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SYSTEMATIC REVIEW

Prevalence and incidence of chronic conditions among adults with cerebral palsy: A systematic review and meta-analysis

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Abstract

Aim: To assess the prevalence and incidence of chronic conditions among adults with cerebral palsy (CP) and compare them to the prevalence and incidence among adults without CP.

Method: We searched MEDLINE and Embase for studies reporting the prevalence or incidence of one or more chronic conditions among adults with CP. Two independent reviewers screened titles, abstracts, and full-text articles. Two independent reviewers extracted data relating to prevalence and incidence and appraised study quality. We performed random-effects meta-analyses to pool prevalence and incidence.

Results: We identified 69 studies; 65 reported the prevalence of 53 conditions and 13 reported the incidence of 21 conditions. At least 20% of adults had the following conditions: depression (21%); anxiety (21%); mood affective disorders (23%); asthma (24%); hypertension (26%); epilepsy (28%); urinary incontinence (32%); malnutrition (38%); and scoliosis (46%). Adults with CP were more likely to have type 2 diabetes, anxiety, bipolar disorder, depression, schizophrenia, hypertension, ischaemic heart disease, stroke, cerebrovascular disease, asthma, liver disease, osteoarthritis, osteoporosis, underweight, and chronic kidney disease than adults without CP.

Interpretation: These data from 18 countries, which provide an international perspective, may be used to promote awareness, identify targets for intervention, and inform the development of appropriate supports for adults with CP.

Data from several countries indicate that most children with cerebral palsy (CP) survive well into adulthood.[1–3] Despite this, CP was historically considered a childhood condition with most research on the topic of CP focusing on children. In 2009, the importance of addressing the health needs of adults with CP was discussed in a special issue of *Developmental Medicine & Child Neurology*. At the time, authors identified that there was little research examining the risk of secondary conditions among adults with CP.[4–7] Encouragingly, as awareness and acknowledgement of the ongoing health needs of adults with CP increased, since 2009 the volume of research examining the health of adults with CP also rapidly increased.

In 2021, a review exploring the risk of neurological conditions among adults with CP identified that adults with CP experience increased risk of conditions such as stroke and myelopathy, decline in mobility, chronic fatigue, and pain.[8] A meta-analysis published in 2020 indicated that approximately 23% of adults with CP were obese, 28% had epilepsy and asthma, 21% had hypertension, and 65% had pain.[9] In 2018, a review examined the burden of cardiovascular disease, cancer, chronic respiratory disease, and diabetes

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Abbreviations: CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease.

among adults with CP.[10] Although only seven studies were identified from the search, all reported an increased risk of these conditions or an increased risk of mortality due to these conditions among adults with CP. Similarly, a review published in 2019 reported an increased prevalence of cardiovascular disease among adults with CP but identified just one study examining prevalence.[11]

These reviews are vital for summarizing the health issues experienced by adults with CP. However, many studies examining the health of adults with CP have been published even in the short time since these reviews were conducted. Furthermore, no review to date has summarized the prevalence or incidence of a wide range of chronic conditions among adults with CP, such as cancer, arthritis, asthma, and mental health conditions. Many chronic conditions are among the leading causes of mortality worldwide.[12] However, chronic conditions are not just a health issue; experiencing a chronic health condition may exacerbate the barriers adults with CP already face to participating in all areas of life including employment and social activities.[13,14] Research describing the prevalence and incidence of chronic conditions among adults with CP is essential to empower adults with knowledge to manage their CP, reduce their risk of developing chronic conditions, and advocate for support. It is also essential for increasing awareness among health professionals about adults' potential risk of chronic conditions, identifying targets for intervention, and justifying the development of health services and supports for adults with CP. However, the volume of research on this topic can make it challenging for knowledge users, such as adults with CP, health professionals, and policymakers, to identify and collate data. A review summarizing the evidence for chronic conditions among adults with CP is required to support knowledge users to translate the data into positive health impacts.

Therefore, this systematic review aimed to assess the prevalence and incidence of chronic conditions among adults with CP. We also compared the prevalence or incidence of chronic conditions between adults with and without CP.

What this paper adds

- The prevalence of several chronic physical health conditions was higher among adults with cerebral palsy (CP) than adults without CP.
- The prevalence of several chronic mental health conditions was higher among adults with CP than adults without CP.
- Adults with CP were more likely to develop several chronic physical and mental health conditions than adults without CP.
- No study reported the prevalence or incidence of 22 chronic conditions that we specified a priori.

METHOD

This review was registered in the PROSPERO database (no. CRD42021250459). The review was originally registered as a rapid review. Rapid reviews are a type of knowledge synthesis for which the steps of the systematic review are streamlined or accelerated; rapid reviews typically take 5 to 12 weeks to complete while systematic reviews typically take 12 to 24 months.[15] However, we identified a large number of reports and were thus unable to complete the review in the time frame of a rapid review; instead, we completed a systematic review. The methods were guided by the JBI guidance on systematic reviews of prevalence and incidence.[16] Results are reported using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).[17]

Changes to the review protocol

In the protocol, we stated that a single reviewer would extract data and complete quality appraisal, with a second reviewer verifying data and appraisals for all studies. We amended this for the systematic review; two reviewers independently extracted data and appraised the studies.

Literature search

An experienced information specialist developed and conducted comprehensive searches of MEDLINE and Embase to 26th January 2022 (Appendix S1). The reference lists of relevant systematic reviews were searched for additional articles.[8–11]

Eligibility criteria

Eligibility criteria were defined according to the PICOTS (Patient population, Intervention, Comparator, Outcome, Timing, Setting) framework. Studies of adults with CP of any severity and type, aged 18 years or older, were included. Studies conducted in any country and published in any language were included.

For the purpose of this review, we defined a chronic condition as one that generally lasts a year or longer and has an impact on a person's life.[18] Examples of chronic conditions include arthritis, asthma, cancer, dementia, diabetes, heart disease, mental health conditions, and stroke. We identified a preliminary list of chronic conditions to include in this review from three sources: (1) diseases in the Quality and Outcomes Framework of the UK general practice contract[19] and those reported as the most prevalent long-term conditions according to the Quality and Outcomes Framework in the Department of Health's Long Term Conditions Compendium of Information;[20] (2) a list of long-term disorders identified as important by NHS Scotland;[13] (3) a list of chronic diseases included in multimorbidity indices.[21] There was significant duplication of chronic conditions across

these sources. After removal of duplication, we identified 88 chronic conditions. The research team, which included an adult with CP, a neurologist with specialist knowledge and experience of CP, and physiotherapists and researchers with expertise in CP reviewed the 88 conditions and reduced the number of conditions. The team considered the potential magnitude of the impact of the condition on a person with CP in terms of the need for long-term treatment, reduced function, reduced quality of life, and risk of future morbidity and mortality when deciding on the final chronic conditions to include. Sixty-three chronic conditions were identified for inclusion in the review (Appendix S2). Any study reporting the prevalence or incidence of one or more of these chronic conditions among adults with CP were included regardless of whether this was the primary aim of the study.

Cross-sectional and cohort studies were included. Case–control studies, case series, case reports, qualitative studies, and intervention studies including randomized controlled trials were excluded. Since prevalence and incidence probably change over time, we included studies published during or after 2001 only to identify evidence most relevant to the current time.

Study selection process

Two independent reviewers screened titles and abstracts. Full texts were obtained for potentially eligible studies. The same reviewers independently reviewed the full texts. We used a machine translation engine (Google Translate) to translate non-English language papers into English.

Data items and data extraction

Before data extraction, reviewers piloted a data extraction form on three included studies. Two reviewers independently extracted items including study characteristics (e.g. study design, country where conducted, year[s] of data collection), participant characteristics, and outcome data. The participant characteristics extracted were: age; sex; Gross Motor Function Classification System level; intellectual disability; and socioeconomic status. Outcome data extracted were: prevalence or incidence of the condition in adults with CP; prevalence or incidence of the condition in adults without CP; and a ratio (e.g. odds ratio [OR], hazard ratio [HR]) comparing the association between CP and the condition. The exact description of the chronic condition used in the original article was extracted. Chronic conditions were categorized according to International Classification of Diseases, 11th Revision headings. Discrepancies were resolved through discussion when required.

Quality appraisal

Quality appraisal was conducted independently by two reviewers using the appropriate JBI critical appraisal tool for prevalence studies (i.e. cross-sectional studies reporting prevalence only), analytical cross-sectional studies (i.e. cross-sectional studies comparing prevalence between adults with and without CP), and cohort studies (Appendix S3). Discrepancies were resolved through discussion when required. Separate tools were used to appraise the study in relation to the data extracted for each aim of this review. For example, the tool for prevalence studies was used to appraise a study that described prevalence of a condition(s) in adults with CP. If the study also provided data on prevalence of the condition(s) in adults without CP, we also appraised the study using the tool for analytical cross-sectional studies. Since the tool for cohort studies relates to studies comparing incidence between exposed and unexposed groups, we only used this tool to appraise studies that compared incidence of a condition(s) between adults with and without CP. We used the tool for prevalence studies for all cohort studies that reported the incidence of a chronic condition(s) in adults with CP only. For all tools, we summed the number of questions that were rated as 'yes' to create a total score. The critical appraisal tool for prevalence studies produced a score between 0 and 9. We classified studies reporting prevalence or incidence as being of low, moderate, and high quality when the obtained score was between 0 and 4, between 5 and 7, and either 8 or 9 respectively. The critical appraisal tool for analytical cross-sectional studies produced a score between 0 and 7; we classified studies as being of low (between 0 and 3), moderate (4 or 5), and high (6 or 7) quality. The critical appraisal tool for cohort studies produced a score between 0 and 11; we classified studies as being of low (between 0 and 4), moderate (between 5 and 8), and high (between 9 and 11) quality.

Synthesis

We produced a descriptive summary of the studies included in the review. Unadjusted prevalence and incidence were calculated based on the data on crude numerators and denominators provided by individual studies. We reported the prevalence and incidence of each condition in tables. We reported ratios (e.g. OR, HR) describing the association between the presence of CP and each chronic condition, if provided by the original study. Where ratios were not provided, we calculated unadjusted ORs with exact 95% confidence intervals (CIs) if sufficient data were available to do so. Where available, results on non-ambulatory and ambulatory individuals, and on individuals with and without intellectual disability, were presented separately.

We performed random-effects proportional meta-analyses to pool data on the prevalence of similar conditions and pool data on the incidence of similar conditions, if data from at least three studies were available. Data were transformed using the double arcsine transformation (Freeman–Tukey transformation) to stabilize the variances. We only pooled data on a condition if it was described similarly by each study. Several conditions identified in the review may refer to the same condition, for example, myocardial infarction and ischaemic heart disease, stroke and cerebrovascular disease, or depression and

mood affective disorders. However, we counted them separately because there were sufficient differences in the terminology used to create uncertainty about the validity of combining them. Subgroup analyses were also conducted to pool prevalence in people who were ambulatory and non-ambulatory and with or without intellectual disability. We did not conduct a meta-analysis of the relative risk of each condition between adults with and without CP because ratios describing the association between the presence of CP and each condition were not reported by at least three studies for most conditions. I^2 and p-values from associated χ^2 tests are presented. However, meta-analyses of prevalence often yield high I^2 values, which do not necessarily indicate important heterogeneity.[22,23] Therefore, we also inspected prevalence and incidence estimates from individual studies to gain an understanding of the consistency of results.[22] Data analysis was conducted using Stata v15.1 (StataCorp, College Station, TX, USA).

RESULTS

Study selection is described in Figure S1. Searches of MEDLINE and Embase up to 26th January 2022 identified 17 238 records. One additional reference was identified from manual searching of reference lists of systematic reviews. After removal of duplicates, there were 10 435 records. After limiting records to those published during or later than 2001, there were 8131 records. Of these, 7887 were excluded after title and abstract screening and 243 full texts were obtained. A further 172 records were excluded after full-text screening (Appendix S4), resulting in 71 reports of 69 studies. Four reports provided data on the same conditions from the same samples; two reported data on obesity, hypercholesterolaemia, and hypertension from the same sample[24,25] and two reported data on epilepsy from the same sample.[26,27] Therefore, we did not include data from two reports.[25,27] Where two reports described identical data on several conditions, we only included data from one report.[26,28–30]

Description of the studies included in the review

Sixty-five studies reported the prevalence of chronic conditions (Table S1). Age, sex, Gross Motor Function Classification System level, and intellectual disability status of participants are described in Table S1. Data on socioeconomic status were not provided for most studies and are therefore not reported. Of these 65 studies, 34 (52%) reported data on adults with CP living in the USA. The remaining studies reported data on adults living in the Netherlands ($n = 4$), Republic of Korea ($n = 4$), Sweden ($n = 3$), UK ($n = 3$), Canada ($n = 2$), Italy ($n = 2$), Japan ($n = 2$), Turkey ($n = 2$), Australia ($n = 1$), Bosnia ($n = 1$), Brazil ($n = 1$), France ($n = 1$), Iraq ($n = 1$), Ireland ($n = 1$), Norway ($n = 1$), Spain ($n = 1$), and Taiwan ($n = 1$). Sample size ranged from 22 to 154 219, with 27 studies (41%) including at least 384 adults and thus providing an estimate of prevalence within a 5% margin of error. Twelve studies provided data on adults without CP that allowed comparison of prevalence between the total sample of adults with and without CP.

Thirteen studies reported the incidence of chronic conditions (Table 1). Of these, nine reported data on adults living in the USA, four reported data on adults living in the UK, and one reported data on adults living in Taiwan. Sample size ranged from 1703 to 16 728. Seven of the 13 studies provided data on adults without CP that allowed comparison of incidence between the total sample of adults with and without CP.

In terms of prevalence, the most frequently reported conditions were hypertension (19 studies), epilepsy (18 studies), and diabetes (15 studies). A further four studies reported the prevalence of type 2 diabetes specifically. The incidence of chronic kidney disease (CKD) was reported by three studies (Table 1). The incidences of all other conditions were only reported by at most two studies (Table 1). We did not find studies reporting the prevalence or incidence of 22 of the chronic conditions that we identified a priori (highlighted in Appendix S2). Appraisals of study quality are provided in Tables S2 to S5 and summarized for prevalence and incidence data in Tables 1 and S1. Of the 65 studies that reported prevalence, 27 were low quality, 22 were moderate quality, and 16 were high quality. Of the 13 studies that reported incidence, one was low quality, three were moderate quality, and nine were high quality. Of the 13 analytical cross-sectional studies, four were low quality, five were moderate quality, and four were high quality. All seven cohort studies were high quality.

The prevalence of each condition, categorized according to International Classification of Diseases, 11th Revision headings, is described in Tables S6 to S15. Comparison of the prevalence of each condition between adults with and without CP is reported in Table 2. The incidence of each condition, and comparison of incidence between adults with and without CP, is described in Table 3. Results from meta-analyses are included in Table S16.

Cancer

The prevalence of cancer was 6.8% (95% CI = 4.3%–9.9%; $I^2 = 99.5\%$, $p < 0.01$; $n = 4384$ out of 62 314; six studies).[28,29,31–34] The prevalence of cancer among adults with intellectual disability from one study was 4.9%.[26] The prevalence of metastatic cancer was 0.6%.[33] The cumulative incidence of cancer was 0.9% and the incidence rate was 1.03 cases per 1000 person years.[35] There was no evidence from adjusted analyses that the prevalence or incidence of cancer was higher in adults with CP than in adults without CP.[35]

Diseases of the blood

The prevalence of blood loss and deficiency anaemias reported by two studies was 12.7%[28] and 16.9%.[33] The prevalence of blood loss and deficiency anaemias among adults with intellectual disability was 14.7%.[26]

TABLE 1 Description of studies reporting the incidence of conditions among adults with cerebral palsy.

Study	Years completed	Country	*n*[a]	Age, years[a]	Female, %	GMFCS	Intellectual disability, %	Disorder or disease	Quality appraisal[b]	Comparison to adults without CP
Etter et al.[31]	2011–2016	USA	9776	NR	48	NR	NR	COPD, interstitial lung disease	8/9	No
McDermott et al.[65]	1990–2003	USA	NR	NR	53	NR	87	Depression	4/9	Yes
O'Connell et al.[90]	1987–2015	UK	1705	Median = 29; IQR = 20–42	47	NR	NR	Osteoarthritis, osteoporosis, inflammatory musculoskeletal diseases	8/9	Yes
Peterson et al.[51]	2002–2009	USA	2659	NR	48	NR	NR	Diabetes, cardiac dysrhythmias, hypercholesterolaemia, hypertension	7/9	No
Ryan et al.[35]	1987–2015	UK	1705	Median = 29; IQR = 20–42	47	NR	NR	Hypertension, ischaemic heart disease, cerebrovascular disease, asthma, COPD, cancer, type 2 diabetes, heart failure	8/9	Yes
Smith et al.[41]	1987–2015	UK	1705	Mean = 33; SD = 16	47	NR	21	Anxiety, depression	8/9	Yes
Smith et al.[40]	1987–2015	UK	1703	Mean = 33; SD = 16	47	NR	NR	Dementia	8/9	Yes
Whitney et al.[49]	2013–2017	USA	9238	NR	50	NR	11	CKD	8/9	No
Whitney et al.[70]	2013–2016	USA	5029	NR	46	NR	20	Mood affective disorders	8/9	No
Whitney et al.[32]	2011–2016	USA	9357	NR	49	NR	NR	Cerebrovascular disease, ischaemic heart disease	8/9	No
Whitney et al.[39]	2013–2017	USA	7675	Mean = 49; SD = 20	50	NR	20	CKD	7/9	No
Whitney et al.[83]	2013–2017	USA	7291	NR	NR	NR	NR	CKD	7/9	Yes
Wu et al.[45]	2004–2008	Taiwan	1975	NR	54	NR	NR	Stroke	8/9	Yes

Abbreviations: CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CP, cerebral palsy; GMFCS, Gross Motor Function Classification System; IQR, interquartile range; NR, not recorded.

[a]At the start of follow-up.

[b]Incidence data assessed using a checklist for prevalence studies; the number indicates the number of items assessed as 'yes'.

Diseases of the skin

The prevalence of pressure ulcers reported by two studies was 7.8% and 9.2%.[36,37] The prevalence of pressure ulcers was 1.8% among ambulatory individuals and 27.9% among non-ambulatory individuals with CP.[33] The prevalence of pressure ulcers was 35.3% among people with intellectual disability and 1.7% among people without intellectual disability.[33]

Endocrine diseases

Prevalence of diabetes (type not specified) was 9.6% (95% CI = 6.9%–12.6%; I^2 = 99.3%, p < 0.01; n = 11 723 out of 71 815; 15 studies).[28,31-34,37–46] Age-adjusted prevalence of diabetes reported in one study was 9.2%.[47] The prevalence of diabetes among non-ambulatory individuals with CP in two studies was 7.0% and 8.6%.[37,46] The prevalence of diabetes among ambulatory individuals with CP in two studies was 8.2% and 13.1%.[37,46] The prevalence of type 2 diabetes was 14.8% (95% CI = 12.6%–17.1%; I^2 = 97.4%, p < 0.01; n = 6151 out of 39 598; four studies).[28,30,48,49] The prevalence of type 2 diabetes was 16.4% and prevalence of diabetes was 2.9% among adults with intellectual disability.[26,37] The prevalence of diabetes among people without intellectual disability was 9.2%.[37] The prevalence of hypothyroidism was 15.5% (95% CI = 10.3%–21.5%; I^2 = 98.0%, p < 0.01; n = 3914 out of 20 049; three studies).[28,33,44] The prevalence of hypothyroidism was 26.7% among people with intellectual disability.[26] The prevalence of hyperthyroidism was 0.9%.[44] The prevalence of thyroid dysfunction was 7.8% in adults with intellectual disability.[50]

The cumulative incidence of diabetes was 11.6%.[51] The cumulative incidence of type 2 diabetes was 2.8%.[35] The incidence rate of type 2 diabetes was 3.26 cases per 1000 person years.[35]

There was evidence from adjusted analysis that prevalence of type 2 diabetes, but not of diabetes type not specified, was higher in adults with CP than in adults without CP.[29,47] There was also no evidence that the incidence of type 2 diabetes was higher in adults with CP than in adults without CP.[35]

Nutritional disorders

The prevalence of obesity was 18.6% (95% CI = 13.2%–24.7%; I^2 = 93.3%, p < 0.01; n = 607 out of 3640; 15 studies).[24,35,37,43,44,46,52–60] The prevalence of obesity was 14.1% (95% CI = 9.3%–19.6%; I^2 = 41.5%, p < 0.01; n = 66 out of 398; six studies) among non-ambulatory people with CP and 19.6% (95% CI = 10.8%–30.1%; I^2 = 81.5%, p < 0.01; n = 117 out of 464; six studies) among ambulatory people with CP.[24,37,46,54,55,59] The prevalence of obesity among adults with intellectual disability was 17.6% and 23.5%, and 21.8% among adults without intellectual disability.[37,60]

The prevalence of underweight was 16.5% (95% CI = 8.9%–25.9%; I^2 = 96.6%, p < 0.01; n = 442 out of 3180; 11 studies).[35,37,43,52,53,56,58,61,62] The prevalence of underweight was 22.9% (95% CI = 11.1%–37.1%; I^2 = 67.9%, p < 0.01; n = 30 out of 128; three studies) among non-ambulatory adults[37,58,59] and 1.0% and 2.9% among ambulatory adults.[37,58] The prevalence of underweight was 11.8% and 17.6% among adults with intellectual disability and 0% among adults without intellectual disability.[37,60] The prevalence of malnutrition was 38.3% (95% CI = 7.6%–75.5%; I^2 = 99.5%, p < 0.01; n = 21 294 out of 15 4625; three studies).[59,61,63] The prevalence of malnutrition was 48.8% among non-ambulatory adults.[59]

There was no evidence that the prevalence of obesity was higher in adults with CP than in adults without CP.[35,43] The prevalence of underweight was higher among adults with CP compared to adults without CP.[35,43]

Mental, behavioural, or neurodevelopmental disorders

The prevalence of anxiety or anxiety disorders was 20.7% (95% CI = 17.8%–23.9%; I^2 = 97.5%, p < 0.01; n = 9836 out of 39 672; six studies).[29,33,34,37,44,64] The prevalence of anxiety was 0% among non-ambulatory people and 16.4% among ambulatory people with CP.[37] The prevalence of anxiety reported by two studies was 5.9% and 23.0% among adults with intellectual disability and 13.4% and 26.8% among adults without intellectual disability.[37,64] The prevalence of dementia was 3.8% (95% CI = 2.0%–6.1%; I^2 = 99.0%, p < 0.01; n = 1677 out of 37 135; four studies).[28,33,48,49] The prevalence of dementia among adults with intellectual disability was 16.0%.[26] The prevalence of depression was 20.7% (95% CI = 12.1%–30.8%; I^2 = 99.7%, p < 0.01; n = 6615 out of 36 366; 10 studies).[28,33,37,40,44,57,64–67] The prevalence of depression was 37.2% among non-ambulatory people and 22.7% among ambulatory people with CP.[37] The prevalence of depression among adults with intellectual disability was 24.9% (95% CI = 0%–70.7%; I^2 = 99.9%, p < 0.01; n = 3817 out of 11 380; three studies).[26,37,64] The prevalence of depression among people without intellectual disability was 11.8% (95% CI = 2.7%–25.6%; I^2 = 95.3%, p < 0.01; n = 640 out of 9608; three studies).[37,64,68] The prevalence of mood affective disorders was 22.9% (95% CI = 18.0%–28.1%; I^2 = 99.5%, p < 0.01; n = 13 840 out of 56 570; five studies).[29,34,48,49,69]

The prevalence of bipolar disorder was 2.3% in all adults with CP, 2.7% in adults with intellectual disability, and 2.1% in adults without intellectual disability.[64] The prevalence of alcohol misuse was 1.3%,[44] substance use was 2.8%,[64] substance abuse disorders was between 3.0% and 10.7%,[34,48,49] and alcohol or drug abuse was 2.0%.[33] The prevalence of substance use was 1.6% among adults with intellectual disability and 3.4% among adults without intellectual disability.[64] The prevalence of schizophrenia or other psychotic disorders was 3.5%,[44] psychotic disorders was 3.2%,[64] psychoses was 16.1%,[33] and schizophrenia was 2.4%.[64] The prevalence of psychotic disorders was 5.4% among adults with intellectual

TABLE 2 Prevalence in adults with cerebral palsy compared to prevalence in adults without cerebral palsy.

Condition	Study	%	Comparison to adults without CP,[a] (95% CI)
Cancer			
Cancer	Etter et al.[31]	12.4	Unadjusted OR = 1.08 (1.01–1.14)
Malignant cancer	Whitney et al.[29]	4.0	OR = 1.10 (0.96–1.27)
Endocrine diseases			
Diabetes	Smith et al.[40]	3.5	Unadjusted OR = 0.70 (0.52–0.94)
Diabetes	Etter et al.[31]	15.1	Unadjusted OR = 1.33 (1.27–1.40)
Diabetes	Smith et al.[41]	3.2	Unadjusted OR = 0.75 (0.54–1.02)
Diabetes	Whitney et al.[43]	2.2	Unadjusted OR = 1.67 (0.54–5.63)
Diabetes mellitus	Wu et al.[45]	6.4	Unadjusted OR = 1.22 (0.97–1.49)
Diabetes	Peterson et al.[47]	9.2[b]	OR = 1.18 (0.92–1.51)
Type 2 diabetes	Whitney et al.[29]	12.4	OR = 1.28 (1.15–1.37)
Nutritional disorders			
Obesity	Whitney et al.[43]	16.4	Unadjusted OR = 1.04 (0.72–1.51)
Obesity	Ryan et al.[35]	9.6	Unadjusted OR = 0.82 (0.68–0.99)
Underweight	Whitney et al.[43]	24.3	Unadjusted OR = 143.8 (24.9–5741.1)
Underweight	Ryan et al.[35]	6.4	Unadjusted OR = 4.59 (3.37–6.28)
Mental, behavioural, or neurodevelopmental disorders			
Anxiety	McMorris et al.[64]	25.5	PR = 1.33 (1.29–1.36)
Anxiety disorders	Whitney et al.[29]	23.7	OR = 1.82 (1.68–1.91)
Bipolar disorder	McMorris et al.[64]	2.3	PR = 2.03 (1.83–2.26)
Depression	McMorris et la.[64]	6.1	PR = 1.65 (1.54–1.76)
Depression	Smith et al.[40]	18.2	Unadjusted OR = 1.09 (0.95–1.26)
Mood affective disorders	Whitney et al.[29]	23.4	OR = 2.19 (2.07–2.28)
Substance use	McMorris et al.[64]	2.8	PR = 0.76 (0.69–0.84)
Psychotic disorders	McMorris et al.[64]	3.2	Unadjusted PR = 3.63 (3.31–3.97)
Schizophrenia	McMorris et al.[64]	2.4	PR = 3.44 (3.10–3.83)
Mental, behavioural, or neurodevelopmental disorders: intellectual disability			
Anxiety	McMorris et al.[64]	23.0	PR = 1.21 (1.15–1.28)
Depression	McDermott et al.[65]	12.3	OR = 0.40 (0.24–0.65)
Depression	McMorris et al.[64]	5.5	PR = 1.51 (1.34–1.70)
Psychotic disorders	McMorris et al.[64]	5.4	PR = 6.26 (5.55–7.05)
Schizophrenia	McMorris et al.[64]	4.4	PR = 6.46 (5.65–7.38)
Bipolar disorder	McMorris et al.[64]	2.7	PR = 2.44 (2.06–2.89)
Substance use	McMorris et al.[64]	1.6	PR = 0.44 (0.36–0.55)
Mental, behavioural, or neurodevelopmental disorders: no intellectual disability			
Anxiety	McMorris et al.[64]	26.8	PR = 1.38 (1.34–1.43)
Depression	McMorris et al.[64]	6.4	PR = 1.72 (1.59–1.86)
Psychotic disorders	McMorris et al.[64]	2.0	PR = 2.22 (1.93–2.56)
Schizophrenia	McMorris et al.[64]	1.4	PR = 1.98 (1.67–2.35)
Bipolar disorder	McMorris et al.[64]	2.1	PR = 1.83 (1.60–2.10)
Substance use	McMorris et al.[64]	3.4	PR = 0.92 (0.83–1.03)
Diseases of the nervous system			
Epilepsy	Smith et al.[41]	20.8	Unadjusted OR = 27.1 (19.9–37.5)
Epilepsy	Smith et al.[40]	25.1	Unadjusted OR = 24.1 (18.5–31.7)
Epilepsy	Whitney et al.[78]	24.3	Unadjusted OR = 28.9 (27.4–30.5)

(Continues)

TABLE 2 (Continued)

Condition	Study	%	Comparison to adults without CP,[a] (95% CI)
Diseases of the circulatory system			
Hyperlipidaemia	Whitney et al.[43]	3.1	Unadjusted OR = 2.83 (0.95–10.12)
Hyperlipidaemia	Wu et al.[45]	6.1	Unadjusted OR = 1.02 (0.82–1.25)
Hypertension	Etter et al.[31]	38.8	Unadjusted OR = 1.58 (1.51–1.64)
Hypertension	Peterson et al.[47]	30.0[b]	OR = 1.32 (1.04–1.67)
Hypertension	Wu et al.[45]	11.4	Unadjusted OR = 0.97 (0.83–1.13)
Hypertension	Whitney et al.[43]	11.7	Unadjusted OR = 4.12 (2.21–8.15)
Coronary heart disease	Wu et al.[45]	4.3	Unadjusted OR = 1.11 (0.86–1.41)
Ischaemic heart disease	Whitney et al.[29]	5	OR = 1.38 (1.22–1.57)
Myocardial infarction	Whitney et al.[43]	2.0	–[c]
Coronary artery disease	Whitney et al.[43]	0.2	–[c]
Stroke	Peterson et al.[47]	4.6[b]	OR = 1.59 (1.18–2.15)
Stroke	Smith et al.[40]	4.1	Unadjusted OR = 2.14 (1.54–2.95)
Stroke	Whitney et al.[43]	0	–[c]
Cerebrovascular disease	Whitney et al.[29]	6.8	OR = 4.74 (4.24–5.27)
Diseases of the respiratory system			
Asthma	Peterson et al.[47]	20.7[b]	OR = 1.65 (1.31–2.07)
Asthma	Whitney et al.[43]	27.0	Unadjusted OR = 1.36 (0.99–1.87)
Emphysema	Whitney et al.[43]	1.0	–[c]
Diseases of the digestive system			
Chronic liver disease	Wu et al.[45]	5.8	Unadjusted OR = 1.18 (0.95–1.47)
Liver disease	Whitney et al.[29]	4.1	OR = 1.41 (1.23–1.62)
Diseases of the musculoskeletal system			
Osteoarthritis	Whitney et al.[43]	5.3	Unadjusted OR = 1.34 (0.69–2.66)
Osteoarthritis	Whitney et al.[29]	14.9	OR = 2.32 (2.14–2.50)
Any osteoarthritis	French et al.[83]	20.3	OR = 1.88 (99.5% CI = 1.68–2.11)
Arthritis	Peterson et al.[47]	31.4[b]	OR = 1.71 (1.38–2.11)
Osteoporosis	French et al.[85]	12.8	Unadjusted OR = 30.5 (29.4–31.6)
Osteoporosis	Whitney et al.[29]	5.5	OR = 5.76 (5.06–6.53)
Rheumatoid arthritis	Whitney et al.[43]	4.0	Unadjusted OR = 2.28 (0.93–6.12)
Diseases of the genitourinary system			
Chronic kidney disease	Etter et al.[31]	3.5	Unadjusted OR = 1.31 (1.18–1.45)
Chronic kidney disease	Whitney et al.[29]	4.3	OR = 2.37 (2.07–2.71)

Abbreviations: CI, confidence interval; CP, cerebral palsy; OR, odds ratio; PR, prevalence ratio.

[a]Adjusted association unless stated otherwise.

[b]Age-adjusted prevalence.

[c]Prevalence 0% in adults without cerebral palsy.

disability and 2.0% among adults without intellectual disability.[64] The prevalence of schizophrenia among adults with intellectual disability was 4.4% and 1.4% among adults without intellectual disability.[64]

The cumulative incidence of anxiety was 15.3%.[41] The incidence rate of anxiety was 20.19 cases per 1000 person years.[41] The cumulative incidence of dementia was 1.1%.[40] The incidence rate of dementia was 1.30 per 1000 person years.[40] The cumulative incidence of depression was 15.3%[65] and 18.3%.[41] The incidence rate of depression was 24.68 cases per 1000 person years.[41] The cumulative incidence of mood affective disorders was 7.7%.[70] The incidence rate of mood affective disorders was 75.95 cases per 1000 person years.[70]

There was evidence from adjusted analyses that the prevalence of anxiety, bipolar disorder, depression, mood affective disorders, psychotic disorders, and schizophrenia was higher in adults with CP than in adults without CP.[29,64] Similarly, in adjusted analyses, adults with CP and intellectual disability and adults with CP without intellectual disability had a higher prevalence of anxiety, psychotic

TABLE 3 Incidence of chronic conditions among adults with cerebral palsy and comparison to adults without cerebral palsy.

Condition	Study	Study period	n[a]	Total person years	n	%[b]	Rate per 1000 person years	Comparison to adults without CP,[c] (95% CI)
Cancer	Ryan et al.[35]	1987–2015	1705	14 500	15	0.9	1.03	HR = 1.35 (0.71–2.56)
Diabetes	Peterson et al.[51]	2002–2009	2659	NR	308	11.6	–	NR
Type 2 diabetes	Ryan et al.[35]	1987–2015	1705	14 400	47	2.8	3.26	HR = 1.06 (0.71–1.59)
Anxiety	Smith et al.[41]	1987–2015	1705	12 930	261	15.3	20.19	HR = 1.38 (1.15–1.64)
Dementia	Smith et al.[40]	1987–2015	1703	14 570	19	1.1	1.30	HR = 1.76 (0.73–4.25)
Depression	McDermott et al.[65]	1990–2003	177	NR	27	15.3	–	NR
Depression	Smith et al.[41]	1987–2015	1705	12 640	312	18.3	24.68	HR = 1.28 (1.09–1.51)
Mood affective disorders	Whitney et al.[70]	2013–2016	5029	5122	389	7.7	75.95	NR
Cardiac dysrhythmias	Peterson et al.[51]	2002–2009	2659	NR	351	13.2	–	NR
Heart failure	Ryan et al.[35]	1987–2015	1705	14 500	30	1.8	2.07	HR = 2.62 (1.51–4.52)
Heart failure	Whitney et al.[32]	2011–2016	9357	16 105	351	3.8	21.8	NR
Hypercholesterolaemia	Peterson et al.[51]	2002–2009	2659	NR	915	34.4	–	NR
Hypertension	Peterson et al.[51]	2002–2009	2659	NR	768	28.9	–	NR
Hypertension	Ryan et al.[35]	1987–2015	1705	13 400	187	11.0	13.98	HR = 1.64 (1.34–2.01)
Ischaemic heart disease	Ryan et al.[35]	1987–2015	1705	14 400	35	2.1	2.43	HR = 2.32 (1.45–3.71)
Ischaemic heart disease	Whitney et al.[32]	2011–2016	9357	15 951	468	5.0	29.34	NR
Stroke	Wu et al.[45]	2004–2008	1975	6750	111	5.6	16.4	HR = 2.17 (1.74–2.69)
Cerebrovascular disease	Ryan et al.[35]	1987–2015	1705	14 500	36	2.1	2.48	HR = 5.53 (3.04–10.06)
Cerebrovascular disease	Whitney et al.[32]	2011–2016	9357	15 956	476	5.1	29.83	NR
Asthma	Ryan et al.[35]	1987–2015	1705	13 300	197	11.6	14.8	HR = 2.24 (1.82–2.76)
COPD	Etter et al.[31]	2011–2016	9776	16 359	742	7.6	45.36	NR
COPD	Ryan et al.[35]	1987–2015	1705	14 300	38	2.2	2.65	HR = 1.34 (0.89–2.02)
Interstitial lung disease	Etter et al.[31]	2011–2016	10 813	18 547	508	4.7	27.39	NR
Osteoarthritis	O'Connell et al.[90]	1987–2015	1705	13 900	104	6.1	7.48	HR = 1.54 (1.17–2.02)
Inflammatory musculoskeletal diseases	O'Connell et al.[90]	1987–2015	1705	14 500	13	0.8	0.90	HR = 0.89 (0.45–1.75)
Osteoporosis	O'Connell et al.[90]	1987–2015	1705	14 400	41	2.4	2.85	HR = 6.19 (3.37–11.39)
Chronic kidney disease	Whitney et al.[49]	2013–2017	9238	NR	272	2.9	–	NR
Chronic kidney disease	Whitney et al.[39]	2013–2017	7675	23 327	237	3.1	10.16	NR
Chronic kidney disease	Whitney et al.[94]	2013–2017	7291	21 137	241	3.3	11.40	IRR = 2.04 (1.79–2.31)

Abbreviations: CI, confidence interval; COPD, chronic obstructive pulmonary disease; CP, cerebral palsy; HR, hazard ratio; IRR, incidence rate ratio; NR, not recorded.

[a]At risk at the start of follow-up.

[b]Calculated as $n/N \times 100$.

[c]Adjusted association unless stated otherwise.

disorders, schizophrenia, and bipolar disorder compared to adults without CP.[64] Among adults with intellectual disability, there was mixed evidence regarding depression; one study found that prevalence was higher among adults with CP and intellectual disability than in those without CP while another found that it was lower.[64,65] There was evidence that the prevalence of depression was higher among adults with CP without intellectual disability than in adults without CP.[64] There was evidence that the prevalence of substance use was lower in adults with CP with intellectual disability and lower in adults with CP without intellectual disability than in adults without CP.[64]

There was evidence from adjusted analyses that the incidence of anxiety and depression was higher in adults with CP than in adults without CP.[41] There was no evidence that the incidence of dementia was higher in adults with CP.[40]

Diseases of the nervous system

The prevalence of epilepsy was 27.8% (95% CI = 23.1%–32.6%; I^2 = 99.3%, $p < 0.01$; n = 24 486 out of 72 943; 18 studies).[28,33,34,37,40-42,44,49,69,71–78] The prevalence of epilepsy among ambulatory adults was 30.0%; among non-ambulatory adults, it was 25.6%.[37,79] The prevalence of epilepsy among adults without intellectual disability was 21.8% and 33.0%; among adults with intellectual disability, it was 52.9%.[37,79] The prevalence of migraine was 16.2%.[44]

There was evidence from unadjusted analyses that the prevalence of epilepsy was higher among adults with CP than among adults without CP.[40,41,78]

Diseases of the circulatory system

The prevalence of heart failure was 6.0% (95% CI = 4.1%–8.2%; I^2 = 98.5%, $p < 0.01$; n = 2439 out of 37 135; four studies).[28,33,48,49] The prevalence of hypercholesterolaemia among all adults with CP was 14.5% (95% CI = 7.9%–22.7%; I^2 = 95.3%, $p < 0.01$; n = 294 out of 3208; eight studies).[24,43-46,54,56,59] The prevalence of hypercholesterolaemia was 20.8% (95% CI = 10.9%–32.7%; I^2 = 61.8%, p = 0.05; n = 49 out of 249; four studies)[24,46,54,59] among non-ambulatory adults and 26.0% (95% CI = 16.2%–37.1%; I^2 = 39.6%, p = 014; n = 49 out of 260; three studies)[24,46,54] among ambulatory adults. The prevalence of hypertension among all adults with CP was 25.9% (95% CI = 22.2%–29.8%; I^2 = 99.0%, $p < 0.01$; n = 25 941 out of 69 157; 19 studies).[24,28,31–33,37–39,42–45,47–49,54,56,57,59] The prevalence of hypertension among non-ambulatory adults was 15.1% (95% CI = 6.1%–26.7%; I^2 = 56.7%, p = 0.07; n = 19 out of 126; four studies).[24,37,54,59] The prevalence of hypertension among ambulatory adults was 10.0% (95% CI = 3.1%–19.6%; I^2 = 70.8%, $p < 0.01$; n = 31 out of 235; three studies).[24,37,80] The prevalence of hypertension among adults with intellectual disability was 5.9% and 40.0%; among adults without intellectual disability, it was 21.0%.[26,37] The prevalence of ischaemic heart disease was 5.7% (95% CI = 4.5%–7.1%; I^2 = 96.6%, $p < 0.01$; n = 2436 out of 41 333; five studies).[30,34,45,48,49] The prevalence of myocardial infarction was 2.4% (95% CI = 1.8%–3.1%; I^2 = 33.0%, p = 0.22; n = 408 out of 17 560; three studies).[28,43,46] The prevalence of myocardial infarction was 4.0% among non-ambulatory adults and 3.4% among ambulatory adults.[46] The prevalence of myocardial infarction among adults with intellectual disability was 1.6%.[26] The prevalence of stroke was between 0% and 4.1%.[40,43,46] The age-adjusted prevalence of stroke was 4.6%.[47] The prevalence of stroke was 2.3% among non-ambulatory adults and 4.9% among ambulatory adults.[46] The prevalence of cerebrovascular disease was 7.9% (95% CI = 6.5%–9.4%; I^2 = 97.6%, $p < 0.01$; n = 4629 out of 59 178; six studies).[28,30,33,34,48,49] The prevalence of cerebrovascular disease among adults with intellectual disability was 9.5%.[26] The prevalence of cardiac arrhythmias was 14.6% and 18.5%.[26,33] The prevalence of cardiac arrhythmias among adults with intellectual disability was 21.8%.[26] The prevalence of coronary artery disease was 0.2%[43] and 2.1%.[46] The prevalence of coronary artery disease was 1.1% among non-ambulatory adults and 2.9% among ambulatory adults.[46]

The cumulative incidence of cardiac arrhythmias was 13.2%.[51] The cumulative incidence of heart failure was 1.8%[35] and 3.8%.[32] The incidence rate of heart failure was 2.07 cases per 1000 person years[35] and 21.8 cases per 1000 person years.[32] The cumulative incidence of hypercholesterolaemia was 34.4%.[51] The cumulative incidence of hypertension was 28.9%[51] and 11.0%.[35] The incidence rate of hypertension was 13.98 cases per 1000 person years.[35] The cumulative incidence of ischaemic heart disease was 2.1%[35] and 5%.[32] The incidence rate of ischaemic heart disease was 2.43 cases per 1000 person years[35] and 29.34 cases per 1000 person years.[32] The cumulative incidence of stroke was 5.6%.[45] The incidence rate of stroke was 16.4 cases per 1000 person years.[45] The cumulative incidence of cerebrovascular disease was 2.1%[35] and 5.1%.[32] The incidence rate of cerebrovascular disease was 2.48 cases per 1000 person years[35] and 29.83 cases per 1000 person years.[32]

There was evidence from the adjusted analyses that the prevalence of hypertension, ischaemic heart disease, stroke, and cerebrovascular disease was higher in adults with CP than in adults without CP.[29,47] There was also evidence from the adjusted analyses that the incidences of heart failure, hypertension, ischaemic heart disease, stroke, and cerebrovascular disease were higher in adults with CP than in adults without CP.[35,45]

Diseases of the respiratory system

The prevalence of asthma was 24.0% (95% CI = 11.1%–39.9%; I^2 = 97.1%, $p < 0.01$; n = 323 out of 1214; four studies).[37,43,44,46] The age-adjusted prevalence of asthma was 20.7%.[47] Two studies reported that the prevalence of asthma was 4.7% and 20.7% among non-ambulatory adults and 6.4% and 21.8% among ambulatory adults.[37,46] The prevalence of asthma was 2.9% among adults with intellectual disability and 6.7% among adults without intellectual disability.[37] The prevalence of chronic obstructive pulmonary disease (COPD) was 11.4% (95% CI = 8.5%–14.7%; I^2 = 99.3%, $p < 0.01$; n = 7723 out of 64 946; seven studies).[28,31,33,34,44,48,49] The prevalence of COPD among adults with intellectual disability was 13.7%.[26] The prevalence of emphysema was 1.0%[43] and 2.6%.[46] The prevalence of emphysema was 3.4% among non-ambulatory adults and 1.9% among ambulatory adults.[46] The prevalence of interstitial lung disease was 2.5%.[31]

The cumulative incidence of asthma was 11.6.[35] The incidence rate of asthma was 14.8 cases per 1000 person years.[35] The cumulative incidence of COPD was 2.2%[35] and 7.6%.[31] The incidence rate of COPD was 2.65 per 1000 person years[35] and 45.36 per 1000 person years.[31] The cumulative incidence of interstitial lung disease was 4.7% and the incidence rate was 27.39 cases per 1000 person years.[31]

There was evidence from the adjusted analyses that the prevalence and incidence of asthma were higher in adults with CP than in adults without CP.[35,47] There was no evidence from the adjusted analyses that the incidence of COPD was higher in adults with CP than in adults without CP.[35]

Diseases of the digestive system

The prevalence of gastroesophageal reflux disease was 16.0% (95% CI = 1.5%–40.0%; I^2 = 96.8%, $p < 0.01$; n = 118

out of 495; four studies).[42,44,50,75] The prevalence of gastroesophageal reflux disease among adults with intellectual disability was 3.3%.[50] The prevalence of liver disease was 4.7% (95% CI = 4.1%–5.4%; I^2 = 90.3%, $p < 0.01$; n = 2608 out of 53 166; seven studies).[28,29,33,34,45,49,50] The prevalence of liver disease among adults with intellectual disability was 1.1% and 4.9%.[26,50] The prevalence of constipation was 16.9% (95% CI = 11.3%–23.3%; I^2 = 98.4%, $p < 0.01$; n = 1516 out of 17 819; six studies).[37,44,48,49,52,71] The prevalence of constipation among ambulatory adults was 12.7%; among non-ambulatory adults, it was 58.1%.[37] The prevalence of constipation among adults with intellectual disability was 67.6%; among adults without intellectual disability, it was 13.4%.[37] The prevalence of bowel/fecal incontinence was 14.6% (95% CI = 4.8%–28.1%; I^2 = 77.0%, p = 0.01; n = 32 out of 176; three studies).[52,71,81] The prevalence of inflammatory bowel disease was 0.4%[49] and 0.5%.[48] The prevalence of irritable bowel syndrome was 0.7%[49] and 1.3%.[48]

There was evidence from the adjusted analysis that the prevalence of liver disease was higher in adults with CP than in adults without CP.[29]

Diseases of the musculoskeletal system

The prevalence of osteoarthritis was 15.7% (95% CI = 12.6%–19.1%; I^2 = 98.6%, $p < 0.01$; n = 8076 out of 49 309; n = 11 studies).[28,29,36,43,46,48,49,75,82–84] The prevalence of osteoarthritis was 26.4% among non-ambulatory adults and 32.5% among ambulatory adults.[46] The prevalence of osteoporosis was 10.3% (95% CI = 6.7%–14.6%; I^2 = 99.4%, $p < 0.01$; n = 5217 out of 53 836; seven studies).[29,44,48,49,82,85,86] The prevalence of rheumatoid arthritis was 1.9% (95% CI = 1.3%–2.8%; I^2 = 89.3%, $p < 0.01$; n = 279 out of 19 542; five studies).[43,46,48,49,82] The prevalence of rheumatoid arthritis was 4.0% among non-ambulatory adults and 2.9% among ambulatory adults.[46] The prevalence of scoliosis was 46.3% (95% CI = 10.1%–84.9%; I^2 = 97.3%, $p < 0.01$; n = 159 out of 906; three studies).[75,81,87]

The prevalence of osteoarthritis and allied disorders was 16.0% and 19.6% among all adults and 15.9% among adults with intellectual disability.[26,33] The prevalence and age-adjusted prevalence of arthritis (type not specified) were 10.4% and 31.4% respectively.[39,47] The prevalence of rheumatoid arthritis and other polyarthropathies was 1.6% among all adults and 1.5% among adults with intellectual disability.[26,28] The prevalence of spondylosis was 29.5%[88] and the prevalence of spondylopathies was 61.5%.[57] The prevalence of chronic low back pain among adults without intellectual disability was 47.0%.[89]

The cumulative incidence of osteoarthritis was 6.1% and the incidence rate was 7.48 cases per 1000 person years.[90] The cumulative incidence of inflammatory musculoskeletal diseases was 0.8% and the incidence rate was 0.90 cases per 1000 person years.[90] The cumulative incidence of osteoporosis was 2.4% and the incidence rate was 2.85 cases per 1000 person years.[90]

There was evidence from the adjusted analyses that the prevalence of osteoarthritis, arthritis type not specified, and osteoporosis was higher in adults with CP than in adults without CP.[29,47,83] There was also evidence from the adjusted analyses that the incidence of osteoarthritis and osteoporosis, but not inflammatory musculoskeletal diseases, was higher in adults with CP than in adults without CP.[90]

Diseases of the genitourinary system

The prevalence of CKD was 5.3% (95% CI = 3.9%–6.8%; I^2 = 98.7%, $p < 0.01$; n = 4025 out of 85 071; 10 studies).[29,31,32,34,38,39,44,48,49,91] The prevalence of renal disease was 0.5% to 7.1%.[28,33,45] The prevalence of renal disease among adults with intellectual disability was 0% and 6.2%.[24,26,50] The prevalence of urinary/bladder incontinence was 32.4% (95% CI = 17.8%–48.9%; I^2 = 92.4%, $p < 0.01$; n = 211 out of 522; five studies).[44,71,81,92,93] The cumulative incidence of CKD was 3.1% (95% CI = 2.9%–3.3%; I^2 = 0%, p = 0.42; n = 750 out of 24 204; three studies).[39,49,94] The incidence rate was 10.16 cases per 1000 person years[39] and 11.40 cases per 1000 person years.[94]

There was evidence from the adjusted analyses that the prevalence and incidence of CKD were higher in adults with CP than in adults without CP.[29,94]

DISCUSSION

We identified the prevalence and incidence of a wide range of chronic conditions among adults with CP. Data came from 69 studies conducted in 18 countries; thus, the findings provide an international perspective. Hypertension, epilepsy, and diabetes were the most frequently examined conditions. Approximately 28% of adults had epilepsy, 26% had hypertension, and 9% had diabetes. There was consistent evidence that adults with CP were more likely than adults without CP to have and develop several physical and mental health conditions. In summary, the prevalence of type 2 diabetes, anxiety, bipolar disorder, depression, schizophrenia, hypertension, ischaemic heart disease, stroke, cerebrovascular disease, asthma, liver disease, osteoarthritis, osteoporosis, CKF, and underweight was higher among adults with CP than among adults without CP after adjustment for potential confounding factors. Adults with CP were also more likely to develop anxiety, depression, heart failure, hypertension, ischaemic heart disease, cerebrovascular disease, asthma, COPD, osteoarthritis, osteoporosis, and CKD than adults without CP.

Sixty-five studies examined the prevalence of 53 conditions. The most prevalent conditions were scoliosis (46%), malnutrition (38%), and urinary incontinence (32%). However, these estimates should be interpreted with caution. The CIs associated with the estimates were very wide indicating that the pooled estimate of prevalence is imprecise. Many other conditions were experienced by at least

20% of adults including anxiety (21%), depression (21%), mood affective disorders (23%), epilepsy (28%), hypertension (26%), and asthma (24%). The prevalence of epilepsy, diabetes, hypertension, asthma, and osteoarthritis in this review was similar to that reported in a review conducted in 2018.[9] However, we included more studies in meta-analyses for most conditions and thus this review provides more current estimates of prevalence. This highlights how quickly the literature in this area is growing.

Only 12 studies compared prevalence between adults with and without CP; comparisons were reported for 25 chronic conditions. The prevalence of 18 of these conditions was higher among adults with CP. Seven studies compared the incidence of chronic conditions between adults with and without CP. Studies that compared incidence were generally appraised as being of high quality and all included at least 1700 adults with CP. The incidence of 11 conditions, out of the 15 conditions that were examined, was higher among adults with CP after adjusting for potential confounding factors.

This review provides evidence that adults with CP have higher risk of chronic conditions than adults without CP. However, the findings do not provide any indication of why they have an increased risk and future research is needed to explore this. Few studies explored prevalence or incidence in subgroups of adults with CP, such as ambulatory and non-ambulatory adults. Where data were provided, there were clear differences in the prevalence of some conditions between ambulatory and non-ambulatory adults. Specifically, the prevalence of pressure ulcers, underweight, malnutrition, and constipation was higher among non-ambulatory adults than among ambulatory adults. The prevalence of epilepsy was also considerably higher in adults with intellectual disability than in adults without intellectual disability. However, prevalence estimates among subgroups of adults typically came from single studies and so it is difficult to determine if differences in estimates are due to the characteristic of the subgroup or other factors. There were also insufficient data for us to conclude that, relative to adults without CP, the risk of chronic conditions was increased in a subgroup of adults with CP only, such as those with intellectual disability.

Many of the conditions that adults with CP are at increased risk of share modifiable risk factors, such as physical inactivity, tobacco use, unhealthy diet, excess intake of alcohol, and sleep problems.[10,95–97] Tobacco use and consumption of alcohol is generally low in adults with CP.[10] However, there is consistent evidence that people with CP participate in low levels of physical activity from a young age.[10] Many children and adults with CP also experience sleep problems and have an unhealthy diet.[98–101] There is an interrelationship between these risk factors, pain, fatigue, and mobility decline,[102,103] which are commonly experienced by adults with CP,[9] making it challenging to intervene to reduce risk factors. Furthermore, people with CP face environmental barriers to modifying participation in physical activity.[104,105] These factors limit the potential effectiveness of individual-based approaches to behaviour change[106] and highlight the need for population-based approaches to modify risk factors and reduce risk of chronic disease.

Several of the most prevalent conditions among adults with CP, such as malnutrition, anxiety, depression, and hypertension, may be prevented or ameliorated with appropriate and timely screening and intervention. However, lack of knowledge about the potential complications of CP in adulthood among adults with CP and health care providers may contribute to inadequate provision of health services and support. Adults with CP report lacking information about their CP and the potential complications of CP.[107,108] Those who lack understanding of the impact of ageing on their physical and mental health are less likely to use health services.[109] Limited awareness of the potential complications of CP may prevent adults from seeking support to reduce the risk of developing chronic conditions and of developing poorer outcomes from chronic conditions. Furthermore, even when adults seek support from health services, they frequently encounter barriers to receiving appropriate support. These include both physical barriers to accessing health services, including preventive services,[109] and health care providers who lack knowledge about CP.[109] Thus, adults with CP have to self-manage and educate health care providers about their condition.[109] This relies on their ability to self-advocate, which is made more challenging when adults themselves lack knowledge about the potential complications of living with CP.[109]

The selection and definition of chronic conditions to include in this review were inevitably partly subjective. The difficulties with selecting chronic conditions can be seen in the literature regarding multimorbidity (i.e. the presence of two or more chronic conditions) where studies vary in terms of the chronic conditions that qualify for multimorbidity.[21] We took a systematic approach to selecting chronic conditions a priori based on the literature and expert knowledge from researchers, clinicians, and individuals with CP. Although this review includes data on many chronic conditions, there were no data available for 22 of the conditions that we specified a priori, including feeding or eating disorders, endometriosis, menstrual disorders, and prostate disorders. Examining the burden of these conditions is an area for future research.

The results of this review should be interpreted in light of some limitations. The methodological quality was low or moderate for 49 of the 65 studies reporting prevalence. Particularly, fewer than half of prevalence studies had an adequate sample size. Similarly, methodological quality was low or moderate for 9 of the 13 analytical cross-sectional studies. I^2 was more than 90% for most meta-analyses. However, high I^2 values occur when there is minimal overlap between CIs for individual studies and do not necessarily indicate important heterogeneity.[22] Inspection of prevalence estimates from individual studies indicate consistent results between studies for several conditions, with estimates varying by less than 10% for cancer, type 2 diabetes, hypothyroidism, dementia, heart

failure, ischaemic heart disease, myocardial infarction, cerebrovascular disease, liver disease, and rheumatoid arthritis. However, estimates from individual studies varied by at least 40% for malnutrition, epilepsy, asthma, constipation, scoliosis, and urinary incontinence. This may be due in part to poor methodological quality of the studies assessing these conditions. True heterogeneity may also exist because of variation between studies in terms of time, location, and characteristics of the population, such as ambulatory status and age.[22] The mean age of participants in prevalence studies ranged from 21 to 58 years, which probably contributed to variation in prevalence estimates given that the prevalence of many chronic conditions increases with advancing age. Additionally, certain chronic conditions, such as malnutrition, are complex to define and differences in the methods used to define the condition may contribute to differences in estimates.

When interpreting the findings from this review, it is important to consider that most studies came from the USA. Therefore, the prevalence or incidence we identified for several conditions may not be applicable to other countries. However, when studies compared the prevalence and incidence of conditions between adults with and without CP, data came from the same population. Thus, findings of increased risk of chronic conditions among adults with CP are unlikely to be due to selection bias. Furthermore, this review included prevalence and incidence estimates from studies regardless of whether the derivation of that estimate was the primary aim of the study. Where estimating the prevalence or incidence of chronic conditions was not the primary aim of the study, the methods used to address the specific study objective may result in a biased estimate of certain chronic conditions. For example, a study may omit individuals with type 2 diabetes to address the aim, which may lead to a lower prevalence of hypertension in that sample. However, this possible source of bias is anticipated to have a small to negligible impact on the conclusions drawn.

In conclusion, this review summarizes the prevalence of 53 chronic conditions and the incidence of 21 chronic conditions among adults with CP. There was consistent evidence that adults with CP were more likely than adults without CP to have and develop several chronic health conditions, including asthma, anxiety, depression, epilepsy, hypertension, ischaemic heart disease, cerebrovascular disease, osteoarthritis, and CKD. These data may be used to promote awareness, identify targets for intervention, inform development of appropriate services and supports for adults with CP, and inform future research.

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DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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SUPPORTING INFORMATION

The following additional material may be found online:

Table S1 Description of studies reporting the prevalence of chronic conditions among adults with cerebral palsy
Table S2 Quality appraisal for prevalence studies
Table S3 Quality appraisal of cohort studies reporting incidence (using checklist for prevalence studies)
Table S4 Quality appraisal for analytical cross-sectional studies comparing prevalence between adults with and without cerebral palsy
Table S5 Quality appraisal for cohort studies comparing incidence between adults with and without cerebral palsy
Table S6 Prevalence of cancer, diseases of the blood, and diseases of the skin
Table S7 Prevalence of endocrine diseases
Table S8 Prevalence of nutritional disorders
Table S9 Prevalence of mental, behavioural, or neurodevelopmental disorders
Table S10 Prevalence of diseases of the nervous system
Table S11 Prevalence of diseases of the circulatory system
Table S12 Prevalence of diseases of the respiratory system
Table S13 Prevalence of diseases of the digestive system
Table S14 Prevalence of diseases of the musculoskeletal system
Table S15 Prevalence of diseases of the genitourinary system
Table S16 Results from meta-analyses of prevalence and incidence of chronic conditions
Figure S1 Study selection
Appendix S1 Search strategy
Appendix S2 Chronic conditions identified for inclusion a priori
Appendix S3 JBI critical appraisal tools
Appendix S4 Characteristics of excluded studies

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