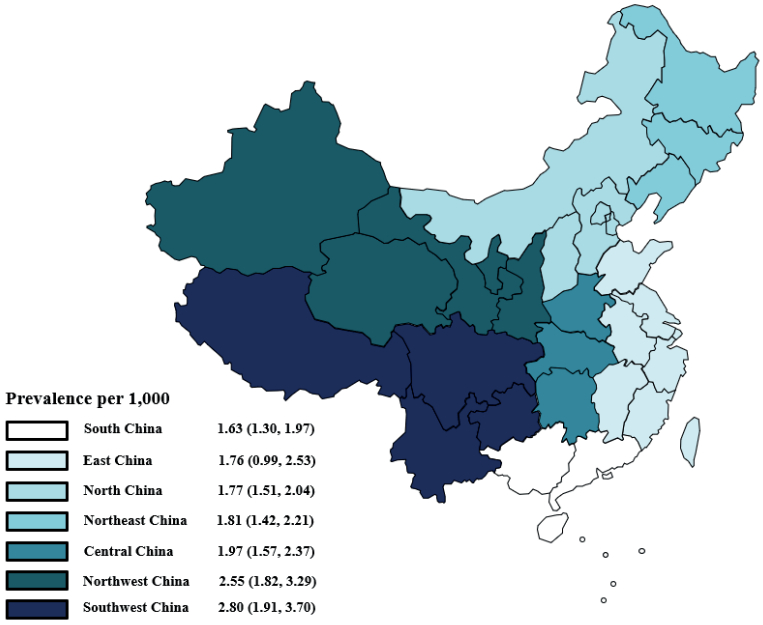

Fig. 4. Prevalence of cerebral palsy (CP) in children and adolescents in different geographical locations of China.

95% CI 1.82–3.29‰), and was lowest in South China (1.63‰, 95% CI 1.3–1.97‰) (p-value <0.001, Fig. 3 and Fig. 4). Urban residents had a much lower prevalence of CP (1.90‰, 95% CI 1.75–3.95‰) compared with rural residents (2.75‰, 95% CI 0.73–3.08‰, Fig. 3).

Prevalence of CP by classification of CP. As for the prevalence of CP by different classifications of CP, spastic was highest (1.31‰, 95% CI 1.07–1.55‰) and ataxic the lowest (0.08‰, 95% CI 0.05–0.11‰).

Prevalence of CP by birthweight. The prevalence of CP among children with birthweights under 2.5 kg (20.55‰, 95% CI 14.01–27.09‰) and over 4 kg (2.02‰, 95% CI 1.08–2.96‰) was significantly higher than those of birthweight 2.5–4 kg (1.82‰, 95% CI 1.40–2.23‰), especially for the group under 2.5 kg (p-value <0.001, Fig. 3).

Prevalence of CP over time

Continuous fractional polynomial regression modelling on the midpoint of each study period was used to estimate the trend in CP in Chinese children over time (Fig. 5). The trend increased continuously over time, and could be divided into 3 stages. From 1988 to 1996, and 2008 to 2019, the mean annual increases in prevalence were approximately 9.14% and 38.13%, respectively, and between 1996 and 2008 the prevalence increased by approximately 9% per year.

Publication bias

Egger's test showed that there was significant publication bias in this meta-analysis (t=-4.6, p-value<0.05) (Fig. 6).

Sensitivity analysis and meta-regression analysis

Sensitivity analysis was conducted with 43 studies that were distributed on both sides of the pooled prevalence (1.02–7.59‰). After excluding the 3 articles with 5 or 6 quality scores and the 2 articles that were not cross-sectional studies, the prevalence of CP was similar to the overall pooled estimates (2.05‰ and 2.07‰), which strengthened the credibility of the original analysis results.

A meta-regression analysis was performed to evaluate the potential risk factors for the prevalence of CP (p-va-

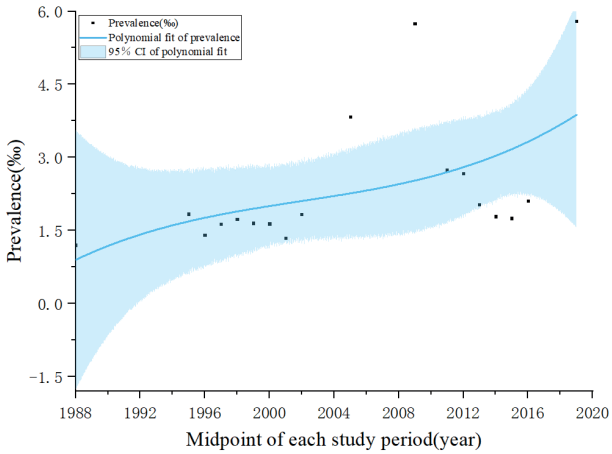

Fig. 5. Long-term trend in prevalence of cerebral palsy (CP) in Chinese children and adolescents over time. 95% CI: 95% confidence interval.

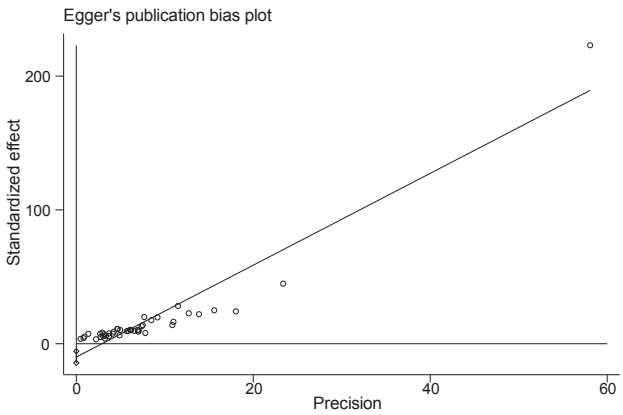

Fig. 6. Egger's publication bias plot of the prevalence of cerebral palsy (CP) (p-value<0.05).

Table II. Results of meta-regression for prevalence of cerebral palsy (CP)

Covariate	Meta-regression coefficient	95% CI	*p*-value	Adjusted R-squared (%)
Univariate analyses				
Year of studying	0.0334	0.0093 to 0.0574	0.008	23.46
Geographical location[a]	0.089	−0.0266 to 0.2047	0.128	3.48
Male/total%	2.4178	−4.7218 to 9.5573	0.498	1.84
Mean age	−0.0942	−0.2585 to 0.0700	0.253	2.22
Quality scores	−0.0149	−0.1830 to 0.1533	0.859	4.82
Sample size	−2.16E−07	−1.29E−06 to 8.62E−07	0.688	6.87
Research type[a]	0.2253	−0.7403 to 1.1909	0.640	1.66
Multivariable analyses				24.12
Year of study	0.0387	0.0121 to 0.0654	0.006	
Geographical location[a]	0.1101	−0.0058 to 0.2260	0.062	
Male/total%	4.8524	−1.8162 to 11.5210	0.148	
Mean of age	−0.0144	−0.1719 to 0.1432	0.854	
Quality score	−0.0729	−0.2344 to 0.0885	0.365	
Sample size	3.91E−08	−9.42E−07 to 1.02E−06	0.936	
Research type[a]	−0.1032	−0.1006 to 0.8000	0.818	

[a]Studies restricted to East China = 1, Central China = 2, South China = 3, Southwest China = 4, Northwest China = 5, North China = 6, Northeast China = 7 and data from cross-sectional studies = 1, baseline investigations from prospective studies = 2.

lue=0.049, I^2=87.48%) (Table II). In the univariate analyses, the heterogeneity was not modified by geographical location, male/total, mean age, quality scores, sample size or research type, but the year of study was significantly associated with the prevalence of CP (*p*-value=0.008 for the year of study). As shown by multivariable analysis, the year of study was significantly associated with prevalence of CP (*p*-value=0.006) (Table II).

DISCUSSION

A total of 43 studies were included in this systematic review, for which the data were collected between 1988 and 2019. The pooled prevalence of CP was 2.07‰, which was a little higher than reported in a review in China, in 2015 (1.8‰) (14), and lower than the mean of 2.21‰ worldwide in 2013 (8). In addition, the continuous fractional polynomial regression model showed that the prevalence of CP among children in China has increased continuously over the 32-year period from 1988 to 2020.

There are a number of reasons associated with the increasing prevalence of CP in China. With economic development, medical conditions have gradually improved. The availability of neonatal intensive care units and high-technology diagnostic procedures in China has led to increased survival of premature infants, which may be associated with higher risk of CP (19, 20). Urbanization entered a period of accelerated development in the 1990s (21). According to the sixth national census in 2010, half of China's population was living in urban areas (22). Urbanization not only transforms the urban environment, increasing air pollution, occupational and traffic hazards, but encourages changes in people's lifestyle (22), factors which are associated with the prevalence of CP (23). With economic development and improved living conditions in China, women are consuming increasing amounts of sugar and fats, which may be risk factors for gestational hypertension and diabetes mellitus (23). Lastly, previous estimates suggest that the contribution of genetic variants to the burden of CP is approximately 12% (24). Established environmental risk factors for CP may interact with predisposing genetic variants, potentiating and multiplying the risk of CP (25). Furthermore, familial clustering of CP has been described as the risk of CP for the sibling of a child with CP, and this is increasing (26).

In 2013, China applied the policy allowing marital couples in which at least 1 of the partners was an only-child to have 2 children, and in 2015, China finally ended all 1-birth restrictions and moved to a nationwide 2-child policy (27), which resulted in an increase in multiparous mothers and mothers aged 35 years and over (28). However, multiple pregnancies, elderly maternal age (35 years and over), and parity of 3 or more were the risk factors for preterm infants (23, 29). In addition, the model indicated a sharply increasing trend in the prevalence of CP before 1996. However, only 3 studies from 1988 to 1996 were included in the analysis, which might have introduced some heterogeneity. In addition, the denominator used in 1988 was the number of the children <14 years of age, while the denominator in 1995 was the number of children <13 years, which may have led to a sharp increase in prevalence before 1996 when these 2 age groups were considered as denominators.

The longitudinal trend in childhood CP in China for this period is different from that in more developed countries, whose trends decreased. Population-based databases and registers in Europe and Australia show that the trend in childhood CP was decreasing (30). In Norway, the prevalence of CP decreased from 2.62 per 1,000 live births in 1999 to 1.89 per 1,000 live births in 2010 (4). In Sweden, the prevalence of childhood CP has been continuously reported (31, 32) to have been decreasing significantly since the 1980s up to the birth-year period 1995–1998, although this overall trend ceases in the birth-year period 1999–2002 (31–33). In Asia, the overall prevalence of childhood CP increased from 1988 to 1997 and decreased from 1998 to 2007 in Okinawa, Japan (34), which was different from the increasing trend in China. In South Korea, the prevalence of childhood CP has decreased significantly from 2007 to 2103 (35).

The current subgroup analysis showed that the prevalence of CP was significantly higher among males (2.25‰) than females (1.9‰) (*p*-value <0.001). This

difference between the sexes is consistent with results from previous studies in other populations (35, 36). In addition, this research indicated that the prevalence rate was highest among children in the age group 0–1 years old (1.95‰), while the rate in other groups fluctuated. There is agreement that a threshold age is generally not given for the appearance of symptoms early in life; the great majority of children with CP present with symptoms as infants or toddlers, and the diagnosis of CP is made before the age of 2 years (16). It is also important to note that the rate of spastic CP was the highest type, which was similar to the results of studies in countries other than China (37).

The prevalence of CP varied significantly in different geographical regions. The pooled prevalence of CP was highest in Southwest China, followed by Northwest China and Central China. The prevalence showed a decreasing trend from west to east of China. In addition, urban residents had a much lower prevalence of CP (2.54‰) compared with rural residents (1.9‰). Such differences might be related to unbalanced regional development, such as variability in medical conditions and economic development. In urban areas, pregnant women may be more able to attend prenatal examinations and consultations (38).

The analysis of CP according to birthweight showed, as expected, that the prevalence decreased significantly among children with a birthweight >2,500 g, which was similar to the trend seen in Japan and other European countries (34, 36, 39). Before the early 1980s, Hagberg (37) found that these very low birthweight children with CP were, in general, severely dyskinesic and frequently had additional serious impairments, such as being seriously multi-impaired (SMR), and having infantile hydrocephalus and epilepsy. Therefore, more attention should be paid to health services for low-birthweight infants and their families.

Strengths and limitations

This systematic review was performed using a complete search strategy and rigorous inclusion and exclusion criteria, which adhered to 2009 PRISMA guidelines (15). In comparison with previous reviews (14), this review included studies extracted from more databases, a larger sample size and national representativeness, and further subgroup analysis on the heterogeneity was performed. The longitudinal trend in children with CP in China over the 32-year period from 1988 to 2020 was analysed.

This review has several potential limitations. Firstly, some factors could affect the heterogeneity of included studies, including different denominators, study design, diagnostic criteria for CP, genetic background, nutrition levels, etc. Secondly, owing to the lack of a population-based registration system for CP, the nationwide prevalence of CP in China is unknown; the study covered only part of mainland China in evaluating the trend in CP. Thirdly, possible biases in selection and information, sample representativeness, specificity of diagnostic tools, and missing data in this cross-sectional survey might have resulted in underestimation of the pooled results, and, as only Chinese- and English-language literature were included, this may also have led to publication bias.

Conclusion

This study shows a trend of continuous increase in the prevalence of CP in children and adolescents over the 32-year period from 1988 to 2020 in China, especially since 2008. Multiple counter-measures should be taken to reduce the prevalence of CP in China. Pregnant women should be provided with prenatal examinations, consultations and health education to raise awareness of CP, especially in northern China and rural inland areas. Furthermore, it is essential to strengthen the health monitoring and management of infants and young children. Therefore, more research is necessary among children and adolescents with CP.

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