# Preterm Birth/Low Birth Weight and Markers of Wealth in Adulthood: A meta-analysis

Ayten Bilgin[1,2], PhD, Marina Mendonca[1], PhD, Dieter Wolke[1,3], PhD Dr rer nat h.c.

**Affiliations:** [1]Department of Psychology, University of Warwick; [2]Department of Psychology, Istanbul Medeniyet University; [3]Division of Mental Health and Wellbeing, Warwick Medical School, University of Warwick, Coventry, UK

**Address correspondence to:** Dieter Wolke; University of Warwick, Department of Psychology, Coventry CV4 7AL, United Kingdom; telephone number: +44 (0)24 7657 3217; fax number: + 44 (0) 24 7652 4225; email: D.Wolke@warwick.ac.uk

**Short Title**: Preterm Birth and Adulthood Wealth

**Abbreviations:** LBW (Low Birth Weight), VPT (Very Preterm), MLPT (Moderate-to-Late-Preterm), PT/LBW (Preterm/Low Birth Weight), VPT/VLBW (Very Preterm/Very Low Birth Weight), CI (Confidence Interval)

**Funding Source:** This study has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No: 733280.

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

**Conflict of Interest:** The authors have no conflicts of interest to disclose.

**Table of Contents Summary:** A meta-analysis of the association between preterm birth and wealth in adulthood, which was assessed by higher educational qualifications, employment, social benefits and independent living.

**Contributor's Statements:**

Ayten Bilgin: Dr. Bilgin was involved in the conception of the study, carried out the data collection and analyses, drafted the manuscript, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Marina Mendonca: Dr. Mendonca was involved in the conception of the study, conducted the data collection, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Dieter Wolke: Prof. Wolke conceptualized and designed the study, supervised the study, reviewed and revised the manuscript, and approved the final manuscript as submitted.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

**Abstract**
**Context:** Preterm birth/low birth weight (PT/LBW) increases the risk of cognitive deficits which suggests an association between PT/LBW and lower wealth in adulthood. Nevertheless, studies have revealed inconsistent findings so far.
**Objective:** To systematically investigate whether PT/LBW is associated with markers of adulthood wealth.
**Data Sources:** We searched MEDLINE, PubMed, PsycINFO, Web of Science, and Embase.
**Study Selection:** Prospective longitudinal and registry studies that reported on selected wealth related outcomes in PT/LBW born adults compared to full-term born controls.
**Data Extraction:** Two independent reviewers extracted data on educational qualifications, employment rates, social benefits, and independent living.
**Results:** Of 1347 articles screened, 23 studies met the inclusion criteria. PT/LBW was associated with decreased likelihood of attainment of higher education qualifications (OR= 0.74; 95% CI= 0.69-0.80), lower employment rate (OR = 0.83; 95% CI= 0.74-0.92), and increased likelihood of receiving social benefits (OR= 1.25; 95% CI= 1.09-1.42). A dose-response relationship according to gestation was only found for education qualifications. PT/LBW born adults did not differ significantly from those born full-term in independent living.
**Limitations:** There was high heterogeneity between studies. There were unequal numbers of studies from different regions in the world.
**Conclusions:** PT/LBW is associated with lower educational qualifications, decreased rate of employment and an increased rate of receipt of social benefits in adulthood. Low educational qualifications were most prevalent in those born very preterm and consistent across geographic regions. However, the findings are less clear for independent living.

## Introduction

Around 11.1% of children are born preterm (<37 weeks gestation) worldwide and 8.6% in developed countries.[1] Improvements in neonatal care, such as the use of assisted ventilation, the introduction of advanced technology[2,3] and changing attitudes towards intensive care,[4] have resulted in marked increases in the survival rate of preterm infants. Across the lifespan, preterm birth is associated with an increased risk of disability,[5,6] neurocognitive impairment,[7-10] learning difficulties[7,10] and mental health problems,[11-13] and the association is stronger in those who were born very preterm.[7,14,15] Generally, disability, neurocognitive impairment and mental health disorders in childhood and early adulthood have been associated with markers of reduced wealth such as attainment of poorer educational qualifications, lower employment and increased receipt of social benefits in young adults in adulthood.[16]

Large, registry-based studies from Scandinavian countries have further documented that preterm birth may not be only associated with adverse functional outcome but with a decrease in markers of wealth across adulthood, such as lower levels of education, lower rates of employment, education, independent living and higher rates of receiving social security benefits compared to those born at term.[15,17-20] This would suggest that apart from increased health care costs,[21] there may be long term adverse effects on individual wealth and social cost for society. In contrast, few prospective cohort studies have included adult wealth-related outcomes after preterm birth and these studies have produced inconsistent findings.[6,22-25] For example, a cohort study of Canadian extremely low birth weight infants found no significant differences in the years of education between preterm and full-terms,[6,24,25] while other studies from the UK and USA found that preterm birth was associated with a decrease in educational qualifications.[22,23] Regarding employment, Saigal[25] found similar rates among preterms and full-terms in young adulthood,

though extremely low birth weight born were less likely to be employed in middle adulthood.[6] Thus, there are variations in findings and differences in markers of wealth may depend on degree of prematurity, region in the world, study design or length of follow-up.

The aim of this study was to systematically investigate if preterm birth/low birth weight (PT/LBW) is associated with a decrease in markers of wealth in adulthood as assessed by educational qualifications attained, employment rate, receiving social benefits and independent living, while assessing whether there is a dose-response effect according to gestational age at birth (very preterm (VPT): < 32 weeks gestation or moderate-to-late preterm (MLPT): 32 to 36 weeks gestation at birth), and moderation by geographical region (Europe, North America, Australasia), study type (registry or cohort) and assessment age (middle or young adulthood).

**Methods**

This meta-analysis was registered with the PROSPERO International prospective register of systematic reviews with the following number: CRD42017064788 and was conducted in line with the PRISMA guidelines.[26]

**Study Selection Criteria**

Prospective longitudinal and registry studies were eligible for this meta-analysis. Studies were included in the analysis according to 5 criteria. First, articles should report on at least one of the following variables assessing wealth: higher education qualifications (postsecondary education, i.e., qualifications you can attain at a university or other higher education institutions), employment (full-time or part-time employment), receiving social benefits (government social welfare subsidies) and independent living (not living in parents' house). Second, studies had to include a full-term healthy control group. Third, studies had to include participants with a mean age of ≥18 years at the time of outcome assessment. Fourth, enough statistical information

(means, SDs, frequencies) should be reported in the articles or provided by authors after contacting them to enable computing effect sizes. Last, the articles had to be in either English or in German. Studies not fulfilling these criteria were excluded (Fig 1).

**Search Strategy**

A literature search was conducted for longitudinal studies of markers of wealth in adults who were born preterm (<37 weeks gestation) or low birth weight (<2500g at birth), published between January 1980 and May 2017. The article search was finalized on 15 May, 2017. The following electronic databases were searched: MEDLINE, PubMed, PsycINFO, Web of Science, and Embase. The keywords used were as follows: (preterm OR low birth weight OR prematur*) AND (socioeconomic status OR wealth OR employment OR academic OR education OR benefits OR independent) AND (adult*).

The Medline search yielded 248 articles, PubMed yielded 324 articles, PsycINFO yielded 106 articles, Web of Science yielded 357 articles, and Embase yielded 307 articles. Furthermore, 5 articles were found from bibliography search. Overall, 1347 articles were included in the literature search. 317 duplicates were removed from the search. Overall, the final literature search included 1030 articles (see Fig 1). After the title screening, 196 articles were left for abstract screening. 139 articles were excluded on the basis of the abstract only. We reviewed the full text of the remaining 57 articles according to the inclusion criteria, and 34 articles were excluded. In some cases, multiple reports were published on the same cohort assessed at different time periods in adulthood.[6,24,27] In order to avoid inappropriate double-counting of participants which may have influenced study weighting, only one study was included in any meta-analysis. When a choice was required, those studies with the best profile, for example, the largest sample sizes and the broadest concept coverage, were selected for inclusion in meta-analysis.

Nevertheless, two studies[6,25] were included from the same Canadian sample since Saigal et al (2006)[25] reported on independent living which was not available in the largest sample size study from the same cohort.[6] Moreover, one study reported on two samples[22] resulting in a total of twenty-three articles with 23 samples being included in the meta-analysis (Table 1). The article selection process was performed by AB and MM independently. The overall agreement in the selection of articles according to the predefined criteria was Cohen's k 0.84 at the abstract selection stage and 0.90 at the full-text retrieval stage. The discrepancies in four articles were discussed and mutually resolved by the coders and DW.

**Quality Assessment**

The Newcastle-Ottawa Scale[28] was used to assess the quality of studies referring to selection, comparability, and outcome or exposure for cohort studies (see Supplemental Table 1). Scores in this scale could range from 0 to 9, with higher scores indicating higher quality. Studies were rated by 2 independent coders, and agreement for the overall rating for each study was found to be high (k = 0.86). The overall ratings of the studies ranged from 6 to 9 (mean = 7.5, SD = 0.7), indicating overall high quality.

**Data Extraction**

Eligible studies were reviewed to extract the wealth data. When available, information on the comparison of PT/LBW and full-term groups was extracted directly from the article. Studies which reported on low birth weight and preterm birth were grouped into the same category since infants with low birth weight were mostly also born preterm. Studies provided data in different formats: sample size with means and SDs, or frequencies. When any of this information was unavailable, it was requested from the authors. In cases in which the researchers reported the statistical information according to different gestational age subgroups,[15,17,19,20] the data was

combined into three groups by degree of prematurity: 1) VPT (<32 weeks), 2) MLPT (32-36 weeks), 3) full term (>36 weeks). Nevertheless, Mannisto et al (2015)[29] reported on an early preterm (<34 weeks) subgroup overlapping with MLPT subgroup. In this case, we excluded this statistical information from the analysis. Categorical information regarding the degree of prematurity (VPT or MLPT), geographical setting (Australasia, Europe, North America), the type of study (cohort or registry), assessment age in adulthood (young adulthood ≤30 years or middle adulthood >30 years) was extracted from the articles (Table 1). The categorization of these variables was completed by AB under the supervision of the senior author DW.

**Data Analysis**

Analysis was conducted with Comprehensive Meta-Analysis version 2 software.[30] Mean effect sizes were calculated with the Comprehensive Meta-Analysis software when studies reported group differences at different time points. Since the eligible studies varied in many aspects, differences in the outcomes between PT/LBW and full-term adults were assessed using random effects meta-analyses, an approach that assumes the studies included in the analyses are random samples from a larger population of studies, and likely to exhibit different effect sizes.[31] We calculated odds ratios and their confidence intervals. Heterogeneity of studies was assessed with Cochran's Q and Higgins $I^2$. Subgroup analyses were conducted with 4 variables: degree of prematurity, type of study, geographical setting, and assessment age in adulthood (young vs middle adulthood).

Publication bias analysis was assessed by using three strategies. First, the trim and fill procedure was used to examine the symmetry of effect sizes plotted by the inverse of the SE.[32] Ideally, the effect sizes should mirror one another on either side of the mean. Second, The Begg and Mazumdar rank correlation test was used to examine the likelihood of bias in favour of small

sample size studies.[33] Nonsignificance of correlation indicates no publication bias. Last, Egger's test examined whether publication bias related to the direction of study findings.[34] The intercept value provided by this test shows the level of funnel plot asymmetry from the standard precision. In the current meta-analysis, we decided to combine PT and LBW into one group. As it was essential to demonstrate that the findings of the meta-analysis were not dependent on this decision, a sensitivity analysis was undertaken, in which we repeated the analysis just for studies reported on PT excluding the studies that reported on low birth weight only.

**Results**

The 23 samples and 23 studies of adulthood wealth-related outcomes represented a total of 5.917.101 participants, 271.767 of whom were born preterm/LBW and 5.645.334 were born full-term. Seven (30.4%) of the samples reported on birth weight, fifteen (65.2%) reported on gestational age and one study[35] reported on both birth weight and gestational age. Sample sizes for the PT/LBW group ranged from 35 to 114.890 individuals and for the full-term group, from 30 to 3.146.386 individuals. Mean birth weight was 1618.5 (SD= 717.4) grams for PT/LBW participants, and 3494.9 (SD= 189.9) grams for full-term participants. The mean gestational age of the PT/LBW children was 30.4 weeks (SD= 2.8 weeks) compared with 39.6 weeks (SD= 1.1 weeks) for the full-term comparisons. The age of participants at assessment ranged from 18 to 66 years. Ten (43.8%) of the samples included participants ≤29 years and the other 13 (56.2%) samples included participants older than 29 years. Eighteen of the studies reported on higher education qualifications, 15 on employment, 7 on receiving social benefits and 6 on independent living. The majority of the studies were from Europe (N= 17). There were few studies from North America (N= 4) and Australasia (N= 2) and no studies from elsewhere in the world. Of the

articles included, 18 (78.3%) reported on a cohort sample and the remaining 5 (21.7%) reported on registry samples.[15,17]

**Differences in Higher Education Qualifications between Adults born Preterm/Low Birth Weight and Full-term**

There was a significant negative association between PT/LBW and achievement of higher education qualifications (OR= 0.74; 95% CI= 0.69-0.80), indicating that preterm birth was associated with a decrease in the likelihood of completing education beyond high school (Table 2). Heterogeneity analysis indicated significant and high variation in education effects between studies ($Q = 111.63$; $I^2 = 85$, $p < 0.001$). Subgroup analysis according to the degree of prematurity showed a significant difference between the two groups ($Q= 7.48$; $I^2=86.6$, $p<0.05$) in which both VPT (OR= 0.60; 95% CI= 0.48-0.74) and MLPT (OR= 0.82; 95% CI= 0.78-0.85) decreased the likelihood of attainment of higher education qualifications (Supplemental Fig 1). Comparison of the region of the studies indicated that in all three regions, Australasia, Europe and North America (OR= 0.59; 95% CI= 0.26-1.32, OR=0.76; 95% CI= 0.71-0.82 and OR= 0.66; 95% CI= 0.49-0.90) that preterm birth decreased the likelihood of achieving higher education qualifications in adulthood (Supplemental Fig 2). This association was significant in both cohort and registry studies, respectively (OR= 0.59; 95% CI= 0.48-0.74 and OR= 0.79; 95% CI= 0.74-0.85). When comparing young and middle-aged adults, the PT/LBW group was less likely to achieve higher education qualifications compared to full-term group both in young adulthood (OR= 0.61; 95% CI= 0.49-0.77) and middle adulthood (OR= 0.77; 95% CI= 0.72-0.84).

**Differences in Employment between Adults born Preterm/Low Birth Weight and Full-term**

The combined odds ratio of the employment rate was 0.83 (95% CI= 0.74 to 0.92; $p< 0.001$), indicating that preterm birth was associated with a decrease in the likelihood of being employed in adulthood (Table 2). Heterogeneity analysis indicated significant and high variation in employment effects between studies ($Q = 144.45$; $I^2 = 90$, $p< 0.001$). Subgroup analysis showed that both the VPT and MLPT group were less likely to be employed in adulthood compared to the full-term group (OR= 0.87; 95% CI= 0.76-0.99 and OR= 0.81; 95% CI= 0.70-0.95) even though there was no significant difference between the VPT and MLPT groups. In comparing the regions, studies from both Europe and North America (OR= 0.84; 95% CI= 0.75-0.93 and OR= 0.37; 95% CI= 0.15-0.93) revealed that the PT/LBW group had a decreased likelihood of employment in adulthood; nevertheless, this association was not significant in Australasia. There was a significant association between PT/LBW and employment in both cohort and registry studies (OR= 0.76; 95% CI= 0.61-0.95 and OR= 0.91; 95% CI= 0.86-0.97). When comparing young and middle-aged adults, PT/LBW born were less likely to be employed compared to full-term group only in middle adulthood (OR= 0.76; 95% CI= 0.62-0.93).

**Differences in Social Benefits between Adults born Preterm/Low Birth Weight and Full-term**

There was a significant positive association between preterm birth and receiving social benefits (OR= 1.25; 95% CI= 1.09-1.42), suggesting that preterm birth was associated with an increase in the likelihood of receiving social benefits (Table 3). Heterogeneity analysis indicated significant and high variation in benefit usage effects between studies ($Q = 148.92$; $I^2 = 96$, $p < 0.001$). Subgroup analysis according to degree of prematurity found that adults were more likely to receive benefits both in the VPT group (OR= 1.78; 95% CI= 1.09-2.91) and MLPT group (OR= 1.16; 95% CI= 1.14-1.19), however the difference between the VPT and MLPT groups was not

significant. In comparing the region of the studies, studies from both Australasia and Europe (OR= 2.67; 95% CI= 1.51-4.75 and OR= 1.20; 95% CI= 1.05-1.37) revealed that adults born PT/LBW were more likely to receive benefits in comparison to full-term born. No studies from North America reported on receiving benefits after preterm birth. In comparing the studies according to study type, preterm adults were more likely to receive benefits in both cohort and registry studies (OR= 3.98; 95% CI= 1.39-11.37 and OR= 1.18; 95% CI= 1.04-1.35) in comparison to full-term adults. When comparing young and middle-aged adults, PT/LBW born were more likely to receive benefits compared to full-term born in both young adulthood (OR= 2.12; 95% CI= 1.00-4.48) and middle adulthood (OR= 1.14; 95% CI= 1.05-1.35).

**Differences in Independent Living between Adults born Preterm/Low Birth Weight and Full-term**

The combined mean odds ratio of independent living was 0.78 (95% CI= 0.60-1.01), indicating no difference in independent living away from their parents between PT/LBW and full-term comparison adults (Table 3). Heterogeneity analysis indicated significant and high variation in independent living effects between studies ($Q = 31.13$; $I^2 = 80.72$, $p < 0.001$). Subgroup analyses according to the degree of prematurity and region showed no significant difference between preterm and full-term comparison adults in independent living. However, PT/LBW adults were less likely to live independently according to cohort studies (OR= 0.59; 95% CI= 0.44-0.79) but more likely to live independently according to registry studies (OR= 1.09; 95% CI= 1.01-1.18).

**Publication Bias**

Under the random effects model, the point estimate (95% confidence interval) for the combined studies is 0.75 (0.70, 0.80) for higher education qualifications and 0.82 (0.74, 0.92) for employment. With the use of trim and fill, these values remained unchanged for both higher

education qualifications and employment, indicating no publication bias. The Begg and Mazumdar rank correlation and Egger's test were not statistically significant for both employment and higher education qualifications, indicating no evidence of publication bias.

Under the random effects model, the point estimate (95% confidence interval) for the combined studies is 1.11 (1.10, 1.13) for receiving social benefits. With the use of trim and fill, the imputed point estimate changed to 1.18 (1.04, 1.35), indicating publication bias. On the other hand, The Begg and Mazumdar rank correlation and Egger's test were not statistically significant, indicating no evidence of publication bias.

Under the random effects model, the point estimate (95% confidence interval) for the combined studies is 0.78 (0.60, 1.01) for independent living. With the use of trim and fill, these values remained unchanged, indicating no publication bias. The Begg and Mazumdar rank correlation was not statistically significant, however Egger's test was statistically significant (p =0.01), indicating publication bias. However, Egger's test has low power when few studies are included in the analysis and when there is high heterogeneity between studies.[36,37]

**Sensitivity Analysis**

Since the current meta-analysis included a mixture of studies reporting on birth weight and gestational age, we repeated the meta-analysis excluding the studies which reported on birth weight to check whether this altered the results.[38] Results remained the same when the studies reporting on birth weight were removed from the analysis. Preterm born adults were less likely to attain higher education qualifications (OR= 0.77; 95% CI= 0.72-0.83), be employed (OR= 0.84; 95% CI= 0.75-0.93) and more likely to receive social benefits (OR= 1.19; 95% CI= 1.04-1.36) in comparison to full-term born adults. There was no significant difference between the two groups in terms of the likelihood of independent living (OR= 0.81; 95% CI= 0.61-1.06).

## Discussion

Our findings revealed that adults born PT/LBW are less likely to achieve higher education qualifications, less likely to be employed and they are more likely to receive social benefits in comparison to those born full-term. On the other hand, PT/LBW and full-term born adults were similar in the likelihood of independent living.

With respect to study type, cohort studies revealed generally poorer outcomes in higher education qualifications and employment rates for PT/LBW born adults than registry studies, along with increased rate of receiving social benefits. As cohort studies are prone to selective drop-out (i.e., participants with worst social conditions and problems are more likely to drop-out),[39,40] cohort studies would have been expected to have reported on less problems in comparison to registry studies. This difference according to study type may be related to the fact that all registry studies were from Scandinavian countries, where inclusive education, employment rates and educational qualifications could be relatively high compared to other countries.[41] It could also be related to the fact that the majority of cohort studies included VPT/VLBW individuals whereas registry studies included the full range of preterm birth. With respect to region, the inverse association between preterm birth and higher education qualifications in adulthood was more pronounced in Australasia and North America in comparison to Europe. This finding could be due to having less of a social care network for preterms in these regions than Europe.[42] On the other hand, it could also be a methodological issue due to having registry studies in Europe but not in other regions.

Despite poorer education, being less likely to be employed and receiving social benefits, preterm born adults were as likely to live independently as full-term born adults. We found that this was particularly evident in registry studies, which indicates that welfare and cultural

practices might have an influence on this outcome. To illustrate, in Northern European countries it is socially expected for young people to leave home and the state usually supports this transition.[43] However, it should be noted that cohort studies did report less independent living of PT/LBW. Thus, cohort studies may provide more sensitive measurement of independent living since they usually include detailed information about the living arrangements whereas registry studies may only be reporting based on a registered address which might not indicate where the individual actually lives.[35]

The primary and sub-group analyses allow for interpretation of the evidence using the Bradford-Hill Framework (a tool to assess for causality between two variables), based on the following: the temporal relationship of the association, strength and consistency of the association, presence of a dose-response relationship, plausibility, and whether an alternate explanation for the associations is possible.[44]

With respect to temporality, longitudinal prospective studies showed a significant association between PT/LBW and markers of adulthood wealth, particularly for higher education qualifications, employment and social benefits. Thus, there is evidence of a temporal relationship showing PT/LBW preceded later consequences regarding economic functioning.

The magnitude of the associations was generally small and diverged depending on the study type, degree of prematurity, region and participant age. To illustrate, cohort studies revealed more negative associations between PT/LBW and higher education qualifications and employment in comparison to registry based studies. Despite some variability, PT/LBW was found to significantly decrease the likelihood of attainment of higher education qualifications and employment and increase the likelihood of receiving social benefits. These findings suggest robust associations between PT/LBW and markers of adulthood wealth.

Consistency of the associations between PT/LBW and a decrease in markers of adulthood wealth was demonstrated in the estimated effect sizes across studies. The significant association was consistent across different geographic regions, degree of prematurity and study type for higher education qualifications, and employment. The significant association was consistent across different regions for social benefits. Inconsistent associations were observed for independent living and it is possible that publication bias or assessment method affected the results for independent living.

With respect to dose-response relationship, available evidence suggests that among preterm born, being born before 32 weeks (very preterm) is specifically associated with impairments in multiple areas of development.[7,45] Similarly, this study suggests a dose-response relationship between PT/LBW and markers of adulthood wealth, in particular for higher education qualifications. An increase in the degree of prematurity (i.e., decrease in gestational age) resulted in the lowest point of estimates for higher education qualifications and employment. To illustrate, VPT infants had significantly lower likelihood of attainment of higher education qualifications in comparison to MLPT infants. Even though the difference between VPT and MLPT infants in the likelihood of employment was not significant, the point estimate for VPT infants was lower than MLPT infants. VPT resulted in the highest point of estimates for receiving social benefits even though the difference between VPT and MLPT was not statistically significant.

In infants born preterm, the normal processes of intrauterine brain development are altered or impaired during the second half of gestation (20 to 40 weeks) with the maturation of cerebral pathways, the formation of synapses, and brain growth being interrupted.[46,47] The severity of these alterations has been associated with neurocognitive deficits in later life.[48,49]

Thus, it is plausible that PT/LBW would be associated with low employment and educational qualifications in adulthood.

There are alternative explanations for the association between PT/LBW and decrease in markers of wealth in adulthood. One factor related to increased rates of preterm birth is low socioeconomic status of the mother which has been consistently reported in several countries such as USA,[50] Sweden,[51] Finland,[52] or UK.[53] Social disadvantage has been shown to be an equally important factor in explaining the cognitive deficits as very preterm birth.[54,55] The impact of gestational age on cognitive deficits decreases after controlling for social disadvantage while growing up[56] and the effects of social disadvantage and VPT have been shown to be additive.[55] Nevertheless, some studies included in the meta-analysis reported an association between PT/LBW and decreased employment[35] and educational qualification rates[17] even after controlling for the impact of socioeconomic status of the mother.

Using the above mentioned criteria, we can conclude that there is 'convincing evidence' for an association between PT/LBW and decreased likelihood of higher education qualifications and employment. This evidence is based on substantial number of cohort and registry studies identified in this meta-analysis including prospective cohort studies of sufficient size, duration and quality showing consistent effect sizes. We conclude that probable evidence of an association exists between PT/LBW and increased likelihood of receiving social benefits. This evidence is mainly based on findings from registry studies and two cohort studies. More studies are needed to support these tentative associations. Further research with more fine-graded assessment is needed to better examine if any associations exist between PT/LBW and independent living.

There are some limitations of the current meta-analysis. There were too few studies from North America and Australasia and no studies from other regions. These would be needed to understand the impact of PT/LBW on wealth in all regions of the world. Information on the disability of the participants was also not available for the majority of studies and thus could not be considered as a moderator in our analysis. Therefore, it could not be assessed whether disability accounted for the association between PT/LBW and wealth-related outcomes. It is essential that future studies report on disabilities in individuals born at PT/LBW when reporting on adulthood wealth-related outcomes. Moreover, the heterogeneity was high indicating considerable variation between studies. This might arise from incorporating cohort and registry studies with various sample sizes. To address this possibility, we used random-effects model in the analysis and conducted moderator analyses. Nevertheless, our moderator analysis explained only some of the heterogeneity. Thus, the findings from the current study should be interpreted with caution and the analysis should be repeated when more adulthood data becomes available from the EPT (extremely preterm) cohort studies.[57,58] We were unable to include income as an outcome measure since the definition of low income does differ substantially according to overall distribution of income in each country and reference norms were not available. It was only possible to focus on higher education qualifications among the levels of education since this was the most consistently reported outcome.

In conclusion, there is evidence that PT/LBW is associated with decreased rates of educational qualifications and employment, as well as increased rate of social benefits in adulthood. Although the magnitude of these associations was small in general, they were particularly strong in VPT/VLBW born adults for education qualifications and were consistent across geographic regions. However, the findings are less clear for independent living which

may be related to measurement or cultural practices and support. Future research should identify the major risk, and in particular, protective and resiliency factors related to wealth among preterm individuals in order to improve support and design appropriate interventions to decrease the economic disadvantages of survivors of PT/LBW.

## References


1. Blencowe H, Cousens S, Chou D, et al. Born too soon: The global epidemiology of 15 million preterm births. *Reprod Health.* 2013;10(Suppl 1):S2-S2.
2. Doyle LW, Rogerson S, Chuang SL, James M, Bowman ED, Davis PG. Why do preterm infants die in the 1990s? *Med J Aust.* 1999;170(11):528-532.
3. Saigal S, Doyle LW. An overview of mortality and sequelae of preterm birth from infancy to adulthood. *Lancet.* 2008;371(9608):261-269.
4. Soll RF. Surfactant treatment of the very preterm infant. *Biol Neonate.* 1998;74 Suppl 1:35-42.
5. Doyle LW, Anderson PJ. Adult outcome of extremely preterm infants. *Pediatrics.* 2010;126(2):342-351.
6. Saigal S, Day KL, Van Lieshout RJ, Schmidt LA, Morrison KM, Boyle MH. Health, wealth, social integration, and sexuality of extremely low-birth-weight prematurely born adults in the fourth decade of life. *JAMA Pediatrics.* 2016;170(7):678-686.
7. Aarnoudse-Moens CS, Weisglas-Kuperus N, van Goudoever JB, Oosterlaan J. Meta-analysis of neurobehavioral outcomes in very preterm and/or very low birth weight children. *Pediatrics.* 2009;124(2):717-728.
8. Aylward GP. Update on neurodevelopmental outcomes of infants born prematurely. *J Dev Behav Pediatr.* 2014;35(6):392-393.
9. Breeman LD, Jaekel J, Baumann N, Bartmann P, Wolke D. Preterm cognitive function into adulthood. *Pediatrics.* 2015;136(3):415-423.
10. Kovachy VN, Adams JN, Tamaresis JS, Feldman HM. Reading abilities in school-aged preterm children: A review and meta-analysis. *Dev Med Child Neurol.* 2015;57(5):410-419.
11. Nosarti C, Reichenberg A, Murray RM, et al. Preterm birth and psychiatric disorders in young adult life. *Arch Gen Psychiatry.* 2012;69(6):e1-8.
12. Pyhala R, Wolford E, Kautiainen H, et al. Self-reported mental health problems among adults born preterm: A meta-analysis. *Pediatrics.* 2017;139(4).
13. Jaekel J, Baumann N, Bartmann P, Wolke D. Mood and anxiety disorders in very preterm/very low-birth weight individuals from 6 to 26 years. *J Child Psychol Psychiatry.* 2018; 59(1):88-95. doi: 10.1111/jcpp.12787
14. McGowan JE, Alderdice FA, Holmes VA, Johnston L. Early childhood development of late-preterm infants: A systematic review. *Pediatrics.* 2011;127(6):1111-24.
15. D'Onofrio BM, Class QA, Rickert ME, Larsson H, Långström N, Lichtenstein P. Preterm birth and mortality and morbidity: A population-based quasi-experimental study. *JAMA Psychiatry.* 2013;70(11):10.1001/jamapsychiatry.2013.2107.
16. Copeland WE, Wolke D, Shanahan L, Costello EJ. Adult functional outcomes of common childhood psychiatric problems: A prospective, longitudinal study. *JAMA Psychiatry.* 2015;72(9):892-899.
17. Lindstrom K, Winbladh B, Haglund B, Hjern A. Preterm infants as young adults: A Swedish national cohort study. *Pediatrics.* 2007;120(1):70-77.
18. Mathiasen R, Hansen BM, Nybo Anderson AM, Greisen G. Socio-economic achievements of individuals born very preterm at the age of 27 to 29 years: A nationwide cohort study. *Dev Med Child Neurol.* 2009;51(11):901-908.

19. Moster D, Lie RT, Markestad T. Long-term medical and social consequences of preterm birth. *N Engl J Med.* 2008;359(3):262-273.
20. Swamy GK, Ostbye T, Skjaerven R. Association of preterm birth with long-term survival, reproduction, and next-generation preterm birth. *JAMA.* 2008;299(12):1429-1436.
21. Petrou S. The economic consequences of preterm birth during the first 10 years of life. *BJOG.* 2005;112(Suppl 1):10-15.
22. Basten M, Jaekel J, Johnson S, Gilmore C, Wolke D. Preterm birth and adult wealth: Mathematics skills count. *Psychol Sci.* 2015;26(10):1608-1619.
23. Hack M, Flannery DJ, Schluchter M, Cartar L, Borawski E, Klein N. Outcomes in young adulthood for very-low-birth-weight infants. *N Engl J Med.* 2002;346(3):149-157.
24. Dobson KG, Ferro MA, Boyle MH, Schmidt LA, Saigal S, Van Lieshout RJ. Socioeconomic attainment of extremely low birth weight survivors: The role of early cognition. *Pediatrics.* 2017;139(3).doi: 10.1542/peds.2016-2545
25. Saigal S, Stoskopf B, Streiner D, Boyle M, Pinelli J, Paneth N, Goddeeris J. Transition of extremely low-birth-weight infants from adolescence to young adulthood: comparison with normal birth-weight controls. *JAMA.* 2006;295(6):667-675.
26. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med.* 2009;6(7):e1000097.
27. Boyle MH, Miskovic V, Van Lieshout R, Duncan L, Schmidt LA, Hoult L, Paneth N, Saigal S. Psychopathology in young adults born at extremely low birth weight. *Psychol Med.* 2011;41(8):1763-1774.
28. Wells GA SB, O'Connell D, et al. *TheNewcastle-Ottawa Scale (NOS) for Assessing the Quality of Nonrandomized Studies in Metaanalysis.* Ottawa, Canada: Ottawa Health Research Institute; 1999.
29. Männistö T, Vääräsmäki M, Sipola-Leppänen M, et al. Independent Living and Romantic Relations Among Young Adults Born Preterm. *Pediatrics.* 2015;135(2):290-297.
30. Borenstein M HL, Higgins J,, H. R. *Comprehensive Meta Analysis. Version 2.* Englewood, NJ: Biostat; 2005.
31. Borenstein M HL, Higgins JPT,, HR R. *Introduction to Meta Analysis.* Chichester, United Kingdom: John Wiley & Sons; 2009.
32. Duval S, Tweedie R. A nonparametric "trim and fill" method of accounting for publication bias in meta-analysis. *J Am Stat Assoc.* 2000;95(449):89-98.
33. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. *Biometrics.* 1994;50(4):1088-1101.
34. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ.* 1997;315(7109):629-634.
35. Baumann N, Bartmann P, Wolke D. Health-related quality of life into adulthood after very preterm birth. *Pediatrics.* 2016;137(4): e20153148
36. Terrin N, Schmid CH, Lau J, Olkin I. Adjusting for publication bias in the presence of heterogeneity. *Stat Med.* 2003;22(13):2113-2126.
37. Ioannidis JP, Trikalinos TA. The appropriateness of asymmetry tests for publication bias in meta-analyses: A large survey. *Can Med Assoc J.* 2007;176(8):1091-1096.
38. Bown MJ, Sutton AJ. Quality control in systematic reviews and meta-analyses. *Eur J Vasc Endovasc Surg.* 2010;40(5):669-677.

39. Wolke D, Sohne B, Ohrt B, Riegel K. Follow-up of preterm children: Important to document dropouts. *Lancet.* 1995;345(8947):447.
40. Hille ET, Elbertse L, Gravenhorst JB, Brand R, Verloove-Vanhorick SP. Nonresponse bias in a follow-up study of 19-year-old adolescents born as preterm infants. *Pediatrics.* 2005;116(5):e662-666.
41. OECD. Employment rate (indicator). 2018. doi: 10.1787/1de68a9b-en. (Accessed on 18 January 2018).
42. Lawn JE, Davidge R, Paul VK, et al. Born too soon: Care for the preterm baby. *Reprod Health.* 2013;10(Suppl 1):S5-S5.
43. Giuliano P. Living arrangements in Western Europe: Does cultural origin matter? *J Eur Econ Assoc.* 2007;5(5):927-952.
44. Hill AB. The environment and disease: Association or causation? *Proc R Soc Med.* 1965;58(5):295-300.
45. Johnson S, Wolke D. Behavioural outcomes and psychopathology during adolescence. *Early Hum Dev.* 2013;89(4):199-207.
46. Peterson BS, Anderson AW, Ehrenkranz R, et al. Regional brain volumes and their later neurodevelopmental correlates in term and preterm infants. *Pediatrics.* 2003;111(5 Pt 1):939-948.
47. Volpe JJ. Brain injury in premature infants: a complex amalgam of destructive and developmental disturbances. *Lancet Neurol.* 2009;8(1):110-124.
48. Nosarti C, Giouroukou E, Healy E, et al. Grey and white matter distribution in very preterm adolescents mediates neurodevelopmental outcome. *Brain.* 2008;131(Pt 1):205-217.
49. Young JM, Powell TL, Morgan BR, et al. Deep grey matter growth predicts neurodevelopmental outcomes in very preterm children. *NeuroImage.* 2015;111:360-368.
50. Parker JD, Schoendorf KC, Kiely JL. Associations between measures of socioeconomic status and low birth weight, small for gestational age, and premature delivery in the United States. *Ann Epidemiol.* 1994;4(4):271-278.
51. Koupilová, Vågerö, Leon, et al. Social variation in size at birth and preterm delivery in the Czech Republic and Sweden, 1989–91. *Paediatr Perinat Epidemiol.* 1998;12(1):7-24.
52. Olsen P, Laara E, Rantakallio P, Jarvelin MR, Sarpola A, Hartikainen AL. Epidemiology of preterm delivery in two birth cohorts with an interval of 20 years. *Am J Epidemiol.* 1995;142(11):1184-1193.
53. Weightman AL, Morgan HE, Shepherd MA, Kitcher H, Roberts C, Dunstan FD. Social inequality and infant health in the UK: Systematic review and meta-analyses. *BMJ Open.* 2012;2(3).
54. Weisglas-Kuperus N, Hille ET, Duivenvoorden HJ, et al. Intelligence of very preterm or very low birthweight infants in young adulthood. *Arch Dis Child Fetal Neonatal Ed.* 2009;94(3):F196-200.
55. Eryigit Madzwamuse S, Baumann N, Jaekel J, Bartmann P, Wolke D. Neuro-cognitive performance of very preterm or very low birth weight adults at 26 years. *J Child Psychol Psychiatry.* 2015;56(8):857-864.
56. Ekeus C, Lindstrom K, Lindblad F, Rasmussen F, Hjern A. Preterm birth, social disadvantage, and cognitive competence in Swedish 18- to 19-year-old men. *Pediatrics.* 2010;125(1):e67-73.

57. Ancel PY, Goffinet F, Kuhn P, et al. Survival and morbidity of preterm children born at 22 through 34 weeks' gestation in France in 2011: results of the EPIPAGE-2 cohort study. *JAMA Pediatr.* 2015;169(3):230-238.
58. Fellman V, Hellstrom-Westas L, Norman M, et al. One-year survival of extremely preterm infants after active perinatal care in Sweden. *JAMA.* 2009;301(21):2225-2233.
59. Allin M, Rooney M, Cuddy M, et al. Personality in young adults who are born preterm. *Pediatrics.* 2006;117(2):309-316.
60. Batsvik B, Vederhus BJ, Halvorsen T, Wentzel-Larsen T, Graue M, Markestad T. Health-related quality of life may deteriorate from adolescence to young adulthood after extremely preterm birth. *Acta Paediatr.* 2015;104(9):948-955.
61. Cooke RW. Health, lifestyle, and quality of life for young adults born very preterm. *Arch Dis Child.* 2004;89(3):201-206.
62. Dalziel SR, Lim VK, Lambert A, et al. Psychological functioning and health-related quality of life in adulthood after preterm birth. *Dev Med Child Neurol.* 2007;49(8):597-602.
63. Darlow BA, Horwood LJ, Pere-Bracken HM, Woodward LJ. Psychosocial outcomes of young adults born very low birth weight. *Pediatrics.* 2013;132(6):e1521-1528.
64. Heinonen K, Eriksson JG, Kajantie E, et al. Late-preterm birth and lifetime socioeconomic attainments: The Helsinki birth cohort study. *Pediatrics.* 2013;132(4):647-655.
65. Kajantie E, Hovi P, Raikkonen K, et al. Young adults with very low birth weight: leaving the parental home and sexual relationships--Helsinki study of Very Low Birth Weight Adults. *Pediatrics.* 2008;122(1):e62-72.
66. Kroll J, Karolis V, Brittain PJ, et al. Real-life impact of executive function impairments in adults who were born very preterm. *J Int Neuropsychol Soc.* 2017;23(5):381-389.
67. Lærum AMW, Reitan SK, Evensen KAI, et al. Psychiatric disorders and general functioning in low birth weight adults: A longitudinal study. *Pediatrics.* 2017;139(2). doi: 10.1542/peds.2016-2135
68. Lefebvre F, Mazurier E, Tessier R. Cognitive and educational outcomes in early adulthood for infants weighing 1000 grams or less at birth. *Acta Paediatr.* 2005;94(6):733-740.
69. Odberg MD, Elgen IB. Low birth weight young adults: quality of life, academic achievements and social functioning. *Acta Paediatr.* 2011;100(2):284-288.
70. Winstanley A, Lamb ME, Ellis-Davies K, Rentfrow PJ. The subjective well-being of adults born preterm. *J Res Pers.* 2015;59:23-30.

**Table 1.** Summary of the Studies Included in the Analysis of Wealth in Adulthood after preterm birth/low birth weight (18 years or above)

| Author(s) (Year) | Country | Year of Birth | Number of Participants | | Male N(%) | | Outcome Assessment Age (Mean or Range) | Degree of Prematurity | Registry/ Cohort (Name) | Measured Variable(s) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | PT | FT | PT | FT | | | | |
| Allin et al. (2006)[59] | UK | 1979-1981 | 108 | 67 | 51 (47.2%) | 39 (51.2%) | 18 to 19y | VPT | Cohort-NA | Higher education qualifications, employment |
| Basten et al. (2015)[22] BCS | UK | 1958-1970 | 320 | 6378 | 158 (49.4%) | 3045 (47.7%) | 42y | VPT, MLPT | Cohort- the British Cohort Study (BCS) | Higher education qualifications, employment |
| Basten et al. (2015)[22] NCDS | UK | 1958- 1970 | 403 | 8170 | 202 (50.1%) | 4054 (49.6%) | 42y | VPT, MLPT | Cohort- National Child Development Study (NCDS) | Higher education qualifications, employment |
| Batsvik et al. (2015)[60] | Norway | 1982-1985 | 37 | 46 | 19 (51.4%) | 25 (54.4%) | 24y | EPT | Cohort-NA | Higher education qualifications, employment, benefits, independent living |
| Baumann et al. (2016)[35] | Germany | 1985-1986 | 260 | 229 | 118 (45.3%) | 130 (53.7%) | 26y | VPT/ VLBW | Cohort- Bavarian Longitudinal Study | Employment, benefits, independent living |
| Cooke (2004)[61] | UK | 1980-1983 | 79 | 71 | 35 (44.3%) | 30 (42.3%) | 20y | PT | Cohort-NA | Higher education qualifications, employment |
| Dalziel et al. (2007)[62] | New Zealand | 1969-1974 | 126 | 66 | 66 (52.3%) | 33 (50%) | 31y | PT | Cohort-The Auckland Steroid Trial | Higher education qualifications |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Darlow, Horwood, Pere-Bracken & Woodward (2013)[63] | New Zealand | 1986 | 230 | 69 | 104 (45.2%) | 33 (47.8%) | 22 to 23y | VLBW | Cohort- NA | Higher education qualifications, employment, benefits |
| D'Onofrio (2013)[15] | Sweden | 1973–2008 | 154322 | 3,146,386 | 85195 (55.2%) | 1618442 (51.4%) | 38y | VPT & MLPT | Registry | Higher education qualifications, benefits |
| Hack et al. (2002)[23] | USA | 1977-1979 | 242 | 233 | 116 (48%) | 108 (46%) | 20y | VLBW | Cohort- NA | Higher education qualifications |
| Heinonen et al. (2013)[64] | Finland | 1934-1944 | 486 | 8507 | 262 (53.9%) | 4506 (53%) | 56 to 66y | MLPT | Cohort- Helsinki Birth Cohort Study | Higher education qualifications, employment |
| Kajantie et al. (2008)[65] | Finland | 1978-1985 | 162 | 188 | 68 (42%) | 75 (39.9%) | 22.3y | VLBW | Cohort: Helsinki Study of Very Low Birth Weight Adults | Independent living |
| Kroll et al. (2017)[66] | UK | 1979-1984 | 122 | 89 | 76(62%) | 42(47%) | 31.2y | VPT | Cohort-NA | Higher education qualifications, employment, |
| Lærum et al. (2017)[67] | Norway | 1986-1988 | 44 | 81 | 21 (48%) | 38 (47%) | 26y | VLBW | Cohort-NA | Higher education qualifications, employment, social benefits |
| Lefebvre, Mazurier, & Tessier (2005)[68] | Canada | 1976-1981 | 69 | 44 | 29 (42%) | 15 (34.1%) | 18y | ELBW | Cohort- NA | Higher education qualifications |
| Lindstrom, Winbladh, Haglund, & Hjern (2007)[17] | Sweden | 1973-1979 | 90654 | 431,656 | 49242 (54.3%) | 220310 (51%) | 23y to 29y | VPT & MLPT | Registry | Higher education qualifications, employment, benefits, independent living |
| Mannisto et al. (2015)[29] | Finland | 1985-1989 | 397 | 356 | 189 (47.6%) | 170 (47.8%) | 23.2y | VPT & MLPT | Cohort- ESTER | Independent living |
| Mathiasen et al. (2009)[18] | Denmark | 1974-1976 | 1422 | 192,233 | 736 (51.8%) | 98240 (51.1%) | 27y to 29y | VPT | Registry | Higher education qualifications, employment, benefits, independent living |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Moster, Terje Lie, & Markestad (2008)[19] | Norway | 1967-1983 | 39465 | 828,227 | 21715 (55%) | 421568 (50.9 %) | 19y to 35y | VPT & MLPT | Registry | Higher education qualifications, employment, benefits |
| Odberg & Elgen (2011)[69] | Norway | 1986-1988 | 134 | 135 | 61 (54%) | 64 (53%) | 18y 11m | <2000 gr | Cohort | Higher education qualifications |
| Saigal, Day et al. (2016)[6]* | Canada | 1977-1982 | 100 | 89 | 39 (39.0%) | 33 (37.1%) | 32.3y | ELBW | Cohort-McMaster ELBW Cohort | Higher education qualifications, employment |
| Saigal, Stoskopf et al. (2006)[25]* | Canada | 1977-1982 | 149 | 133 | 67 (45%) | 60 (45%) | 23.5y | ELBW | Cohort-McMaster ELBW Cohort | Independent living |
| Swamy, Ostbye, & Skjaerven (2008)[20] | Norway | 1967-1988 | 64956 | 1,648,496 | 33754 (60%) | 566339 (33.7%) | NA | VPT & MLPT | Registry | Higher education qualifications |
| Winstanley, Lamb, Ellis-Davies, & Rentfrow (2015)[70]** | UK | NA | 11,592 | 51,460 | 3554 (30.7%) | 8038 (69.3%) | 31.4y | PT | Cohort-NA | Employment |

PT: Preterm, FT: Full-term, VPT: Very Preterm (<32 weeks gestation), MLPT: Moderate-to-Late Preterm (32-36 weeks); LBW: Low Birth Weight (<2500 gr); VLBW: Very Low Birth Weight (<1500 gr); ELBW: Extremely Low Birth Weight (<1000 gr); VPT/VLBW: Very Preterm/Very Low Birth Weight. NA: not available.

* Same cohort reporting on different age groups. Saigal (2006) was included in the analysis for independent living.

**Please note that in this study preterm birth was self-reported in an online survey

**Table 2.** Associations between preterm birth/low birth weight and higher education qualifications and employment in adulthood

| | Data Points | OR | 95% CI lower bound | 95% CI upper bound | Cochran's Q | $I^2$ | Test for heterogeneity (P value) |
|---|---|---|---|---|---|---|---|
| **Higher Education Qualifications*** | | | | | | | |
| All Studies | 18 | 0.74 | 0.69 | 0.80 | 111.63 | 85 | <0.001 |
| *Degree of Prematurity*** | | | | | | | |
| MLPT (32-36 weeks GA) | 10 | 0.82 | 0.78 | 0.85 | 40.88 | 78 | <0.001 |
| VPT (< 32 weeks GA) | 15 | 0.60 | 0.48 | 0.74 | 263.05 | 95 | <0.001 |
| *Age* | | | | | | | |
| Young Adulthood (18-29 years) | 9 | 0.61 | 0.49 | 0.77 | 14.01 | 43 | 0.08 |
| Middle Adulthood (≥30 years) | 9 | 0.77 | 0.72 | 0.84 | 89.60 | 91 | <0.001 |
| *Study Type* | | | | | | | |
| Cohort | 14 | 0.59 | 0.48 | 0.72 | 27.88 | 53 | 0.01 |
| Registry | 4 | 0.79 | 0.74 | 0.85 | 73.72 | 96 | <0.001 |
| *Region* | | | | | | | |
| Australasia | 2 | 0.59 | 0.26 | 1.32 | 2.98 | 66 | 0.08 |
| Europe | 13 | 0.76 | 0.71 | 0.82 | 99.23 | 88 | <0.001 |
| North America | 3 | 0.66 | 0.49 | 0.90 | 0.84 | 0 | 0.66 |
| **Employment** | | | | | | | |
| All Studies | 15 | 0.83 | 0.74 | 0.92 | 144.45 | 90 | <0.001 |
| *Degree of Prematurity*** | | | | | | | |
| MLPT (32-36 weeks GA) | 7 | 0.87 | 0.76 | 0.99 | 119.68 | 95 | <0.001 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| VPT (< 32 weeks GA) | 10 | 0.81 | 0.70 | 0.95 | 27.61 | 67 | 0.001 |
| *Age* | | | | | | | |
| Young Adulthood (18-29 years) | 8 | 0.86 | 0.73 | 1.02 | 21.69 | 68 | 0.003 |
| Middle Adulthood (≥30 years) | 7 | 0.76 | 0.62 | 0.93 | 122.10 | 95 | <0.001 |
| *Study Type* | | | | | | | |
| Cohort | 12 | 0.76 | 0.61 | 0.95 | 24.36 | 55 | 0.01 |
| Registry | 3 | 0.91 | 0.86 | 0.97 | 12.59 | 84 | 0.002 |
| *Region* | | | | | | | |
| Australasia | 1 | 0.70 | 0.38 | 1.28 | - | - | - |
| Europe | 13 | 0.84 | 0.75 | 0.93 | 140.21 | 91 | <0.001 |
| North America | 1 | 0.37 | 0.15 | 0.93 | - | - | - |

*Higher education qualifications refer to attainment of qualifications beyond high school.**Please note that the number of data points are higher in the degree of prematurity analysis since some studies reported on more than one degree of prematurity. MLPT: Moderate to Late Preterm; VPT: Very Preterm. GA: Gestational Age. Young Adulthood: Between 18 and 29 years; Middle Adulthood: 30 years and above.

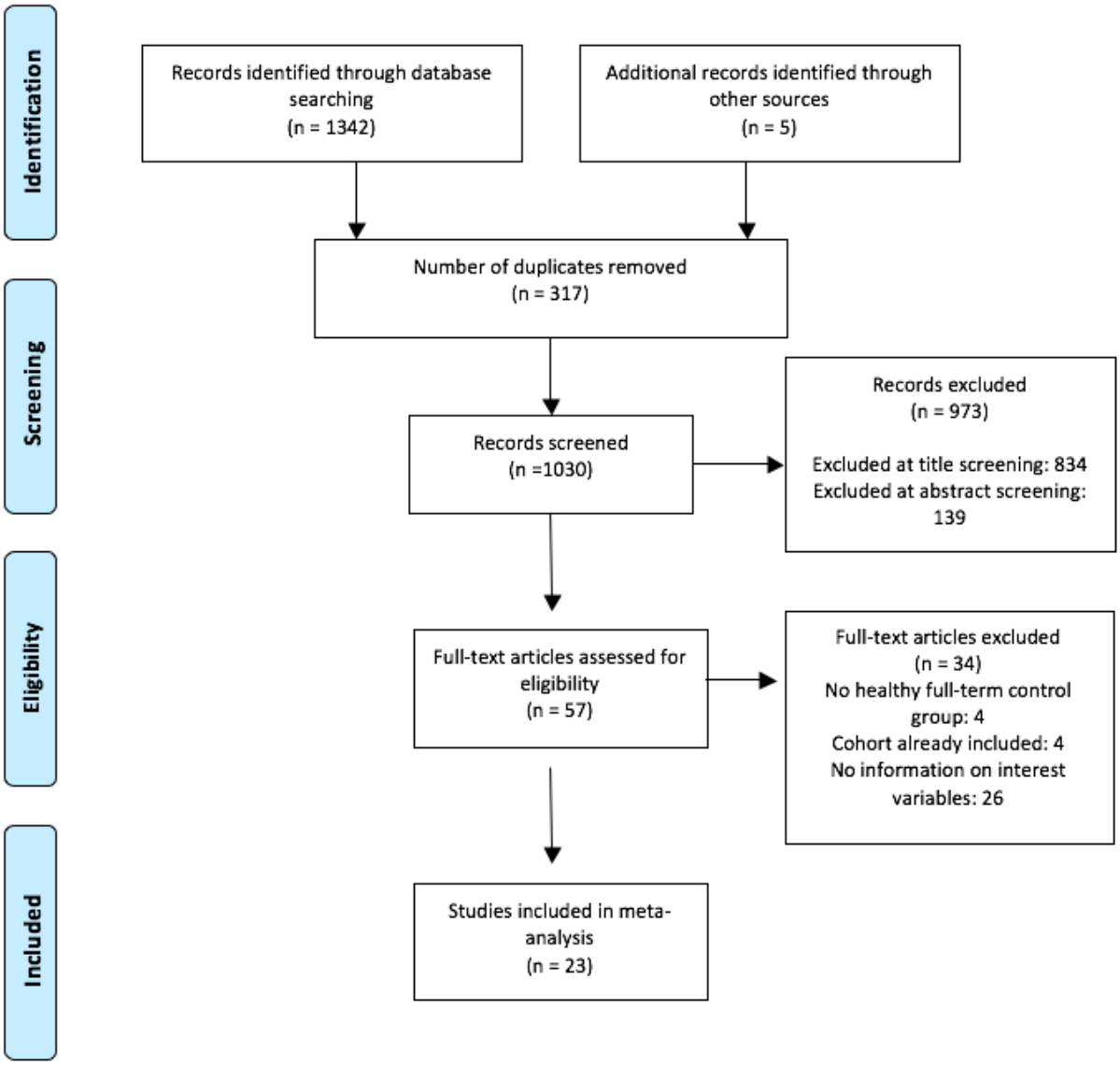
**Table 3.** Associations between preterm birth/low birth weight and benefits and independent living in adulthood

| | Data Points | OR | 95% CI lower bound | 95% CI upper bound | Cochran's Q | $I^2$ | Test for heterogeneity (P value) |
|---|---|---|---|---|---|---|---|
| **Social Benefits** | | | | | | | |
| All Studies | 7 | 1.25 | 1.09 | 1.42 | 148.92 | 96 | <0.001 |
| *Degree of Prematurity** | | | | | | | |
| MLPT (32-36 weeks GA) | 3 | 1.16 | 1.14 | 1.19 | 2.93 | 32 | 0.23 |
| VPT (< 32 weeks GA) | 7 | 1.78 | 1.09 | 2.91 | 236.91 | 97 | <0.001 |
| *Age* | | | | | | | |
| Young Adulthood (18-29 years) | 5 | 2.12 | 1.00 | 4.48 | 116.89 | 97 | <0.001 |
| Middle Adulthood (≥30 years) | 2 | 1.14 | 1.05 | 1.24 | 24.77 | 96 | <0.001 |
| *Study Type* | | | | | | | |
| Cohort | 3 | 3.98 | 1.39 | 11.37 | 2.77 | 28 | 0.25 |
| Registry | 4 | 1.18 | 1.04 | 1.35 | 133.23 | 98 | <0.001 |
| *Region* | | | | | | | |
| Australasia | 1 | 2.67 | 1.51 | 4.75 | - | - | - |
| Europe | 6 | 1.20 | 1.05 | 1.37 | 139.98 | 96 | <0.001 |
| North America | 0 | - | - | - | - | - | - |
| **Independent Living** | | | | | | | |
| All Studies | 7 | 0.78 | 0.60 | 1.01 | 31.13 | 80.72 | <0.001 |
| *Degree of Prematurity** | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| MLPT (32-36 weeks GA) | 2 | 0.73 | 0.30 | 1.77 | 8.49 | 88 | 0.004 |
| VPT (< 32 weeks GA) | 6 | 0.84 | 0.62 | 1.15 | 26.89 | 81 | 0.27 |
| *Age*** | | | | | | | |
| Young Adulthood (18-29 years) | - | - | - | - | - | - | - |
| Middle Adulthood (≥30 years) | - | - | - | - | - | - | - |
| *Study Type* | | | | | | | |
| Cohort | 5 | 0.59 | 0.44 | 0.79 | 5.11 | 22 | 0.28 |
| Registry | 2 | 1.09 | 1.01 | 1.18 | 1.37 | 27 | 0.24 |
| *Region* | | | | | | | |
| Australasia | 0 | - | - | - | - | - | - |
| Europe | 6 | 0.81 | 0.62 | 1.07 | 26.49 | 81.00 | <0.001 |
| North America | 1 | 0.66 | 0.41 | 1.06 | - | - | - |

*Please note that the number of data points are higher in the degree of prematurity analysis since some studies reported on more than one degree of prematurity. MLPT: Moderate to Late Preterm; VPT: Very Preterm. GA: Gestational Age. Young Adulthood: Between 18 and 29 years ; Middle Adulthood: 30 years and above. **Please note that all studies reported on independent living had young adult participants. *** Please note that in one study (Mannisto et al., 2015) the gestational age range for VPT group was overlapping with MLPT, thus independent living data of VPT group of that study was omitted from all analyses.

**Figure 1.** Flow diagram

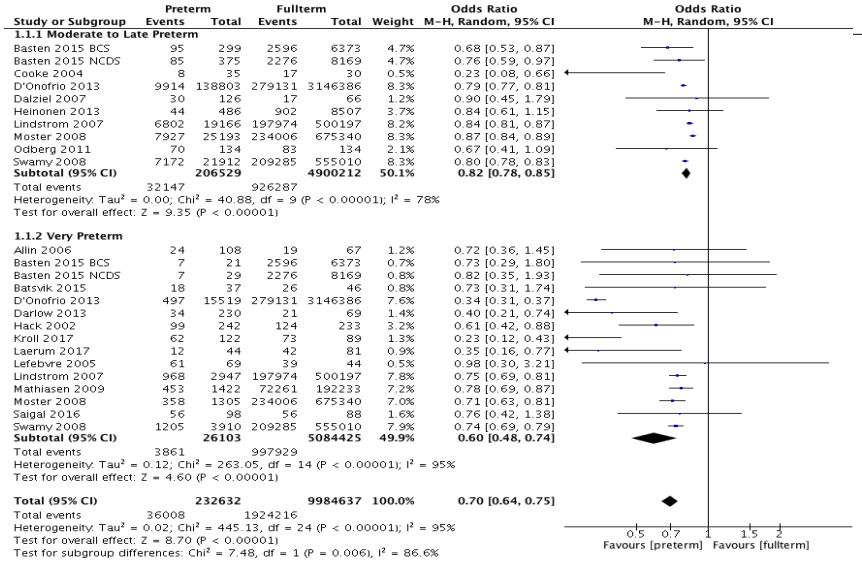


**Supplemental Table 1**. Newcastle-Ottawa Quality Assessment Scale- Cohort Studies

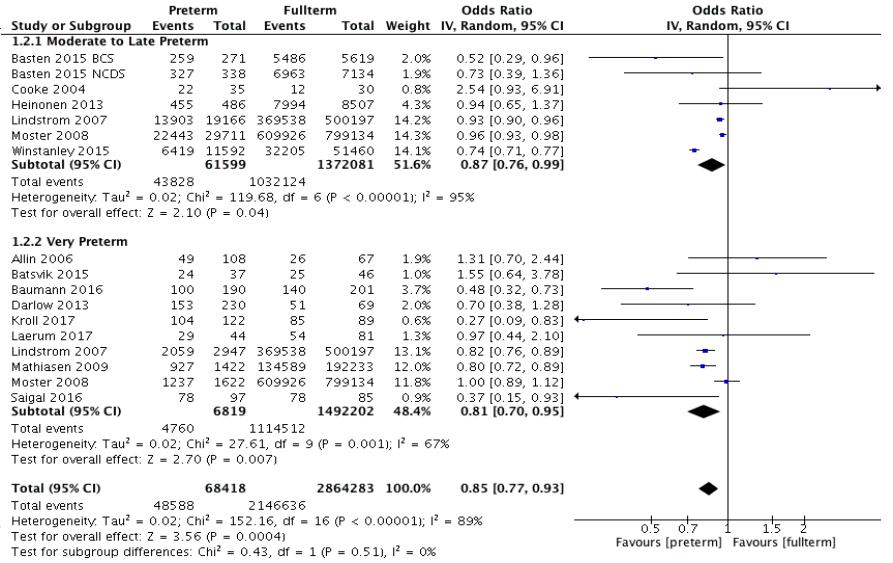
| **Selection** | | | | **Comparability** | **Outcome** | | |
|---|---|---|---|---|---|---|---|
| Representativeness of the exposed cohort<br>a) truly representative of the average _____ (describe) in the community *****<br>b) somewhat representative of the average _____ in the community *****<br>c) selected group of users eg nurses, volunteers<br>d) no description of the derivation of the cohort | Selection of the non-exposed cohort<br>a) drawn from the same community as the exposed cohort *****<br>b) drawn from a different source<br>c) no description of the derivation of the non-exposed cohort | Ascertainment of exposure<br>a) secure record (eg surgical records) *****<br>b) structured interview *****<br>c) written self-report<br>d) no description | Demonstration that outcome of interest was not present at start of study<br>a) yes *****<br>b) no | Comparability of cohorts on the basis of the design or analysis<br>a) study controls for _____ (select the most important factor) *****<br>b) study controls for any additional factor ***** (This criteria could be modified to indicate specific control for a second important factor.) | Assessment of outcome<br>a) independent blind assessment *****<br>b) record linkage *****<br>c) self-report<br>d) no description | Was follow-up long enough for outcomes to occur<br>a) yes (select an adequate follow up period for outcome of interest) *****<br>b) no | Adequacy of follow up of cohorts<br>a) complete follow up - all subjects accounted for *****<br>b) subjects lost to follow up unlikely to introduce bias - small number lost - > ____ % (select an adequate %) follow up, or description provided of those lost) *****<br>c) follow up rate < ____% (select an adequate %) and no description of those lost<br>d) no statement |

**Supplemental Figure 1.** Forest plot of the association between preterm birth and markers of wealth in adulthood by degree of prematurity

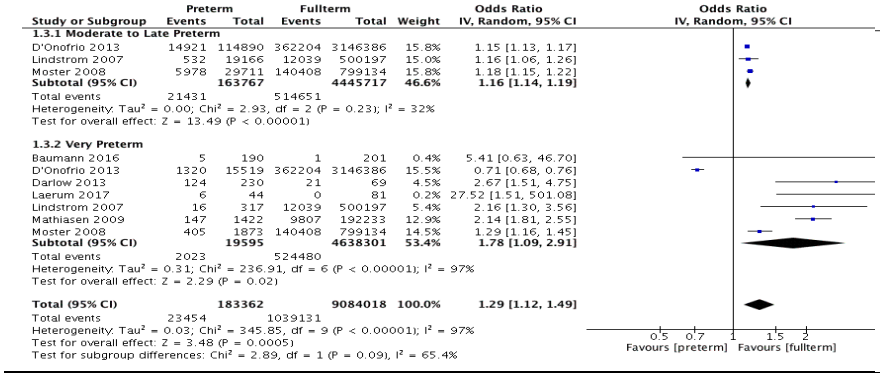
**A**



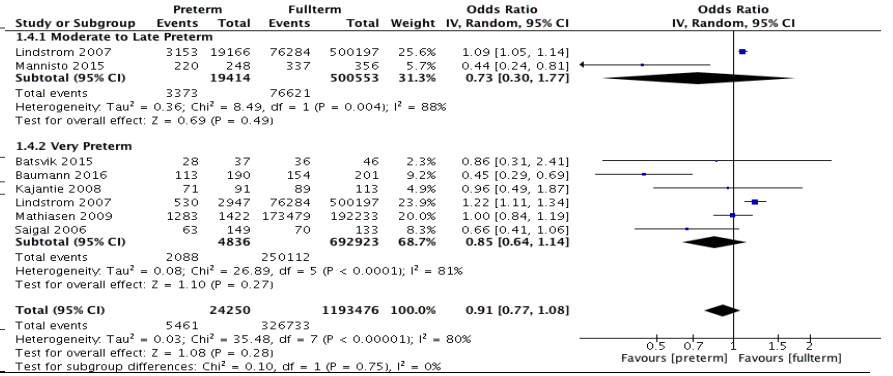

**B**




**C**

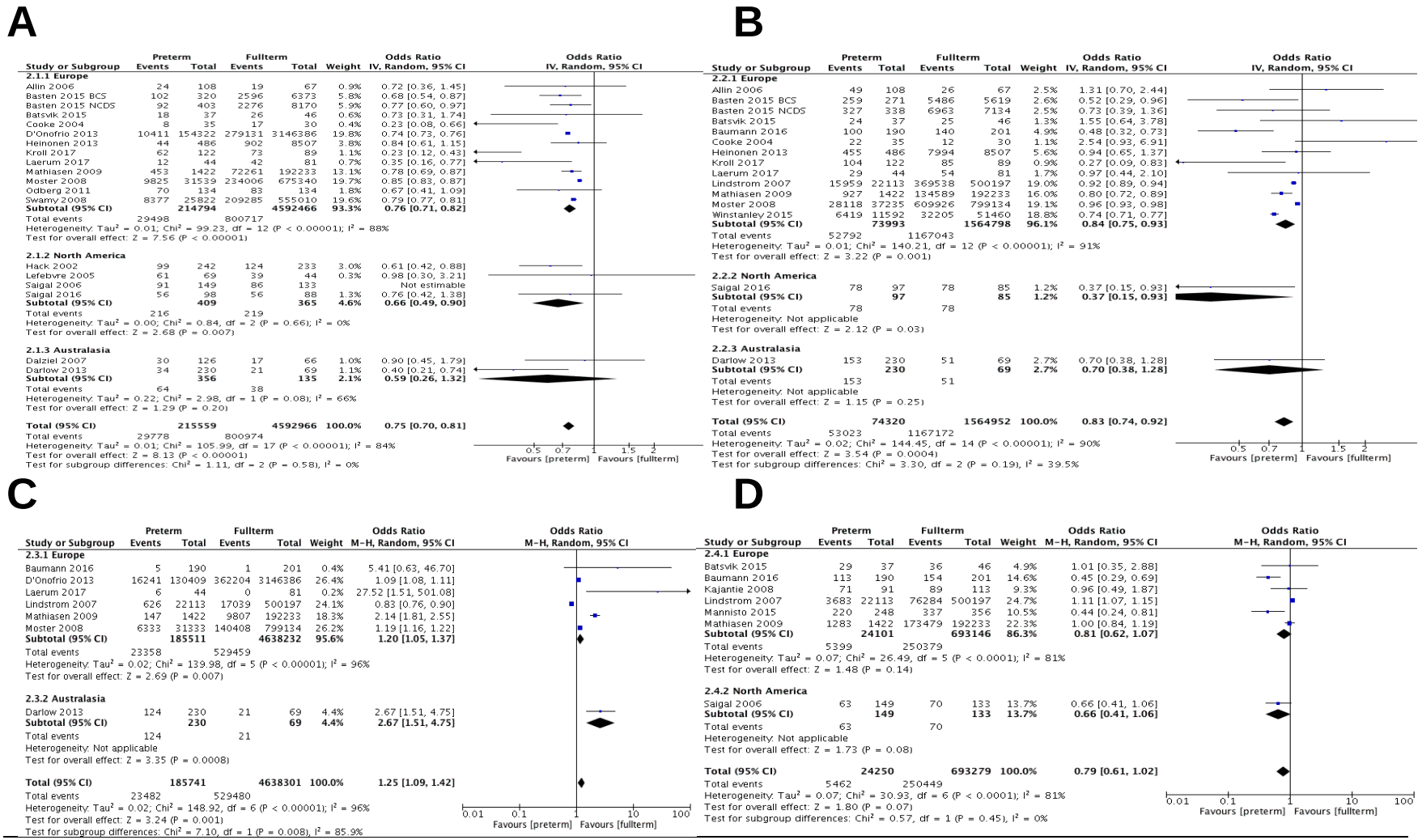



**D**




**A:** Higher education qualification**, B:** Employment**, C:** Social benefits**, D:** Independent living

**Supplemental Figure 2**. Forest plot of the association between preterm birth and markers of wealth in adulthood by region




**A:** Higher education qualification**, B:** Employment**, C:** Social benefits**, D:** Independent living