The risk, burden, and management of non-communicable diseases in cerebral palsy: a scoping review

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AIM To examine the risk, burden, and management of non-communicable diseases (NCDs) among people with cerebral palsy (CP).

METHOD Databases (Ovid MEDLINE, Embase Ovid, CINAHL Plus) were systematically searched up to August 2017. Data on the prevalence of risk factors for, and the burden and management of, cardiovascular diseases, diabetes, cancers, and respiratory diseases were extracted.

RESULTS Thirty-six studies that examined the prevalence of risk factors among people with CP were identified. There was inconsistent evidence that people with CP had higher prevalence of metabolic risk factors such as hypertension, hyperlipidaemia, and obesity, but strong evidence that they participated in low levels of physical activity, compared with people without CP. Seven studies reported on the burden of NCDs. Adults with CP had a higher risk of NCDs, including stroke, chronic obstructive pulmonary disease, and other heart conditions, and death due to NCDs, including cancers, chronic obstructive pulmonary disease, stroke, and ischaemic heart disease, compared with the general population. Only one study reported on the management of NCD, specifically the uptake of breast cancer screening among females.

INTERPRETATION The burden of NCDs is higher among adults with CP compared with the general population. Further research is required to determine the prevalence of metabolic risk factors and management of NCDs among people with CP.

Cerebral palsy (CP) is a developmental disorder that results from an injury to the developing fetal or infant brain.[1] Diagnosis of CP is typically made between 12 and 24 months using a combination of standardized motor assessments, neuroimaging, and a medical history.[2] CP is the most common cause of childhood physical disability with a prevalence of 1.5 to 3.8 per 1000 live births in Europe, Australia, and the USA.[3–5] The causal pathway to CP is not well understood but risk factors include low birthweight, placental abnormalities, birth asphyxia, neonatal infections, emergency Caesarean delivery,[6] maternal obesity,[7–9] and low socio-economic status.[10] Recent evidence suggests that a significant proportion of cases have a genetic component[11,12] and those with a family history of CP have increased risk of CP.[13] Regardless of the aetiology, the hallmark features of CP are abnormal fine and gross motor functioning.[1]

Substantial reductions in mortality rates among children with CP have been observed over the past decades, with most children expected to survive to adulthood.[14–16] Increases in life expectancy have also been observed among adolescents and adults with CP who are unable to self-feed, and this aligns with improvements observed in the general population.[15] However, life expectancy among adults with CP who self-feed has not improved at the same rate as life expectancy in the general population over the past three decades.[15] The cause of this widening gap in life expectancy between adults with CP and the general population is not well understood. It is clear, however, that mobility status and particularly the maintenance of independent mobility into middle age are strongly predictive of survival.[16,17]

Over the past three decades there has been a substantial shift in disease burden worldwide from communicable to non-communicable diseases (NCDs).[18] NCDs now account for nearly two-thirds of deaths worldwide.[19] The leading causes of death due to NCDs are cardiovascular diseases, cancers, respiratory diseases including asthma and chronic obstructive pulmonary disease, and diabetes. In total, these four types of disease account for 82% of NCD deaths.[20]

The underlying causes of NCDs are shared and modifiable risk factors: tobacco use, unhealthy diet, physical inactivity, and excess intake of alcohol.[19,21] These four modifiable risk factors contribute to metabolic risk factors for NCDs including overweight and obesity, high blood pressure, hyperlipidaemia, and hyperglycaemia.[22–26] Leading risk factors for NCDs in the UK are tobacco smoking, high blood pressure, high body mass index (BMI), alcohol consumption, hyperlipidaemia, and hyperglycaemia.[27] However, the combination of physical inactivity, high BMI, and unhealthy diets represents the largest overall contributor to disease burden.[28] Physical inactivity accounts for 3.2 million deaths and overweight and obesity accounts for 3.4 million deaths worldwide per year.[29] In 2006–2007, the cost to the UK's National Health Service related to poor diet was estimated to be £5.8 billion, physical inactivity was £0.9 billion, smoking was £3.3 billion, alcohol was £3.3 billion, and obesity was £5.1 billion.[30] Of importance, there is a robust interrelationship between physical inactivity, unhealthy dietary practices, and obesity; thus it is difficult to unravel the direction of association between these factors, and the progression of and burden attributed to preventable NCD.

The management of NCDs worldwide should focus on reduction of risk factors through primary prevention.[21] Primary prevention includes targeting reductions in tobacco smoking and alcohol consumption, and promoting healthy diets and participation in physical activity.[21] A second priority for prevention of NCDs is opportunistic screening of adults attending primary health care facilities.[21] Screening of adults at risk for cardiovascular disease followed by a multi-factorial lifestyle intervention consisting of individual and group-based counselling can improve long-term alcohol habits, as well as the adoption of a healthy diet and physical activity.[31–33] The World Health Organization endorses total disease risk rather than risk management of single factors, to allow early detection and more cost-effective management of NCDs.[19,34] Timely treatment of NCDs through universally available, affordable, and high-quality drugs is also a priority, as it can reduce NCD deaths and may be cost-effective by reducing the need for more expensive treatment as disease progresses.[21]

Although CP is considered a non-progressive disorder, in that the injury to the brain does not progress with time, adults with CP experience increases in pain, fatigue, and chronic musculoskeletal conditions with age.[35–39] At least a quarter of adults with CP also experience declines in mobility by the age of 40 years.[40–42] It has been proposed that a model of worsening mobility in young adulthood, accelerated loss of muscle mass, muscle weakness and fatigue, progression of motor dysfunction, and reduced participation in physical activity exists among people with CP.[43] The consequence of this negative cycle of events may be an increased risk of NCDs and multimorbidity.[43,44] Additionally, people with physical and intellectual disabilities may be less knowledgeable about modifiable risk factors

What this paper adds

- Adults with cerebral palsy (CP) have an increased risk of non-communicable diseases (NCDs) and increased risk of death because of NCDs.
- Evidence is inconsistent about the elevated prevalence of metabolic risk factors for NCDs.
- Evidence is consistent that people with CP participate in reduced physical activity.
- Only one study reported on management of NCD among people with CP.
- Available evidence suggests people with CP are less likely to receive preventive medicine.

for NCDs, and therefore less likely to participate in health screening services for these diseases.[45,46]

The aim of this review was to examine the risk, burden, and management of NCDs among people with CP. The review focused on the four leading causes of death due to NCD: cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes.[20]

The specific objectives were to examine (1) the prevalence of risk factors for NCDs among people with CP, (2) the burden of NCDs among people with CP, and (3) the management of NCDs among people with CP.

METHOD
Inclusion criteria
Full reports of original research published in English that aligned with the objectives of the review were included. No restrictions were placed on the type of study included in the review. Participants were people with CP of any age, any type of CP, and any functional ability. Studies that included people with CP as a subgroup and reported results for people with CP separately were included.

Search strategy
All available years of the following databases were searched from inception to August 2017: Ovid MEDLINE (1946 to August week 1, 2017); Embase Ovid (1974 to August 11th, 2017); CINAHL Plus (Cumulative Index to Nursing and Allied Health Literature; 1937 to August 13th, 2017). The reference lists of eligible studies were also searched.

Search terms
The full search strategy for each database is reported in Appendix S1 (online supporting information). Terms relating to CP (e.g. cerebral palsy, hemiplegia, spastic, ataxic), NCDs (e.g. cardiovascular disease, diabetes, respiratory disease, cancer), modifiable and metabolic risk factors (e.g. physical activity, smoking, blood pressure), burden (e.g. incidence, prevalence, mortality), and management (e.g. screening, treatment) were included in the search strategy.

Data collection and analysis
Titles and abstracts of search results were screened, and studies that did not meet the inclusion criteria were excluded. If a study seemed to meet the inclusion criteria or if there was any doubt about the inclusion of the study, the full text of the article was retrieved. Data were extracted on participant characteristics (age, sex,

ambulatory status, presence of intellectual disability); prevalence of risk factors among people with CP and comparative values in people without CP if reported; measures of burden of NCDs among people with CP and comparative values in people without CP if provided, including prevalence, risk, and rates; measures of management of NCDs among people with CP and comparative values in people without CP if provided, such as prevalence or incidence of screening.

RESULTS

A summary of the number of records identified in each database is presented Table I. The search of databases identified 116 182 records. An additional 13 records were identified from reviewing reference lists. After removal of duplicate records, 67 247 records were screened by title and abstract. Of these, 67 166 records were excluded. Seventy-nine full-text articles were obtained and reviewed. A further two full-text articles could not be obtained despite contacting the authors.[47,48] Thirty-five reports were excluded after review of the full-text article for the following reasons: they were not applicable to any of the objectives of the review (n=16);[49-64] they did not report results for people with CP separately where those with CP were a subgroup of the sample (n=8);[45,46,65-70] they did not include people with CP or did not state whether people with CP were included (n=8);[71-78] they were not an original research report (n=2);[79,80] and there was a second report of a study already included (n=1).[81] Overall, 44 reports were included in the review (Fig. 1).

Risk of NCDs among people with CP

The search of the literature yielded 38 reports of risk factors for NCDs among people with CP. All were cross-sectional studies. A summary of each study is presented in Table SI (online supporting information). The number of people with CP included in each study ranged from eight to 1397, although most studies (n=24) included fewer than 100 people with CP. Most studies included females and males with CP (n=37). Twenty-two studies included children aged up to 18 years, one study included children aged up to 19 years, one study included children aged up to 20 years, two studies included young adults aged 16 to 24 years, and 12 studies included adults aged 18 years and above.

Table I: Search results obtained from each database

Database	Search date	Database date range	Number of records	Number of records after removal of duplicates
Ovid MEDLINE	August 13th, 2017	1946 to August week 1, 2017	34 815	21 150
Embase Ovid	August 13th, 2017	1974 to August 11th, 2017	74 375	44 286
CINHAL Plus	August 13th, 2017	1937 to August 13th, 2017	6992	5964

Metabolic risk factors

Only five studies reported the prevalence of hypertension in people with CP. The prevalence of hypertensive blood pressure values among adults with CP was 20.0% in Ireland,[82] 25.5% in the Netherlands,[83] and 30.0% in the USA.[84] The prevalence of prehypertension and hypertension was 50% among adults with CP in the USA[44] and 10.5% among children with CP in Ireland.[85] Only three studies provided comparative values in the general population; one reported that the prevalence of hypertension was lower among adults with CP[83] and two reported that it was higher.[84,85]

Four studies reported the prevalence of hyperlipidaemia among adults with CP, but only one compared the prevalence with the general population. The prevalence of hyperlipidaemia ranged from 0% to 30.9%.[44,82-84] Adults with CP had a lower prevalence of hyperlipidaemia compared with the general population.[86] Two studies reported the prevalence of hyperglycaemia among adults with CP as 0% and 5.7% respectively, but neither compared this with the prevalence in the general population.[82,83]

Seventeen studies conducted in 13 countries reported the prevalence of overweight and obesity according to BMI among people with CP. Seven of these included adults[44,82-84,86-88] and 10 included children.[85,89-97] There was large variation in the prevalence of obesity reported (7.3%–41.4% in adults and 3.3%–18.2% in children). Only 10 studies compared the prevalence of obesity among people with CP to the prevalence reported in the general population. Most studies reported that the prevalence of obesity was lower among children and adults with CP,[82,85,87,88,90,96,97] although two reported that the prevalence was higher among children with CP.[89,93] Two studies that directly compared the prevalence of obesity among adults with CP with that in a reference group of people without CP found that the prevalence of obesity was higher among adults with CP.[84,86]

The prevalence of central obesity, as indicated by waist circumference, ranged from 24% to 36.4%.[82,83,86] The only study that compared central obesity with a reference group of people without CP found that the prevalence was similar.[86]

Modifiable behavioural risk factors

A low prevalence of smoking (2%) and alcohol consumption (23%) was reported among 63 females with CP in the USA.[35] However, a larger study reported that the prevalence of smoking among adults with CP was comparable to the general US population (19.7% vs 20.4%).[84] This was similar to that reported among Dutch adults with CP (20.9%).[83] Approximately 49% of Dutch adults with CP reported consuming alcohol, which was lower than the general population.[83]

Twenty-two studies assessed participation in physical activity among people with CP,[35,83,94,98-116] most of which (54.5%) only included people who walked independently with or without a walking aid.[101-108,111-114] There was
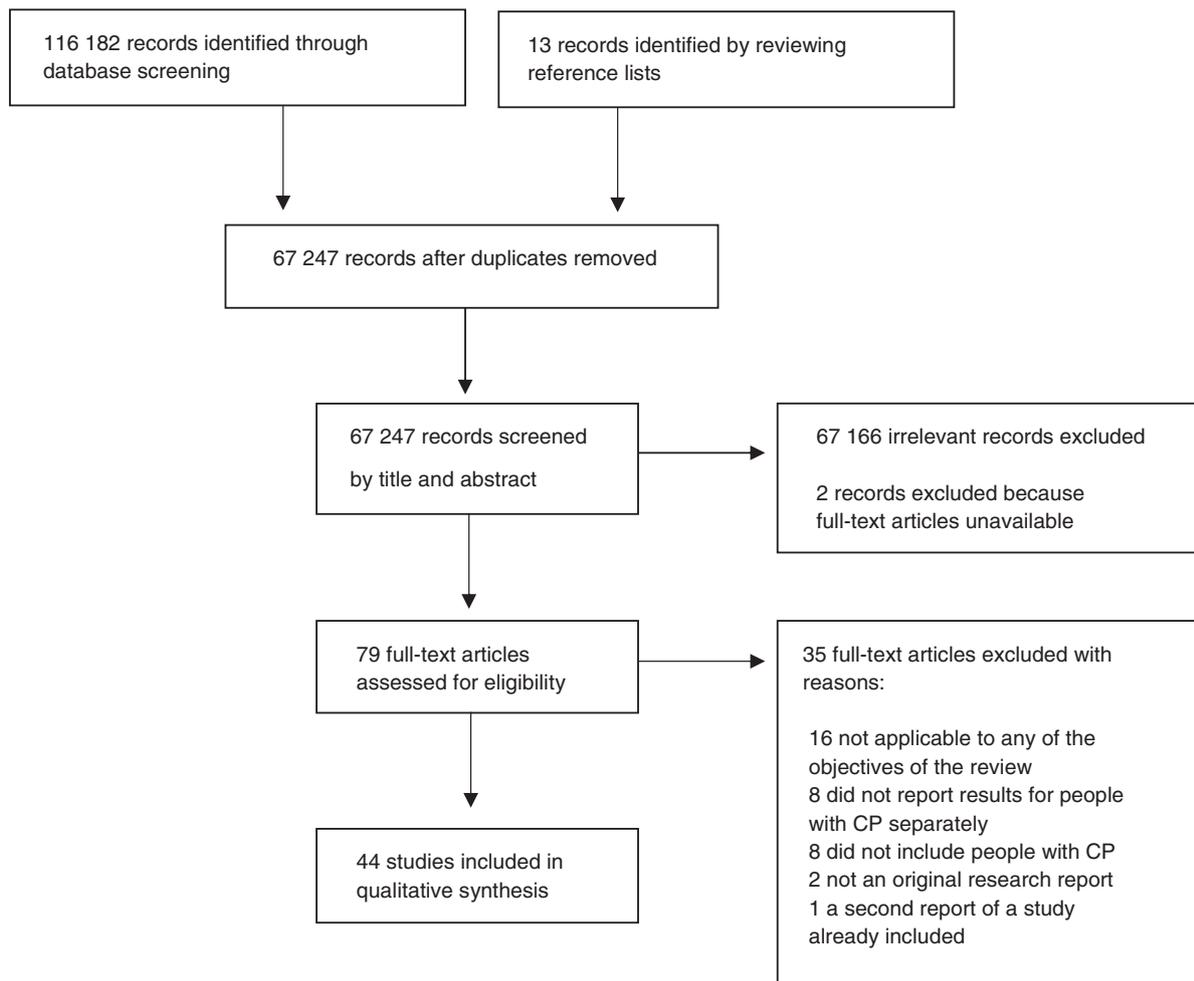
Figure 1: Study flow diagram.

consistently strong evidence that people with CP participated in less physical activity and spent more time in sedentary behaviour than people without CP throughout the lifespan.[83,94,98,101,103–105,108,109,111–113,115,116] The number of children with CP who met guidelines for time spent in physical activity varied significantly between studies, from 7% to 94%.[94,99,102,105,107,110] Some of this variation may be explained by the different methods used to measure physical activity and the different guidelines that children's activity levels were compared with. When directly compared with children having typical development, two out of three studies reported that a lower percentage of children with CP met guidelines.[94,102,105] Similarly, fewer adults with CP met published physical activity guidelines compared with adults without CP (24.4% vs 53.7%).[106]

Burden of NCD among people with CP

Seven studies reporting on the burden of NCDs among people with CP were identified (Table II): three cross-sectional studies[44,84,117] and four cohort studies.[118–121] Three examined the risk of NCDs[44,84,118] and four examined the risk of death due to NCDs among people with CP.[117,119–121] Sample sizes ranged from 341 to 40 482 people with CP. All studies included females and males; three included adults only[44,84,119] and four included adults and children.[117,118,120,121]

All studies reporting on the risk of NCDs found an increased risk among adults with CP. A cohort study of 1975 adults with CP and 9875 age- and sex-matched adults without CP from Taiwan found strong evidence that adults with CP had an increased risk of cerebrovascular disease (hazard ratio 2.17, 95% confidence interval [CI] 1.74–2.69, $p<0.001$).[118] Similarly, a cross-sectional survey of adults with CP in the USA found that they had greater odds of cerebrovascular disease, hypertension, emphysema, asthma, and other heart conditions compared with adults without CP (odds ratios ranged from 1.32 [95% CI 1.04–1.67] for hypertension, to 2.03 [95% CI 1.39–2.97] for emphysema).[84] The prevalence of multimorbidity (i.e. the presence of at least two chronic conditions) among adults with CP in the USA was found to be 57.8%.[44]

Table II: Summary of studies reporting on burden and management of non-communicable diseases

Reference	Country of origin	Study design	Sample size	Description of participants	Summary of results
Burden of non-communicable diseases					
Cremer et al.[44]	USA	Cross-sectional	435	Females (53.8%) Aged 40–60y Ambulatory with/without aids: 54.2% Intellectual disability: not reported	25.7% OB (according to body mass index) 11.5% were smokers 50% with prehypertension/hypertension 19% with hyperlipidaemia 57.8% with multimorbidity (at least two chronic conditions)
Day et al.[120]	USA	Cohort	40 482	Females (45%) Aged ≥2y Severe CP (23%) Comparison group: Age-specific mortality rates in the California population (1988 and 2002)	People with CP have increased risk of mortality due to all malignant neoplasms (SMR: 1.31, 95% CI 1.14–1.51) People with CP have increased risk of mortality due to neoplasms of oesophagus (SMR: 5.40, 95% CI 3.09–8.77), colon (SMR: 2.16, 95% CI 1.35–3.27), liver (SMR: 2.21, 95% CI 1.06–4.06), breast (SMR: 1.93, 95% CI 1.30–2.75), bladder (SMR: 4.57, 95% CI 2.09–8.68), brain (SMR: 2.54, 95% CI 1.48–4.06), and lymphatic and haematopoietic tissue (SMR: 1.61, 95% CI 1.09–2.30) People with CP have reduced risk of mortality due to neoplasms of the trachea, bronchus, lung (SMR: 0.22, 95% CI 0.09–0.43) No evidence of difference in mortality between people with and without CP due to neoplasms of male genitourinary organs (SMR: 0.78, 95% CI 0.21–2.01) or female genitourinary organs (SMR: 0.68, 95% CI 0.25–1.48)
Durufle-Tapin et al.[118]	France	Cross-sectional	3031 deaths	3031 deaths in people with CP were identified: Females (41.9%) Aged 0–14y (4.3%), 15–84y (91.8%), >85y (3.8%) Comparison group: Deaths in general population (number not specified): Females (48.8%) Aged 0–14y (0.9%), 15–84y (64.9%), >85y (34.0%)	Deaths due to diseases of the respiratory system: 19% among people with CP 6% in the general population Deaths due to diseases of the circulatory system: 15% among people with CP 29% in the general population Deaths due to neoplasms: 7% among people with CP 29% in the general population
Hemming et al.[119]	UK	Cohort	341	Females (44%) Age at baseline not reported (cohort selected conditional on surviving—20y) 4% with severe ambulatory disability, 81% with non-severe ambulatory disability, 15% with missing data Intellectual disability: not reported Comparison group: Expected survival proportions for the UK population	Among people aged 20–29y: Deaths due to neoplasms: 11% among people with CP 10% in the general population Deaths due to diseases of the circulatory system: 6% among people with CP 5% in the general population Deaths due to diseases of the respiratory system: 50% among people with CP 3% in the general population Among people aged 30–39y: Deaths due to neoplasms: 0% among people with CP 16% in the general population Deaths due to diseases of the circulatory system: 17% among people with CP 9% in the general population Deaths due to diseases of the respiratory system:

Table II: Continued

Reference	Country of origin	Study design	Sample size	Description of participants	Summary of results
					42% among people with CP 3% in the general population Among people aged 40–49y: Deaths due to neoplasms: 24% among people with CP 27% in the general population Deaths due to diseases of the circulatory system: 19% among people with CP 19% in the general population Deaths due to diseases of the respiratory system: 10% among people with CP 4% in the general population Among people aged 50–59y: Deaths due to neoplasms: 21% among people with CP 40% in the general population Deaths due to diseases of the circulatory system: 21% among people with CP 27% in the general population Deaths due to diseases of the respiratory system: 0% among people with CP 5% in the general population
Peterson et al.[84]	USA	Cross-sectional	1015	Females (31%) Mean age: 58y 2mo Minor or no disability (48.7%), moderate physical disability (8.9%), severe physical disability (40.6%) Intellectual disability: not reported Comparison group: 206 600 adults without CP (48% female) Mean age: 45y 5mo Minor or no disability (82.0%), moderate physical disability (4.9%), severe physical disability (11.3%)	OW/OB according to body mass index: People with CP: 31.2% OW 41.4% OB People without CP: 34.2% OW 29.7% OB Smokers: 19.7% of adults with CP 20.4% of adults without CP Age-adjusted prevalence in people with CP vs people without CP: diabetes (9.2% vs 6.3%) asthma (20.7% vs 9.4%) hypertension (30.0% vs 22.1%) other heart conditions (15.1% vs 9.1%) stroke (4.6% vs 2.3%) emphysema (3.8% vs 1.4%) People with CP have increased odds of all non-communicable diseases except for diabetes (odds ratios range from 1.32, 95% CI 1.04–1.67, for hypertension, to 2.03, 95% CI 1.39–2.97, for emphysema)
Strauss et al.[121]	USA	Cohort	45 292	Females (44.7%) Aged 0 to >55y Ambulatory with/without aids: 51.9% Intellectual disability: not reported Comparison group: For each cause of death, age- and sex-	People with CP have increased risk of death due to all cancers (SMR: 2.5 for people with severe CP; SMR: 2.1 for people with not-severe CP; p<0.001 for both) People with CP have increased risk of death due to breast cancer, cancer of digestive organs, cancer of genitourinary organs, and brain cancer (p<0.01)

Table II: Continued

Reference	Country of origin	Study design	Sample size	Description of participants	Summary of results
				specific mortality rates (deaths per 100 000 person-years of exposure) in the general Californian population	People with CP have reduced risk of death due to lung cancer ($p<0.01$) People with CP have increased risk of death due to chronic obstructive pulmonary disease (SMR: 13.8 for people with severe CP; SMR: 2.3 for people with not-severe CP; $p<0.01$ for both) People with CP have increased risk of death due to ischaemic heart disease (SMRs range from 1.8 to 13.5 across age groups for people with severe CP; SMRs range from 2.2 to 5.5 across age groups for people with not-severe CP; $p<0.01$ for all) People with CP have increased risk of death due to cerebrovascular disease (SMRs range from 2.3 to 38.5 across age groups for people with severe CP; SMRs range from 2.1 to 11.7 across age groups for people with not-severe CP; $p<0.01$ for all) People with CP have increased risk of death due to other heart diseases (SMRs range from 3.3 to 21.8 across age groups for people with severe CP; SMRs range from 2.9 to 13.5 across age groups for people with not-severe CP; $p<0.01$ for all)
Wu et al.[117]	Taiwan	Cohort study	1975	Females (53.9%) Age at baseline: ≤30y (38.5%) 31–40y (11.5%) 41–50y (18.4%) 51–60y (15.4%) 61–70y (9.0%) >70y (7.0%) Ambulatory disability: not reported Intellectual disability: not reported Comparison group: 9875 people without CP matched for age and sex to people with CP in a 5:1 ratio	People with CP had greater risk of stroke compared with people without CP (hazard ratio: 2.17, 95% CI 1.74–2.69, $p<0.001$)

Management of non-communicable diseases

Reference	Country of origin	Study design	Sample size[a]	Description of participants	Summary of results
Sullivan et al.[122]	Australia	Cross-sectional	380 (62)	Females with mild, moderate, and severe intellectual disability (39.5%, 32.1%, and 28.4% respectively) No description of subgroup of participants with CP provided	85.5% of females with CP had not received a breast cancer screening Females with CP had lower odds of receiving mammography screening compared with females with other intellectual disabilities (odds ratio 0.27, 95% CI 0.13–0.57)

[a]Total sample (participants with cerebral palsy [CP]), where people with CP are a subgroup of the total sample. OB, with obesity; SMR, standardized mortality ratio; CI, confidence interval; OW, with overweight.

There was mixed evidence about the risk of death due to NCDs among adults with CP. A descriptive cross-sectional study conducted in France found that the percentage of deaths due to respiratory diseases was higher among adults with CP, but the percentage of deaths due to diseases of the circulatory system and neoplasms was lower.[117] Similarly, in a cohort study of 341 adults with CP in London, a higher percentage of deaths due to respiratory diseases was reported among young adults with CP compared with adults without CP.[119] This difference did not exist between older adults with and without CP.[119] The percentage of deaths due to diseases of the circulatory system and neoplasms was similar between adults with CP and the general population.[119]

In contrast, two cohort studies of over 40 000 people with CP in the USA reported that they had an increased risk of death due to all cancers compared with the general population.[120,121] Specifically, people with CP had increased risk of death due to breast cancer, oesophageal cancer, colon cancer, liver cancer, bladder cancer, and brain cancer, but reduced risk of death due to lung cancer.[120,121] The studies found conflicting evidence about an increased risk of death due to cancer of the genitourinary organs.[120,121] Strauss et al.[121] also reported that adults with CP had at least a twofold increased risk of death due to chronic obstructive pulmonary disease, ischaemic heart disease, cerebrovascular disease, and other heart diseases, compared with the general population.

Only two studies examined differences in the burden of NCDs according to severity of disability.[44,121] Ambulatory males with CP (i.e. Gross Motor Function Classification System [GMFCS] levels I–III) had a higher prevalence of diabetes compared with non-ambulatory males (i.e. GMFCS levels IV and V) and ambulatory females with CP had a higher prevalence of stroke compared with non-ambulatory females.[44] However, non-ambulatory adults with CP had a higher prevalence of multimorbidity compared with ambulatory adults.[44] When examining causes of death among adults with CP, Strauss et al.[121] defined severe CP as 'a condition so substantial that it is exceedingly difficult to find an appropriate placement for the client and/or constant care/supervision is required'. Although in this study people with severe CP of all ages had a greater risk of death due to chronic obstructive pulmonary disease compared with people with non-severe CP,[121] the differences in risk of death due to other NCDs were age dependent.[121] The risk of death due to cancers, ischaemic heart diseases, and other heart diseases was higher among people with severe CP up to the age of 54 years, compared with people without severe CP of the same age, but the risk was similar between people with and without severe CP who were older than 54 years. The risk of death due to stroke was higher among people with severe CP aged 0 to 34 years and older than 54 years, compared with people without severe CP, but was similar between people with and without severe CP aged 35 to 54 years.

Management of NCD among people with CP
One study investigated the management of NCDs among people with CP, and included 62 females with intellectual disability only (Table II). Only 15% of females with CP had received a screening for breast cancer in their life.[122] Moreover, females with CP were 73% (95% CI 43–87%) less likely to have received a mammography screening compared with females with other causes of intellectual disability.[122]

DISCUSSION
In summary, people with CP are at increased risk of NCDs, which may be a direct result of reduced participation in physical activity and screening programmes. There is mixed evidence that people with CP have increased prevalence of metabolic risk factors such as hyperlipidaemia and obesity.

This review highlights the consistent evidence that people with CP participate in reduced levels of physical activity throughout their lifespan. The causal link between lack of physical activity, metabolic risk factors, and NCDs suggests that people with CP may be at increased risk of NCDs as a result of chronic inactivity. Conversely, the few studies that investigated the prevalence of metabolic risk factors among adults with CP reported similar or lower prevalence of risk factors compared with the general population. These studies, however, mostly included small numbers of relatively young adults, and therefore potentially do not give a representative depiction of the prevalence of metabolic risk factors in the CP population.

While the prevalence of overweight and obesity was the most widely reported metabolic risk factor, there was large variation in the prevalence reported between studies. This may partly be because studies used different methods to classify overweight and obesity according to BMI in children, such as the International Obesity Task Force or the World Health Organization cut-offs.[123] Additionally, prevalence of obesity was reported across several countries, which may explain variation. Although many studies reported a lower prevalence of obesity among people with CP compared with the general population, BMI is not sensitive to detect excess body fat in people with CP.[124] Adults with impaired mobility with high body fat may be misclassified as normal weight, resulting in metabolic risk factors not being identified.[125] Further, height is difficult to ascertain in people with CP, particularly among those in GMFCS levels IV and V because of lower limb contractures and reduced standing balance, making BMI potentially unfeasible to assess in the clinic. Indeed, measures of central adiposity are better predictors of metabolic risk factors than BMI among people with CP[53,82] and thus a more accurate and feasible indicator of increased risk of NCDs.

Despite identifying an increased risk of NCDs among adults with CP, this review also highlights the lack of epidemiological data on the risk of NCDs in this population worldwide. Only two studies so far have directly compared

the risk of NCDs between adults with and without CP. Of these, one only investigated the risk of stroke[118] and one was a cross-sectional study using self-reported presence of disease as the outcome.[84] Similarly, only four studies have reported the incidence of death due to NCDs among adults with CP compared with the general population, with conflicting results. Although two large cohort studies conducted in the USA did identify an increased risk of death due to cancers, cardiovascular diseases, and chronic respiratory diseases,[120,121] two smaller studies did not report a difference in the risk of death due to NCDs between people with and without CP.[117,119] Additionally, only two studies examined the burden of NCDs according to disability severity. These studies used different categorizations of disability severity and therefore the results are not comparable. However, the results of both studies suggest that the burden may differ according to disability severity, with more severe disability not necessarily indicating a higher risk of NCDs. Disability severity as a predictor of the risk of NCDs should be examined further to aid efficient identification of adults with CP most at risk.

There is a dearth of literature on preventive medicine for adults with CP. Only one study examined the uptake of screening, specifically breast cancer screening, among females with CP and found a very low rate. Children and adults with disabilities including CP have consistently higher health care use, including more visits to clinicians, more prescriptions dispensed, more hospitalizations, particularly elective and medical admissions, longer length of stay, and higher numbers of procedures per admission.[55,126,127] Despite this increased use, people with disabilities report difficulties accessing needed care.[126] Over 20% of children with CP report unmet therapy services needs,[128] and adults with CP report having inadequate access to the coordinated services that they received as children when they experience chronic health conditions during middle age.[129] These difficulties with accessing health care may contribute to the higher incidence of NCDs in this population, which may be prevented if metabolic risk factors such as hyperlipidaemia were identified and treated early.[21,130] Indeed, McPhee et al.[131] demonstrated that age was significantly associated with decreased endothelial function and arterial stiffness in CP, independent of central adiposity and mobility status. While this review indicates that chronic physical conditions are prevalent among people with CP, a recent review also highlighted the high prevalence of mental health conditions among young people with CP.[132] Given an increasing prevalence of CP, owing in part to the reduction in childhood mortality,[15,133] there is mounting evidence for the need to approach health care delivery for persons with CP within the context of a life-course health development model.[134]

Limitations

Although many studies investigating risk factors for NCDs were identified, most included a small number of participants, making it difficult to generalize the findings to the wider CP population. Additionally, many studies did not directly compare the prevalence of risk factors between people with and without CP. Although some studies provided information on the prevalence of risk factors in the general population, it is possible that any differences observed may have been due to confounding factors. Similarly, three studies reporting the burden of NCD in people with CP only reported descriptive statistics and did not directly compare the burden between people with and without CP adjusting for potential confounders.[44,117,119] Further, at a review level, we were unable to obtain full texts for two articles and therefore may not have included some relevant data.

Epidemiology and surveillance programmes are a key component to prevention of NCDs worldwide, as they provide essential data to identify and track high-risk populations, inform targeted solutions, and monitor trends of health across the lifespan.[130] This review highlights the need for further epidemiological research on the risk of NCDs among adults with CP. Further research is also required to understand current health promotion and screening practices for people with CP worldwide. Understanding these areas, and the barriers people with CP experience to accessing integrated health services throughout their lifespan, are key to identifying ways to reduce the risk of NCDs in this population.

SUPPORTING INFORMATION
The following additional material may be found online:

Appendix S1: Search strategy.

Table SI: Summary of studies reporting on risk factors for non-communicable diseases.

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