Physical and shift work in pregnancy

Occupational aspects of management

A national guideline

Royal College of Physicians

Setting higher medical standards

NHS Plus

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Contents

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Conflicts of interest: none declared.

Executive summary

The purpose of these guidelines is to enable consistent evidence-based advice to be given in relation to pregnant women who are exposed to hazards at work. The guidance is intended for use by health professionals who are advising working women and their employers. The document is focused on a number of specific hazards, namely lifting/manual handling and heavy physical work, prolonged standing, long working hours and shift work (including night shifts). The evidence considered applies to women who are well during their pregnancy; those with pregnancy-related complications need to be considered on an individual basis.

The production of this full guideline and the accompanying short guidance documents for employers, employees and health professionals was overseen by a steering committee, the Guideline Development Group (GDG). The GDG provided multidisciplinary, practitioner-based input both to the process and the emerging messages for practice, and aimed to reduce author bias.

The GDG agreed the scope of the guideline in advance, including the key questions to be addressed. Subsequently a literature search, based upon the key questions, was undertaken by two librarians at the Department of Health. This yielded 270 abstracts, from which selected papers were retrieved according to pre-determined inclusion criteria. Thirty-seven relevant papers met the inclusion criteria and were critically appraised by members of the GDG.

Each paper was appraised using the Scottish Intercollegiate Guidelines Network (SIGN) system. Papers were assigned a SIGN grade, which took account of the type of study and the methodological rigour. In order to increase the consistency and transparency of assignment of the SIGN grading, a standardised scoring system was devised and used by appraisers to assess important methodological limitations such as response rates, bias and confounding. Based upon the critical appraisals, the volume and quality of evidence was synthesised using the SIGN method and a series of graded recommendations were made.

The results show that there is consistent evidence of risk for some adverse pregnancy outcomes in relation to lifting and heavy work, prolonged standing and long working hours, but the level of risk is small. There was reasonable evidence that shift work is not associated with a high risk of adverse pregnancy outcome, although there was some conflicting evidence and further research in this area would be helpful. Apart from one high quality systematic review (including a meta-analysis and rated 1++ according to the SIGN convention), quality ratings were confined to SIGN category 2++ or below. This was partly due to a reliance on observational studies, which are common in occupational epidemiology. Whilst the number of research papers was large for some adverse pregnancy outcomes it was small for others, in particular pre-eclampsia. There were conflicting results for some outcome-exposure combinations (particularly preterm birth with heavy physical work, and preterm birth with shift or night work). Because of these uncertainties, and to adopt a precautionary approach, recommendations have been made for employers to reduce exposure to lifting, heavy physical work and prolonged standing for pregnant employees. Due to a lack of detailed evidence, it was not possible to specify either the level of exposure at which adjustments should be applicable or the stage of pregnancy at which they should be implemented for some of the outcome-exposure combinations. None of the risks were sufficiently strong to justify mandatory exclusion of pregnant women from work for any of the exposures that were considered.

Glossary

Birth weight:
Low birth weight Birth weight <2500 g
Very low birth weight Birth weight <1500 g
Extremely low birth weight Birth weight <1000 g

Dubowitz score A method of clinical assessment in the newborn from birth until five days old that includes neurological criteria for the infant's maturity and other physical criteria to determine gestational age.

Gestation The time from conception to birth. The duration of gestation is measured from the first day of the last normal menstrual period.

Hypertension Diastolic BP ≥110 mmHg on any one occasion, or diastolic BP ≥90 mmHg on two or more consecutive occasions more than four hours apart.
Systolic BP 30 mmHg above earliest recorded in pregnancy or diastolic increase of 15–25 mmHg.

Moderate hypertension (2 readings of >100 mmHg diastolic blood pressure) with significant proteinuria and at least 2 signs or symptoms of imminent eclampsia, will include many women with severe pre-eclamptic toxaemia (PET).

Severe hypertension A diastolic blood pressure >110 mmHg on two occasions, *or* systolic blood pressure >170 mmHg on two occasions.

Intra uterine growth restriction (IUGR) This is a term often used interchangeably with the term SGA (small for gestational age). However, IUGR strictly refers to babies that have failed to reach their genetic growth potential during pregnancy. They are frequently but not always SGA. SGA is variably defined as a baby/fetus with measurements less than the 3rd centile, 5th centile or 10th centile.

Late fetal loss A death occurring between 22 weeks + 0 days and 23 weeks + 6 days. If gestation is not known or not sure, all births of at least 300 g are reported. Late fetal loss and stillbirth are distinguished by gestational age at the time of delivery, which is not necessarily the time of death (CESDI).

Miscarriage The spontaneous loss of a pregnancy before 24 completed weeks of gestation.

Pre-eclampsia Pregnancy-induced hypertension in association with proteinuria (>0.3 g/24 hours) + oedema and virtually any organ system may be affected (eg cardio-vascular, renal, central nervous system, hepatic, coagulation and placenta).

Severe pre-eclampsia Severe hypertension associated with significant proteinuria (at least 1 g/l).

Prelabour rupture of membranes (PROM) Rupture of membranes with leakage of amniotic fluid in the absence of spontaneous uterine activity. Previously often described as premature rupture of membranes.

Preterm prelabour rupture of membranes PROM before 37 completed weeks of gestation.

Preterm labour Onset of labour before 37 completed weeks of gestation.

Preterm delivery Delivery of the fetus before 37 completed weeks of gestation.

Prolonged standing Continuous standing for more than three hours.

Small for gestational age (SGA) See IUGR.

Stillbirth (England and Wales) A child that has issued forth from its mother after the 24th week of pregnancy and which did not at any time, after being completely expelled from its mother, breathe or show any other signs of life.

Stillbirth (Northern Ireland) The complete expulsion from its mother after the 24th week of pregnancy of a child, which did not at any time after being completely expelled or extracted, breathe or show any other evidence of life.

(Note: before 1992, it was 28 weeks' gestation.)

The WHO has chosen 22 weeks rather than 24, but because of the difficulty in date accuracy they use fetal weight: death of a fetus at least 500 g before expulsion/extraction from its mother.

Threatened preterm labour Contractions or cervical change, before 37 weeks' gestation.

Trimester of pregnancy Pregnancy is traditionally divided into three time periods. The first trimester is from conception until 12 completed weeks' gestation. The third trimester is from 28 weeks until delivery.

1 Introduction

Aim

The broad aim of these guidelines is to provide evidence-based advice for health professionals advising pregnant women and employers with respect to identifiable hazards in the workplace. The scope of the document comprises the following specific hazards:

(1) Manual handling/lifting/heavy physical work
(2) Prolonged standing
(3) Long weekly working hours (typically >40 per week)
(4) Shift work including night work.

Background

Women at work

There has been a world-wide increase in the prevalence of women working during pregnancy.[59] In 1995 in the UK, 66% of women of working age were in employment. This figure had risen to 69% by 2000[26] and continued to rise. In 2004, seasonally adjusted figures for the spring quarter showed that 45% of the employed population were women. The majority of these (77%) were of child-bearing age (18–49 years old).[99,109] Over half of women who are pregnant in the UK are in paid employment during their pregnancy and 37% were still working within six weeks of delivery.[61] Every year around 350,000 women continue to work during their pregnancy and, of these, 69% return to work soon after giving birth (Tommy's website: www.tommys.org source: Department of Trade and Industry).

The majority of women remain well throughout their pregnancy. Pregnancy should not be regarded either as an illness or, generally, as a contraindication to work. Indeed there is some evidence of a beneficial effect of work on pregnancy. It has been suggested that the 'reproductive experience' of women who work is better than those who do not.[58] Some studies show that women who are employed have a lower risk of preterm delivery than those who are not.[23,38,138] However, a pregnant woman may be exposed, while at work, to particular hazards that might potentially cause adverse outcomes for mother or fetus. Therefore, where possible, steps should be taken to minimise exposure where there is sufficient evidence that the risk of maternal or fetal harm outweighs any benefit to health. A few workplace exposures (eg lead and ionising radiation)[1,2] are well established as being harmful during pregnancy and the need to limit exposure is explicit in statutory instruments in the UK. However for many other common workplace exposures, including some physical hazards, the evidence to inform a balanced assessment of risk is not available, or is uncertain.

Legal framework

A number of statutory instruments in the UK relate directly to the management of pregnant women at work. Employers have a statutory obligation, as governed by the Management of Health and Safety at Work Regulations 1999,[3] to protect the health and safety of new and expectant mothers. Once informed in writing, the employer is obliged to undertake an

individual risk assessment that aims to identify hazards and assess risks. The employer must take action to remove, reduce, or control any risks that are significant. In the event that significant risks cannot be controlled adequately, the employer has a duty to undertake a hierarchy of measures comprising temporary adjustment in working conditions, provision of alternative work or suspension on paid leave. The Employment Rights Act 1996[4] (amended by the Employment Relations Act 1999)[5] requires employers, when offering suitable alternative work, to ensure that this is appropriate and offered on terms and conditions that are no less favourable than the new or expectant mother's normal terms and conditions.

The Workplace (Health, Safety and Welfare) Regulations 1992[6] require employers to provide suitable rest facilities for workers who are pregnant or breastfeeding. These must be suitably located (eg near to toilets) and, where necessary, should provide appropriate facilities for the new or expectant mother to lie down.

Under the Sex Discrimination Act 1975[7] any breach of health and safety legislation in relation to new and expectant mothers is considered automatically to be sex discrimination.

The Council Directive 92/85/EEC of 19 October 1992 states that, '...pregnant workers [and] workers who have recently given birth or who are breastfeeding must be considered a specific risk group….and measures must be taken with regard to their safety and health'. It further advises that a risk assessment must be undertaken and that the worker is protected.[43]

Existing guidance

The Health and Safety Executive (HSE) provides guidance on risk assessment in respect of pregnant, newly delivered and breast-feeding mothers. This is provided in the form of two booklets which are targeted at employees and health advisers respectively: *A guide for new and expectant mothers who work*,[71] and *New and expectant mothers at work – a guide for health professionals*.[72]

However, with the exception of hazards that are governed by specific legislation, there are no clear guidelines regarding the level of risk at which adjustments to work should be made for pregnant workers, or what adverse outcomes might result from poor risk control. Moreover, existing guidance documents do not describe the scientific justification for decisions about risk controls. There is, therefore, a need for new evidence-based guidelines in this area. These will help to inform both employees and employers more fully of the nature and level of risk to pregnant and newly delivering mothers who work, and their offspring.

Epidemiology of adverse pregnancy outcomes

Fetal outcomes

The adverse outcomes that are measurable immediately after the end of a pregnancy (and which feature in the research literature on workplace hazards) include spontaneous miscarriage, preterm delivery, still birth and low birth weight. Approximately 15% of medically recognised pregnancies end in spontaneous miscarriage,[74] and around 7% of babies are delivered preterm. Figures from 2000 indicate that this rate is lower in Finland (6.3%), Sweden (5.8%), Denmark (3.3%), and Iceland (3.6%) than in the UK (7%).[60] In 1998, in England and Wales, 7.48% of live births were of low birth weight (<2500 g)[90] and the rate of still births per 1,000 total births was 3.9.[20,90] The UK has the highest rate of preterm delivery in Europe (www.tommys.org).

These adverse birth outcomes are clinically important. They are recognised risk factors for poor health in the perinatal period, childhood and even later in life. Birth weight[86] and gestational age are the most important neonatal risk factors that determine perinatal mortality.[83,169] Preterm birth is a major contributor to perinatal mortality and morbidity.[60,65,98,108,133] Low birth weight is related to neonatal mortality, a significant determinant of post-neonatal mortality and infant and childhood morbidity.[161] Moreover, there is considerable evidence that low birth weight predicts poor growth and development, and increases the risk of chronic diseases in adulthood, including coronary heart disease and stroke, hypertension, non-insulin-dependent diabetes, obstructive lung disease and neurological and cognitive impairment.[44,163]

Maternal outcomes

A number of complications of pregnancy that might occur during the period that women are still working can be regarded as adverse maternal outcomes. These include gestational hypertension and pre-eclampsia (gestational hypertension with proteinuria and oedema). Preterm delivery and spontaneous preterm prelabour rupture of membranes may pose a threat to both fetal and maternal health, for example by increasing the risk of intra-uterine infection, which may in turn lead to maternal and fetal sepsis.

Other outcomes

Complications of pregnancy may lead to an early or prolonged period of sickness absence or delayed return to work. These could be regarded as an adverse outcome for both the employee and employer. The tendency to take absence during pregnancy is strongly influenced by health, beliefs and health advice. Therefore, any relationship between workplace hazards and excess absence from work is likely to be biased by individual and societal perceptions of risks to a pregnancy.

General risk factors

There are a number of well-established predictors of adverse pregnancy outcome. These include maternal age, lower education level, low and high body mass index (BMI), smoking and low socio-economic status.[86,88] Others are specifically related to preterm birth[60] or to low birth weight, namely race, father's occupation, education level, history of previous miscarriage or preterm birth and, possibly, age and parity,[108] cigarette smoking, short maternal stature and poor nutrition before and during pregnancy.[86] Some of these factors are clearly more amenable to intervention than others, for example smoking. However, in theory, the majority of hazards to pregnancy that are encountered in the workplace can be modified.[140]

Occupation and pregnancy

A number of studies have pointed to an increased risk of adverse pregnancy outcomes in certain occupations. The McDonald series of papers[103–108] noted that, for fetal death, the odds ratios were significantly increased for nursing aides and orderlies, food and beverage servers and workers in factories ($p<0.01$). Late, but not early, spontaneous miscarriages were significantly raised in radiology technicians ($p<0.01$) and operating room nurses, and those working in agriculture and horticulture ($p<0.05$).[107]

For preterm birth, the observed/expected (O/E) ratios were significantly raised in the food and beverage services ($p=0.03$) and psychiatric nurses ($p<0.01$). The O/E ratios for low birth weight were also significantly raised in the food and beverage services ($p<0.05$), chambermaids and cleaners ($p=0.03$) and metal and electrical manufacturers ($p<0.01$).[107]

Nurses (excluding psychiatric and operating room nurses) and childcare workers had significantly lower mean percentage predicted birth weight for age ($p<0.05$).[14]

With regard to spontaneous miscarriage, odds ratios were significantly raised for both previous and current pregnancies in nursing assistants and attendants, and food and beverage servers ($p<0.05$).[104]

Manual workers and healthcare workers have been found to have a significantly higher risk of intra-uterine growth restriction.[152]

Possible biological mechanisms

It is not entirely understood how the workplace exposures considered in this guideline could result in adverse pregnancy outcomes. A number of biological/physiological mechanisms have been hypothesised, although there is little direct evidence to support them. Plausible explanations for and against a causal pathway for the adverse outcomes of interest are summarised below.

Prolonged standing

It is well established that prolonged standing results in pooling of blood in the veins of the legs, potentially resulting in reduced venous return, cardiac output, and ultimately arterial blood pressure. This effect might be potentiated by the presence of a gravid uterus, particularly in the third trimester of pregnancy. It has been postulated that, under some circumstances, this could lead to a reduction in uterine blood flow. In theory this might increase uterine contractility (and therefore the risk of spontaneous miscarriage or preterm delivery), or potentially reduce the rate of fetal growth.[58] However, it could be argued that strong physiological mechanisms exist to protect fetal blood flow in pregnancy, and that the extent and duration of maternal hypotension required to override this adaptation would be extreme. It is not clear whether this proposed mechanism is likely to occur in the context of prolonged standing at work under normal environmental working conditions.

Hard physical work

Altered body posture and heavy physical exercise or strain might reduce maternal blood pressure and/or blood flow from the uterus to the placenta. It is possible that resulting under-perfusion could result in restricted fetal growth and impaired survival.[9,36,42,68,86,115] There may also be increased substrate utilisation by muscles[68] with increased maternal energy requirements.[86] Theoretically this might use up calories needed by the fetus,[115] resulting in nutritional deficits.[9] These physiological changes are potentially intensified either by an increase in workload or duration of physical activity. However (as for prolonged standing), in order to be a significant threat to fetal growth these changes would have to override the normal physiological adaptations to pregnancy that aim to preserve fetal oxygen consumption and nutrition.

It is has been postulated that physical strain might also cause spontaneous miscarriage by means of increased abdominal pressure, elevated body temperature or sudden change in hormones (increased norepinephrine levels).[68] A further possible mechanism is that physical strain may precipitate uterine contractions, and hence premature cervical effacement and dilatation.[150]

Heavy lifting

It is known that heavy lifting causes a temporary increase in intra-abdominal pressure when the subject holds their breath against a closed glottis (valsalva manoeuvre). Although there is no direct evidence, it has been postulated that raised intra-abdominal pressure might in turn provoke uterine contractions.[9]

Shift work

It has been postulated that shift work might influence reproductive function in humans through hormonal disturbances.[15,25,74,171,172] Both direct (through changes in circadian rhythm) and indirect (through psychosocial stresses and disturbed sleep)[119] mechanisms have been proposed. Zhu *et al* suggested that an increase in oestrogen levels may be linked to adverse pregnancy outcomes.[171] The authors postulated the following causal mechanism: suppression of nocturnal melatonin production by light during the night could lead to increased oestrogen levels which stimulate the growth of hormone-sensitive tumours. Since oestrogen supplementation during pregnancy has been shown to increase the risk of spontaneous miscarriage, increased levels of oestrogens due to night work theoretically could increase the risk of fetal loss.[171]

In summary, a number of mechanisms have been proposed that might explain a causal relationship between some physical aspects of work, or shift work, and adverse pregnancy outcomes. However, these would involve overriding of the normal physiological adaptations to preserve the fetus. Overall it is uncertain whether this would be likely to occur in a work situation. Indeed it seems relatively unlikely unless physical exposures and environmental conditions were particularly severe.

Evidence of variation in practice: relevance to occupational medicine

There is some evidence of inconsistency in the advice given to pregnant women, dependent upon who undertakes the risk assessment and how it is performed. For example, in a study by Conrad,[38] a questionnaire was sent to lead clinicians in NHS occupational health departments in the UK. The questionnaire enquired about the presence of written policies regarding the management of pregnant healthcare workers, whether alternative work was available to replace normal duties, who was responsible for risk assessments and whether work restrictions were suggested with regard to particular hazards. The results indicated that there was substantial variation in practice across the NHS.

In another study in the USA in 1998, a survey was mailed to physicians who were part of either family residency programmes or obstetrics-gynaecology programmes. The physician was given a randomly selected case study and asked whether or not they would recommend restrictions. They were more likely to recommend job restrictions if there were risk factors for preterm birth. However, recommendations about restrictions were not consistent. Variation was most pronounced if there was low obstetrical risk, presumably because recommendation then

depended upon the physician's own perception of risk. For example among physicians who said they would always recommend restrictions for low risk, 35.4% believed that standing is an important risk factor, compared with 6.7% of physicians who said they would sometimes, rarely or never restrict. There were similar beliefs regarding lifting.[52] Evidence of variation of practice is also found in a Danish study.[160]

One method for improving the consistency of practice is to use evidence-based guidance as a baseline for a continuing cycle of audit and review. This approach has been shown to improve clinical effectiveness in other specialties.[134] The same approach will be adopted in relation to occupational heath advice for pregnant women who are exposed to hazards at work, using this guideline as a starting point.

2 Methodology of the evidence review

The population under study was defined as pregnant women at work.

In order to define which hazards and outcomes would be addressed, key questions were formulated by the GDG Leader. After discussion amongst GDG members, a list of possible adverse outcomes was considered. By consensus, a number of outcomes including caesarean section, instrumental delivery, psychological symptoms and stress were omitted. An initial literature search was undertaken to assess the potential volume of available literature for the remaining questions and outcomes of interest. Following this scoping search, the list of questions was revised and agreed by the GDG. The final key questions are shown below.

The key questions narrow the scope of the guidelines to a few hazards only, but the approach could be extended to incorporate other hazards if the guidelines were to be developed further in the future. Similarly the list of adverse outcomes could be expanded in future revisions of the guidelines.

For each of these hazards, the evidence base was assessed to explore the level of risk for each adverse pregnancy outcome. The volume, strength and consistency of the evidence was considered with a view to suggesting recommendations for appropriate adjustments in the workplace.

Key questions

1. What is the effect on mother and fetus of manual handling and prolonged standing?

Population	**Pregnant women at work**
Hazards	Manual handling Prolonged standing
Outcome	1. Fetal morbidity (a) spontaneous miscarriage (b) low birth weight (c) IUGR/SGA* (d) preterm birth (e) stillbirth 2. Maternal morbidity (a) gestational hypertension/pre-eclampsia (b) preterm delivery to include threatened preterm labour and preterm prelabour rupture of membranes 3. Sickness absence

*IUGR = intra-uterine growth retardation; *SGA = small for gestational age. SGA fetuses are small but not necessarily growth restricted, whereas IUGR is defined by serial ultrasound measurements showing diminishing fetal growth.[152]

2. What is the effect on mother and fetus of the mother working more than eight hours on a shift, more than 37 hours a week, or shift work (to include any shift pattern).

Population	Pregnant women at work
Hazards	Working more than eight hours on a shift Working more than 37 hours a week Working any shift pattern
Outcome	1. Fetal morbidity (a) spontaneous miscarriage (b) low birth weight (c) IUGR/SGA (d) preterm birth (e) stillbirth 2. Maternal morbidity (a) gestational hypertension/pre-eclampsia (b) preterm delivery to include threatened preterm labour and preterm prelabour rupture of membranes 3. Sickness absence

3. What is the effect on mother and fetus of the mother working night shifts?

Population	Pregnant women at work
Hazard	Working night shifts
Outcome	1. Fetal morbidity (a) spontaneous miscarriage (b) low birth weight (c) IUGR/SGA (d) preterm birth (e) stillbirth 2. Maternal morbidity (a) gestational hypertension/pre-eclampsia (b) preterm delivery to include threatened preterm labour and preterm prelabour rupture of membranes 3. Sickness absence

The GDG agreed upon standard definitions for maternal and fetal outcomes using standard texts,[90,30] and sought the opinion of the obstetric consultant on the GDG if any definitions were unclear (see Glossary).

Literature search

To form the evidence base, a systematic literature search was undertaken. The terms in the key questions were used as the basis of the literature search.

The search terms and the databases to be searched were defined in collaboration with a Department of Health (DH) librarian. An initial search was carried out in 2004. A repeat search was undertaken the following year (2005) by another librarian to update the evidence base. In addition the GDG was made aware of a high quality meta-analysis[27] that had been submitted for publication in 2006 (published 2007) which it was decided should be included in the

evidence base. The terms were searched as both text and Medical Subject Headings terms (MeSH)®, www.nlm.nih.gov). The numbered list was searched with all the other terms/phrases in the subsequent list. (See Appendix 1 for complete search strategy and databases searched.) A comprehensive evidence-based policy on the management of expectant women from John Lewis Partnership was hand searched. Other papers identified from this search were included if relevant. The following sources were searched for grey literature:

(1) Royal Free Hampstead NHS Trust Research and Development database
(2) Faculty of Occupational Medicine Database of Membership of the Faculty of Occupational Medicine (MFOM) dissertations
(3) Institute of Occupational Safety and Health (IOSH) website
(4) Specifically searching for articles authored by Linda Tapp (manual handling and ergonomics expert as advised by the GDG)
(5) General enquiries made to other colleagues.

The inclusion/exclusion criteria for papers are shown in Table 1.

Table 1 Inclusion/exclusion criteria for papers

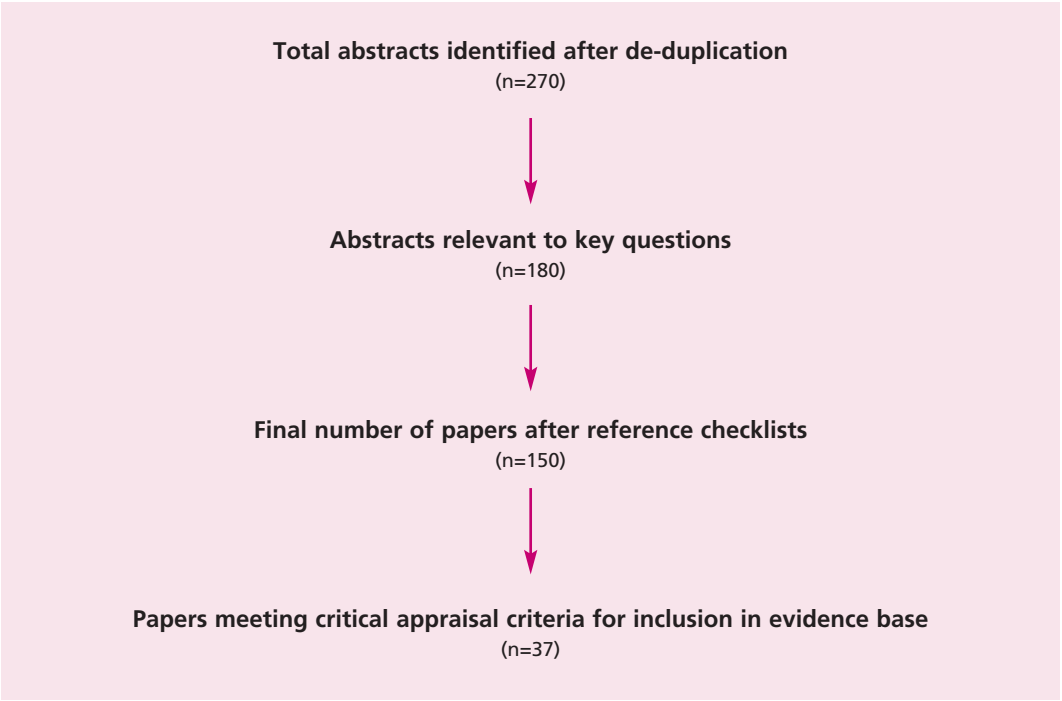
Inclusion criteria	Exclusion criteria
1980–2006*	Does not answer key questions
Observational studies, intervention studies and literature reviews	Multiple pregnancies
Human only	Data collected prior to 1980
Randomised controlled trials (RCTs), case-control studies, longitudinal studies, meta-analyses, review articles	History of chronic illness
	Women not employed during pregnancy

* A high quality meta-analysis that had been submitted for publication in 2006 was included in the evidence base for the guideline.

Following the literature searches, 270 abstracts were found to be relevant to the key questions and fitted the above inclusion criteria. All of the abstracts were read by two GDG members, Paul Grime (PG) and Nadia Sheikh (NS), to reduce bias in literature collection and to ensure consistency in selection of the papers for full appraisal. Having identified papers relevant to the key questions, all were read by the GDG Leader (NS) to determine whether they should be included as part of the critical appraisal. Papers that were not considered to be relevant to the key questions were excluded, and the remainder were critically appraised (see Fig 1). Although some papers were not included as evidence, they still contained some useful/interesting material, and have therefore been included in the introduction.

One paper was included as evidence, even though data was collected prior to 1980, because it was referenced in a number of credible papers and also formed the basis of subsequent research by others. The consensus opinion of the GDG was that in order to help understand the evidence in subsequent papers using the same methodology, this paper should be appraised and included as evidence.[98] It is recognised that the inclusion of this paper may introduce some selection

Fig 1 Flow chart for study selection



bias, however as there is an extensive body of papers involved in the review the GDG considered that the inclusion of this paper would not importantly affect the overall conclusions of the literature review.

Foreign language articles were included in the initial literature search; however these were excluded prior to the critical appraisal stage due to the variety of languages, resource and time limitations for translation.

Due to the nature of the key questions that were being considered, no randomised controlled trials were identified. This is not uncommon in the literature relating to occupational hazards, most of which comprises observational studies. The majority of papers identified in this literature search were case-control or cohort studies. One meta-analysis was identified, but this was excluded after critical appraisal. One systematic review, which has been included, also includes a meta-analysis of some of the exposure-outcome combinations. The majority of review articles that were identified did not follow systematic methodology, and therefore could not be included as evidence. However, relevant references cited in these narrative reviews were retrieved and appraised accordingly.

The number of excluded papers is shown in Table 2.

Table 2 Excluded papers

Initial reason for exclusion							
Does not address key questions	Appraised: 2– or 1– indicating a high risk of bias or confounding	Study population not pregnant women at work	Not original research or not systematic review/ editorial/ book review	Foreign language	British Library unable to retrieve paper	Very old data	**TOTAL EXCLUDED**
44	25	3	30	8	2	1	**113**

Critical appraisal

Each included paper was critically appraised using a standard form (see Appendix 2). Each paper was appraised independently by two committee members, who then discussed the paper and agreed upon a final grade. A total of eight people were involved, to varying degrees, in appraising the evidence. All appraisers received training on critical appraisal techniques. The majority (approximately 75%) of the papers were appraised by Nadia Sheikh (NS) and Paul Grime (PG). NS also reviewed the papers that were appraised by other GDG members, to ensure consistency and accuracy.

Assessing the evidence

Various methods for assessing and grading the evidence in papers have been published. These include grading methods produced by:

- The Health Evidence Network
- Human Fertilisation and Embryology Authority (HFEA) executive
- Scottish Intercollegiate Guidelines Network (SIGN)
- US Government Agency
- NHS Research and Development Centre

All describe similar methods of grading papers based upon the type of paper, eg RCT/meta-analysis, and the quality of the study. The SIGN methodology was used to assess the evidence for this guideline, primarily because it is suitable for use when appraisal will be carried out by members of the GDG (rather than a dedicated academic team). All GDG members who participated in critical appraisal received standard training in critical appraisal techniques. The SIGN grading system is reproduced in Appendix 3.

One of the concerns about the SIGN methodology is the relative lack of transparency of the simple quality scoring system, which does not state in detail the rules for assessment of major methodological issues such as bias and confounding. Therefore, in addition to the SIGN rating, a scoring system was devised for use in assessing the evidence for this guideline. The purpose of this system was to demonstrate more clearly the consistent application of the SIGN quality rating. This additional scoring system was applied to all of the papers that were included as evidence. The detailed scoring tables can be found in Appendix 5.

Development of recommendations

Draft recommendations were produced by the GDG Leader and then circulated to the GDG members for comments and feedback. The draft guideline document was reviewed by three external assessors and the steering group of the Occupational Health Clinical Effectiveness Unit (OHCEU), and revised in response to their comments.

Limitations of the evidence base

General

Heterogeneity

There was considerable heterogeneity among the body of studies that was included in the critical appraisal and final evidence tables. Populations varied in respect of country and occupational group. The range of exposures within a particular type of job might vary by country, thus affecting generalisability to a UK population. However, this was not a major problem as relatively few studies used job title as the main method of exposure assessment.

Outcome definitions and method of outcome assessment also varied, for example both ultrasound scanning and the Dubowitz score were used in different studies as measures of fetal growth (the vast majority of studies used ultrasound for measurement ± last menstrual period, only a few of the older studies used a Dubowitz score). Exposure categories and methods of exposure assessment also varied. This reduced the potential for combining findings in a formal meta-analysis, although one high quality study that did undertake a meta-analysis of a subset of the papers with similar outcome and exposure measures was included. The heterogeneity of outcome and exposure assessment might explain some of the inconsistency between the results of studies that is described in the summary of the findings from the evidence review.

Timing of exposure in relation to different stages of pregnancy

Workplace hazards may present risks at different stages of pregnancy. For example, there may be a greater risk in the early stages of pregnancy when the fetus is not yet fully formed. If a study looks at a particular point of time during pregnancy, for example in a cross-sectional survey, it may miss an association that is present at either an earlier or a later stage. Many of the studies in this review did not include detailed information about the timing of exposure in relation to pregnancy. Where this information was given it has been included in the evidence tables. In addition, the failure to note the timing of the exposure makes it difficult to advise on the application of workplace restrictions/controls.

Bias

A common problem in this literature was the reliance on subjective recall for the assessment of exposure after the outcome of the pregnancy was known (typically by questionnaire at the time of delivery or later). This introduced an important potential for inflationary bias. Mothers who had an adverse outcome might be expected to recall exposures more clearly, or even over-estimate their previous exposures, if they perceived a harmful effect of the exposure on their pregnancy. This could lead to over-estimation of the association between the adverse outcome and the exposure of interest.

Confounding

One of the most striking aspects of the review is the number of potential confounding factors. These include: extremes of maternal age (<20 and >35), lower education level, low pre-pregnancy BMI, smoking, alcohol consumption and low socio-economic status.

Not all papers addressed all of the potentially important confounding factors. Confounders are likely to be most important if the strength of their associations with the risk factor of primary interest, and with the health outcomes, are strong and if the prevalence of the confounder in the population of interest (in this instance working pregnant women) is high. If a study design did not adjust for potential confounders the GDG looked to see if a reasonable justification was provided. For example, in a Chinese study smoking was not thought to be an important confounder because very few women smoked.[170] Failure to attempt to identify or address confounders, or insufficient justification for failure to address potential confounders, was reflected in the grade awarded to the paper. If the appraisers judged there to be a reasonable likelihood that results from a given study were strongly influenced by confounding, the paper was given a low score (1– or 2–) and was excluded from the final evidence tables.

Parity

Some adverse outcomes may be more likely in second and subsequent pregnancies, for example the increased risk of miscarriage if there is previous history. Women may already have modified their job by subsequent pregnancies in light of hazards encountered in the previous pregnancy. Pregnant women may choose to request adjustments at an earlier or a later stage of pregnancy, depending upon the outcome of previous pregnancies. Therefore parity needs to be adjusted for, or at the very least acknowledged as a potential confounder. This was done in most cases, so parity is unlikely to have had an important influence on these results.

Healthy worker effect

It is possible that a significant association was not found in some cases because those women still working during pregnancy are doing so because they are 'healthy' and therefore less likely to experience adverse outcomes. This would tend to lead to an under-estimate of risk.

Exposure assessment

Misclassification bias

Exposure misclassification is more likely to occur with certain methods of exposure assessment, for example using job title alone to assess complicated exposures. As only one paper included evidence assessed on the basis of job category this is not thought to be an important factor in this review.

Night shifts

When studying night shifts, most papers examined the shift pattern rather than the intensity of work being undertaken. Most studies expected the night shift to have the most significant effect, but a few noted that the evening shift had the worst associated outcomes. This could be a reflection of the intensity of work undertaken on that particular shift. Those papers where a significant association was noted were conducted on hospital employees.

Where a woman was working less than 40 hours per week, the out-of-hours work per day was not necessarily quantified.

Physical effort

This was not always quantified in detail, and was generally just classified as light, moderate or heavy. Some papers defined these categories; others did not. One paper defined moderate physical exertion as lifting or carrying anything equal to or more than 10 kg at least three times a day.[133] Another measured physical intensity on the type of physical effort: carrying heavy loads, performing heavy cleaning tasks and sweating whilst undertaking physical activities.[152]

Complexity of exposure assessment

The above comments in relation to night work and physical effort are examples of how complex exposures, consisting of more than one aspect (eg intensity and duration) are oversimplified in assessment for research purposes. This problem also relates to some of the other exposures in this review. If the risk of adverse pregnancy outcome is specific to certain aspects of exposure, and these aspects are not differentiated between as a result of crude exposure assessment, then important effects might be missed due to dilution.

Outcome

Difference between small for gestational age (SGA) and intra-uterine growth restriction (IUGR)

Studies tend to consider one or the other of these as adverse outcomes, even though they are not necessarily the same outcome. SGA fetuses are small but not necessarily growth restricted. Therefore serial ultrasound measurements showing diminishing fetal growth, compared to SGA, may better reflect the occurrence of restricted growth, ie IUGR.[152]

3 Findings and recommendations

Synthesis of the evidence and recommendations

In making recommendations for each of the exposures of interest, a number of factors were taken into account. The quality and consistency of the evidence for similar exposures and outcomes were considered. High quality studies and large studies (high number of pregnancies observed) were given more weight than lower quality or smaller investigations. Statistical significance was not considered in isolation; the magnitude of the associations (size of the risk estimates) and the likely clinical importance influenced the synthesis of evidence strongly. The GDG was cautious not to give too much weight to risk estimates that were rather close to unity (1.3 or less), as it is recognised that associations of this order in observational studies are often due to unrecognised bias or confounding.

In deciding how to approach the uncertainties in the evidence base, the GDG took into account the fact that many of the exposures of interest (for example lifting) are common in the normal daily life of mothers, particularly if they already have young children at home. It would be inappropriate to alarm women about normal everyday activities unless the evidence of harm is compelling. Moreover, it is possible that remaining active during pregnancy, even if it involves, for example, prolonged standing or lifting, may actually be beneficial. Clearly a high level of certainty is required before recommendations are made to exclude pregnant women from activities if these restrictions might actually be bad for health.

1 Manual handling, lifting, heavy physical work

This review identified a total of 17 original papers and one systematic review that addressed the association between manual handling, lifting or heavy physical work and the outcomes of interest. The high quality systematic review[27] included six of the 17 papers identified by this review and 28 additional papers, giving 45 in total that addressed lifting/physical activity in relation to adverse birth outcomes.

(a) Heavy physical effort

Four studies[83,107,133,141] were found (three 2+ and one 2++) that explored the association between physical activity and preterm birth/preterm labour or spontaneous miscarriage (Evidence tables 2 and 3). Of these, three showed a significant positive association,[83,107,133] including risk estimates of 2.91 and 1.87. However there was a substantial body of conflicting evidence that showed no association between heavy physical work and preterm birth, or suggested only a small increase in risk. One paper[141] (2+) identified by this review did not find a significant increase in preterm births according to heavy working conditions. A high quality systematic review[27] (1++) found 20 additional papers (excluding one of the studies in Evidence table 2) that addressed the link between physical workload and preterm delivery. The authors' tables demonstrated that 12 of the studies found risk estimates close to unity (<1.3), and the remainder (eight studies) showed a positive association with risk estimates >1.5. The authors pointed out that risk estimates tended to be lower (<1.3) in prospective studies, and that four of the five largest studies also had rather low risk estimates (<1.3).[27] They concluded that the evidence was less consistent than for other exposures and that more research would be helpful.

Three studies[86,138,152] (2+) (Evidence tables 4 and 6) examined the association of physical activity with low birth weight/IUGR or SGA. All three showed a positive association, with an odds ratio of 2.4 in one. A high quality systematic review[27] (1++) identified an additional seven studies (not included in Evidence table 6) that addressed the association of physical activity with SGA. Three of these studies were positive, showing significantly increased risk between 1.32 and 2.4. In contrast, four studies were negative, with relative risk less than unity.

The same systematic review[27] (1++) identified five studies that explored the relationship between physical activity and pre-eclampsia or pregnancy-induced hypertension. Of these, two showed a significant positive relationship, with relative risks 2.1 and 3.47 respectively. However, three studies were negative.

The same systematic review judged that exposure assessment for heavy physical work was too heterogeneous to allow meta-analysis.[27]

Conclusion

There was a large body of evidence (24 papers including those identified within a systematic review) that addressed the association of heavy physical work with preterm delivery. However, there were some conflicting findings. Overall rather more studies did not find a significant association (13/24) with this outcome than were positive (11/24). Among the studies that were positive, risk estimates were generally ≤2. There were fewer papers (10) about low birth weight, IUGR or SGA and again there was some inconsistency, although rather more papers showed a positive association (6/10) than were negative (4/10). Overall the positive papers pointed to a moderate effect (relative risks up to 2.4). For pre-eclampsia and gestational hypertension there were a limited number of papers (five in all, all identified within a systematic review) and the evidence was inconsistent (2/5 positive and 3/5 negative).

RECOMMENDATIONS

Recommendation	Risk	Grade	Evidence
Pregnant workers should be informed that evidence suggests that heavy physical work carries no more than a moderate risk of low birth weight/IUGR/SGA, but there is only limited and inconsistent evidence of risk for preterm birth and pre-eclampsia	Large body of evidence with some conflicting findings, but reasonably consistent estimates of risk that tend to rule out more than a moderate risk of low birth weight/IUGR/SGA.	B	152, 138, 86, review ref 27 (includes a further 7 papers)
Employers should reduce very heavy physical activities for pregnant workers where possible, particularly in late pregnancy. However, if a pregnant worker who has been informed of the possible risks wishes to continue then there are insufficient grounds upon which to impose restrictions against her will	Large body of studies, but inconsistent findings in relation to risk of preterm delivery. Limited number of studies and inconsistent evidence of risk of pre-eclampsia or pregnancy-induced hypertension.		83, 107, 141, 133, review ref 27 (includes a further 20 papers) Review ref 27 includes 5 papers

The exposure measures for heavy physical work are too heterogeneous to inform a recommendation specifying a level of physical work at which adjustments to work should be implemented.

(b) Lifting

Three studies[9,108,161] were found (one 2++ and two 2+) (Evidence table 2) that explored the relationship between lifting and preterm birth or labour. Of these, two showed no significant association[9,161] and one showed a significant association with a small increase in risk (O/E 1.26).[108] In addition, four studies explored lifting and manual handling and spontaneous miscarriage/perinatal mortality (Evidence table 3). Of these, three showed positive associations[104,107,170] (2+) with risk estimates between 1.5 and 2.0 and one showed no evidence of a relation with frequently lifting >15 lbs[42] (2+). A high quality systematic review (1++) found a further seven studies that examined lifting in relation to preterm delivery.[27] The authors tabulated results from these studies, showing risk estimates below 1.15 in six studies and between 1.3 and 1.49 in two studies. In both of the latter, 95% confidence intervals included 1, so the findings were not statistically significant.

Four studies addressed the association of lifting with low birth weight/IUGR/SGA (Evidence tables 4 and 6). Of these, only two found important positive associations[14,161] (2+) with relative risk 3.5 (risk estimates were not given for the second paper), and a third[9] (2+) was inconclusive. A fourth paper[108] (2++) found a very small increased risk (relative risk 1.25). A high quality systematic review[27] (1++) identified a further three studies (excluding those in Evidence tables 4 and 6) that examined lifting and SGA: all three papers found no significant association.

One paper (Evidence table 5) explored lifting in relation to pre-eclampsia[165] (2+). This study found a positive association with lifting heavy loads in early pregnancy (odds ratio 1.7) and with lifting heavy loads >20 times weekly in early pregnancy (odds ratio 2.0). A high quality systematic review[27] (1++) identified one further study (in addition to the study in Evidence table 5) that examined lifting and pre-eclampsia/pregnancy-induced hypertension. This study showed no association with pre-eclampsia and a significant negative association with pregnancy-induced hypertension (relative risk 0.68).

A systematic review[27] considered that lifting outcomes were too heterogeneous to enable formal meta-analysis.

This literature search identified three studies that looked at the association between lifting or manual handling and sick leave/sick certification.[77,138,155] Two studies showed that pregnant women who lifted heavy loads at work were more likely to take time off sick (odds ratio 1.9)[77] (2+), or to leave work >3 weeks before delivery (odds ratio 1.48)[155] (2+). One of these studies[155] found that if work involved manual handling activities (twisting and bending or working with the hands above shoulders), pregnant women were more likely to leave work >3 weeks before delivery (odds ratios 1.46 and 1.55 respectively) and >8 weeks before delivery (odds ratios 1.32 and 1.36 respectively). This finding does not provide direct evidence of actual harm to the mother or fetus, and probably reflects the societal beliefs about the effects of heavy work on pregnancy. It is not therefore useful in forming recommendations about restriction from work on medical grounds during pregnancy.

Conclusion

There was a substantial body of evidence for preterm delivery, with general consistency of results among 14 studies identified. These showed either no statistically significant association with lifting (9/14) or a modestly elevated risk (6/14, although of these, two were not statistically significant). The evidence in relation to SGA was limited to seven studies. These were generally consistent, showing a weak positive association (3/7), no association (3/7) or inconclusive (1/7). There were very few papers (two papers) addressing pre-eclampsia and pregnancy-induced hypertension, and these gave conflicting results (one positive and one negative association).

RECOMMENDATIONS

Recommendation	Risk	Grade	Evidence
Pregnant employees should be informed about the generally consistent evidence suggesting that lifting carries no more than a moderate risk of preterm birth and low birth weight, but limited inconsistent evidence for pre-eclampsia	Large and generally consistent body of evidence rules out more than a modest risk (relative risk <1.3) of preterm delivery	B	9,161, 108, 104, 107, 170, 42 review ref 27 (includes a further 7 papers)
Employers should reduce lifting for pregnant workers where possible, particularly in late pregnancy. However, if a pregnant worker who has been informed of the possible risks wishes to continue then there are insufficient grounds upon which to impose restrictions against her will	Reasonable body of evidence, generally consistent in suggesting no effect for low birth weight/IUGR/SGA.		14, 108, 161, 9, review ref 27 includes a further 3 papers
	Very limited evidence for pre-eclampsia/pregnancy-induced hypertension		165, review ref 27 includes 1 further paper

The exposure measures for lifting work are too heterogeneous to inform a recommendation specifying the actual level of physical work at which adjustment to work should be implemented.

2 Prolonged standing

One systematic review and 11 original papers were identified that examined the relationship between prolonged standing or standing and walking and the adverse pregnancy outcomes of interest.

Five papers addressed preterm delivery[65,98,133,140,159] (three 2+ and two 2++) (Evidence table 2) and five papers addressed spontaneous miscarriage/perinatal mortality [11,42,46,104,107] (four 2+ and one 2++) (Evidence table 3). Prolonged standing was defined variously as >3 hours (3 papers), >5 hours (1 paper) or >6 hours (1 paper). All five studies for preterm delivery showed a statistically significant positive association between preterm delivery and risk estimates 1.26–4.10 (two below 2.0 and three above 2.0). All five studies for spontaneous miscarriage/perinatal mortality showed a statistically significant association with risk estimates 1.32–4.32 (two below 1.5 and three above 1.5). A high quality systematic review[27] (1++) identified a further 16 papers (in addition to those in Evidence tables 2 and 3). The authors describe moderately elevated risks of preterm delivery in seven studies with relative risks >1.5. However, they comment that in the largest studies relative risks were in the range 1.07–1.56. They also carried out a meta-analysis

across 12 studies that compared standing for at least three hours, and found a pooled estimate of risk of 1.28 (95% CI 1.11 to 1.47; Q=16.50, p=0.12).

Three studies addressed low birth weight[58,65,159] (2+) (Evidence table 4). Two showed a significantly increased risk with standing. The risk estimate was not stated in one study[58], but in the other was 3.3.[65] The third[159] showed a positive association between standing and low birth weight (relative risk 1.40; 95% CI 0.64 to 3.03). The association in the standing group compared with the sedentary group was not statistically significant at the 5% level. A high quality systematic review[27] (1++) identified a further eight papers (that were not identified in this review) relating to SGA, including four of high quality. Of these, six showed no effect with relative risks close to unity. Two studies had statistically significant relative risks, one of 1.4, and one a relative risk of 2 that was not statistically significant.

No original papers were found for pre-eclampsia, but this outcome was addressed in a high quality systematic review[27] (1++). The authors found five studies, although only one was of high quality. None of the studies showed a significant positive risk from prolonged standing.

Conclusion

There was an extensive body of evidence for the association of standing with preterm delivery, spontaneous miscarriage and perinatal mortality for which the findings were broadly consistent. The evidence pointed to no more than a moderate risk from prolonged standing (14/21 studies, risk estimates <1.5). Moreover it tended to rule out a large effect (high quality meta-analysis with pooled risk 1.28). A reasonable body of evidence for low birth weight was also consistent, and suggested no effect (6/11 studies negative and at least one further study with risk estimate <1.5). A small body of evidence for pre-eclampsia was limited in quality (although included one high quality study) but showed no effect.

RECOMMENDATIONS

Recommendation	Risk	Grade	Evidence
Pregnant employees should be informed about the generally consistent evidence suggesting that prolonged standing (>3 hours) carries no more than a small risk of preterm birth and low birth weight/ IUGR/SGA, and limited evidence for no effect for pre-eclampsia	Good evidence suggesting no more than a small risk of preterm birth	A	11, 42, 46, 65, 98, 104, 107, 133, 140, 159, review ref 27 includes a further 16 papers
	Large body of consistent evidence suggesting no risk or no more than a small risk of low birth weight		58, 65, 159, review ref 27 includes a further 8 papers
If employees stand for >3 hours/day, employers should consider reducing this or providing alternative work for that period of time, to reduce hours of standing to the minimum possible	Limited evidence suggesting no effect for pre-eclampsia		Review ref 27 includes 5 papers
However, if a pregnant worker who has been informed of the possible risks wishes to continue then there are insufficient grounds upon which to impose restrictions against her will			

From current evidence it cannot be stated conclusively at which stage of pregnancy these recommendations should be implemented. Most studies used three hours or more to define prolonged standing, so it seems reasonable to implement adjustments at this level.

3 Working hours

Different exposure criteria were used in different studies, but in general studies considered working longer than around 40 hours, compared to 40 or less. Most of the data for these studies were collected after delivery.

One systematic review and nine original papers were identified that examined the relationship between working hours and the outcomes of interest.

Eight papers addressed preterm delivery, spontaneous miscarriage or perinatal mortality[42,81,88,98,104,107,108,140] (five 2++ and three 2+) (Evidence tables 2 and 3). Five showed an increased risk of preterm birth with long working hours, with risk estimates of 1.24–1.7. Two showed an increased risk of spontaneous miscarriage, and one showed no effect with working >40 hours a week in previous pregnancies. A high quality systematic review[27] (1++) identified a further 11 papers (in addition to those in Evidence tables 2 and 3). Of these, eight were negative with relative risks close to unity, and five showed an increased risk of preterm delivery with relative risks of up to 1.87. However, the authors point out that the findings were statistically significant in only two of the four studies, where relative risks exceeded 1.5, and at least two studies had methodological limitations. Moreover, in the four largest studies (>2000 pregnancies analysed), relative risks were between 0.59 and 1.34. They carried out a meta-analysis, and found a pooled relative risk of 1.31 (95% CI 1.16 to 1.47, Q=4.33, p=0.74).

Two studies assessed low birth weight, IUGR or SGA in relation to long working hours[108,161] (2+ and 2++) (Evidence tables 4 and 6). Both showed a positive relationship, with risk estimates 1.34 and 2.4. A high quality systematic review[27] (1++) identified a further six papers (in addition to those in Evidence tables 4 and 6), five of which were of high quality. The largest study found an increased risk (odds ratio 1.7), but the other five were all negative with relative risks close to unity.

One paper that examined pre-eclampsia was identified[73] (2+) (Evidence table 5). This study found a two-fold increase in the risk of pre-eclampsia (the study compared female residents with the spouses of male residents). A high quality systematic review[27] (1++) identified a further two papers (in addition to the paper in Evidence table 5). Both were of high quality and showed no relation between working hours and pre-eclampsia.

Conclusion

There was a large body of evidence for preterm delivery, spontaneous miscarriage/perinatal mortality. There was reasonable consistency, with 9/19 studies showing no effect and 10/19 showing risk estimates of no greater than 2.0. A high quality meta-analysis gave a pooled relative risk of 1.3. Overall the evidence suggested a low risk, and made more than a moderate risk unlikely. The evidence for low birth weight/IUGR/SGA was reasonable in volume and consistency, tending to suggest no effect or no more than a moderate effect. There was very limited evidence for pre-eclampsia.

RECOMMENDATIONS

Recommendation	Risk	Grade	Evidence
Pregnant employees should be informed about the generally consistent evidence suggesting that long working hours carry no more than small to moderate risk of preterm birth, and low birth weight/SGA, but there is limited inconsistent evidence for pre-eclampsia	No greater than a low risk of preterm birth, preterm labour or spontaneous miscarriage	A	42, 81, 88, 98, 104, 107, 108, 140, review ref 27 includes a further 11 papers
	No more than a moderate risk of low birth weight		108,161, review ref 27 includes a further 6 papers
Employers should reduce long working hours for pregnant workers, particularly in late pregnancy. Working hours should be limited as far as possible to a 'standard' working week of approximate 40 hours per week. However, if a pregnant worker who has been informed of the possible risks wishes to continue then there are insufficient grounds upon which to impose restrictions against her will.	Insufficient evidence for pre-eclampsia		81, review ref 27 includes a further 2 papers

Most studies about long working hours used >36 or >40 hours as a definition, therefore it seems reasonable to use 40 hours as the threshold for applying adjustments to work. It is unclear from current evidence at which stage of pregnancy this is advisable.

4 Shift work

This review identified nine studies and one systematic review that examined shift work or night work in relation to the outcomes of interest.

Seven studies addressed preterm birth, spontaneous miscarriage or perinatal mortality[15,25,49,104,107,169,171] (six 2+ and one 2++) (Evidence tables 2 and 3). Of three that examined preterm birth, two found an increased risk with odds ratios 5.6 and 2.0. One found a risk of 1.45, but this was not statistically significant. Among four that looked at spontaneous miscarriage, one did not find a significant association; but three showed an increased risk, including one with high risk estimates of 2.7 for two-shift schedules and up to 6.89 for night work. A high quality systematic review[27] (1++) identified a further nine papers (excluding those in Evidence tables 2 and 3), all but one of which were high quality. In five, the risk estimates were close to one. Four showed an increase risk with risk estimates ≥1.5. However, the authors pointed out that the positive studies tended to be small, and the four largest studies found little association between shift work and preterm delivery. The pooled estimate of risk across 13 studies was 1.2 (95% CI 1.01 to 1.42, Q=31.3, p=0.002).

Four studies were found that explored low birth weight[14,17,15,169] (2+) (Evidence table 4). All four showed an increased risk of low birth weight, including three for rotating shifts (risk

estimate stated by one study was 2.5) and two for night or evening shifts (odds ratio in one study 5.6). A high quality systematic review[27] (1++) identified a further five papers (in addition to those in Evidence tables 4 and 6), including four of high quality. One of these showed an elevated risk with relative risk 1.5, but the rest showed risk estimates close to unity. In particular, a very large study of >35000 pregnancies showed no relationship between shift work and SGA. Moreover, the authors carried out a meta-analysis, which gave a pooled estimate of risk from six studies as 1.07 (95%CI 0.96 to 1.19, Q=3.30, p=0.51).

One study was identified that looked at pre-eclampsia[165] (2+) (Evidence table 5), finding a relative risk of 1.3 (although this was not statistically significant). A high quality systematic review[27] (1++) identified one further paper (in addition to the one in Evidence table 5). This showed no significant association (relative risk 0.9).

Conclusions

There was a reasonable body of evidence for shift work and preterm birth, but this was conflicting. Nine of the 16 papers identified (including those in a systematic review) showed an increased risk, including some with high relative risks of >2.0. However, seven studies had risk estimates close to one, and a high quality meta-analysis (that included four of the positive studies) showed a pooled estimate of 1.2. Similarly for low birth weight there was a reasonable volume of evidence but conflicting findings. About half of the studies gave positive and half negative results, although a meta-analysis supported no effect. There was insufficient evidence for pre-eclampsia (two papers).

There is insufficient evidence of a risk to pregnant women to make recommendations to restrict shift work, including rotating shifts or night/evening work.

5 Fatigue score

This score was devised by Mamelle[99] and is based upon five sources of occupational fatigue (posture, work on industrial machine, physical exertion, mental stress, and the working environment); Mamelle *et al* constructed an index based on these fatigue sources whereby a high score relates to increasing fatigue. In two studies a fatigue score ≥3 was related to a risk of preterm birth[88,98] (2++). A dose-response relationship was found in the first study.[98] Other studies[116,94] have found an association with each component of the fatigue score and preterm rupture of membranes, and adjusted odds ratios were significant for posture and physical exertion.

Overall, based on just three studies, there is insufficient evidence to make recommendations about the use of the fatigue score to manage pregnant women at work. In addition it is difficult to give advice on how a fatigue score would translate into work place restrictions.

4 Future research

The literature review on which these guidelines are based identified a substantial body of research into the workplace risk factors for adverse outcomes of pregnancy. However, the GDG has been unable to make recommendations for practice in some areas due to a relative paucity of evidence that is both of high quality and consistent. The main priorities for new research are specific exposures and pregnancy outcomes for which the current evidence is either small in volume (small number of papers) or where there is currently an important degree of inconsistency of results or serious methodological limitations.

The impact of working shift patterns and night work, particularly on measures of impaired fetal growth and pre-eclampsia, is an important priority area. At present the balance of evidence points to no effect or at most a low risk, but a small number of studies reported high risks (>2). As shift patterns are very common in some female-dominated jobs (eg nursing) more research would be helpful in guiding practice in this area.

The number of studies that addressed pre-eclampsia and pregnancy-induced hypertension were generally fewer than for the other outcomes, and this is another important priority area for further research. A systematic review[27] highlighted a problem with variation in the definition of pre-eclampsia (degree of proteinuria or level of blood pressure required for diagnosis) that would need to be addressed in future studies in this area.

The evidence base for preterm delivery and spontaneous miscarriage was more extensive than the other outcomes of interest, and (with the possible exception of heavy physical work) it was fairly consistent. However, a degree of inconsistency was seen for heavy physical work, with a moderate number of studies finding risk estimates >1.5. Moreover, there was considerable heterogeneity in exposure assessment. Therefore some more research into the consistent categorisation of heavy work and the association with preterm labour would be useful.

Finally, a common problem with the existing literature in this field is the reliance on retrospective assessment of exposure at the end of the pregnancy. In view of the important potential for bias when the outcome of pregnancy is known, there is a need for more prospective studies of the effect of work and working conditions on pregnancy outcome.

Recommendations for research

(1) Prospective studies of the effect of shift work and night work on birth weight.
(2) Prospective studies of the effect of workplace exposures on pre-eclampsia, with agreement of common definitions for outcome assessment.
(3) Prospective studies of lifting and heavy physical activity, using consistent methods of exposure assessment and examining all adverse outcomes of pregnancy.

5 Audit criteria

Audit question	Standard
Is a risk assessment being undertaken by the employer upon notification of pregnancy?	100%
Is the pregnant employee given appropriate information about health risks in the workplace, including physical work and working hours?	100%
Is restriction of duties allowed if the pregnant worker requests it? And, if yes, are pay and conditions preserved?	100%

Evidence table 1 Summary of papers included as evidence

First author	Location	Study period	Study design	Exposure	Method of exposure assessment	Outcome(s)
Ahlborg (1990)[9]	Orebro, Sweden	1980–3	Prospective cohort	Lifting	Self-administered questionnaire during pregnancy with follow-up after delivery	Preterm birth Low birth weight Spontaneous miscarriage
Armstrong (1989)[14]	Montreal, Canada	1982–4	Retrospective cohort	Lifting Shift work		Low birth weight
Ali (2002)[11]	Peninsular Malaysia	2002	Case-control	Prolonged standing	Questionnaire	Perinatal mortality
Axelsson (1989)[17]	Sweden	1980–4	Cross-sectional	Shift work	Mailed questionnaire	Low birth weight
Axelsson (1996)[15]	Sweden	1989	Retrospective cohort	Shift work in first trimester	Mailed questionnaire	Spontaneous miscarriage
Bodin (1999)[25]	Sweden	1980–7	Retrospective cohort	Shift work	Mailed questionnaire	Low birth weight Preterm birth
Bonzini (2007)[27]	Worldwide	1966–2005	Systematic review and meta-analysis	Working hours Shift work Lifting Standing Physical activity	Systematic review of literature	Preterm delivery Small-for-gestational-age Pre-eclampsia/ hypertension
Eskenazi (1994)[42]	California, USA	1986–7	Case-control	Physical exertion Heavy lifting Working hours	Questionnaire after delivery	Spontaneous miscarriage
Fenster (1997)[46]	California, USA	1990–1	Case-control and part of prospective cohort	Standing	Interview using computer-assisted telephone interview system	Spontaneous miscarriage
Fortier (1995)[49]	Quebec city, Canada	1989	Retrospective cohort	Shift work Working hours Standing Lifting Physical activity	Telephone interview after delivery	Preterm delivery Small-for-gestational-age
Ha (2002)[58]	Beijing, China	1996–8	Prospective cohort	Physical activity Standing	Interview using structured questionnaire	Low birth weight
Henriksen (1995)[64]	Netherlands	1989–91	Prospective cohort	Standing Walking	Self-administered questionnaire at two stages of pregnancy	Preterm birth
Henriksen (1995)[64]	Denmark	1989–91	Prospective cohort	Standing Walking	Self-administered questionnaire at 16 weeks and 30 weeks gestation	Low birth weight

continued

First author	Location	Study period	Study design	Exposure	Method of exposure assessment	Outcome(s)
Infante-Rivard (1993)[74]	Canada	1987–9	Case-control	Shift work	Face-to face interview post delivery	Spontaneous miscarriage
Kaerlev (2004)[77]	Denmark	1995–9	Retrospective cohort	Working hours Shift work Lifting Standing Walking	Self-administered questionnaire	Sick leave
Klebanoff (1990)[81]	USA	1985	Retrospective cohort and case-control	Working hours Shift work	Mailed questionnaire	Preterm labour Pre-eclampsia
Koemeester (1995)[83]	Netherlands	1989–90	Prospective cohort	Physical workload	Questionnaire and interview at various stages of pregnancy	Gestational age
Lima (1999)[86]	Brazil	April–December 1992	Retrospective cohort	Heavy work	Interviews in hospital after delivery	Low birth weight
Luke (1995)[88]	USA	1991	Case-control	Working hours Occupational fatigue (defined by fatigue score)	Mailed structured questionnaire	Preterm birth
Mamelle (1984)[98]	France	1977–8	Retrospective cohort	Working hours Standing Occupational fatigue (defined by fatigue score)	Questionnaire based interview immediately after delivery	Preterm birth
McDonald (1986)[104]	Montreal, Canada	1982–4	Retrospective cohort	Lifting Standing Working hours Shift work	Questionnaire based interview soon after delivery	Spontaneous abortion
McDonald (1988)[107]	Montreal, Canada	1982–4	Retrospective cohort	Lifting Standing Physical activity Working hours	Questionnaire based interview soon after delivery	Spontaneous abortion
McDonald (1988)[108]	Montreal, Canada	1982–4	Retrospective cohort	Lifting Working hours Physical effort Standing Shift work	Questionnaire based interview soon after delivery	Preterm birth Low birth weight
Newman (2001)[116]	USA		Prospective cohort	Occupational fatigue (defined by fatigue score)	Nurse-administered standard questionnaire at enrolment; follow-up questionnaire between 27 and 31 weeks	Preterm birth
Ritsmitchai (1997)[133]	Thailand	1993	Case-control	Standing Physical exertion	Interview using structured questionnaire	Preterm birth

continued

Evidence table 1 Summary of papers included as evidence

First author	Location	Study period	Study design	Exposure	Method of exposure assessment	Outcome(s)
Saurel-Cubizolles (1987)[138]	France	1981	Cross-sectional study taken from a national survey	Physical effort Standing and carrying a heavy load	Interview using a standardised questionnaire within six days of delivery	Preterm birth Low birth weight
Saurel-Cubizolles (1991)[141]	France	1987–8	Retrospective survey	Standing Lifting Working hours	Structured questionnaire after delivery in hospital	Preterm birth
Saurel-Cubizolles (2004)[140]	17 European countries	1994–7	Case-control	Standing Working hours	Interview using questionnaire after delivery	Preterm birth
Spinillo (1996)[152]	Italy	1989–94	Case-control	Physical effort	Structured interview at birth	Fetal growth restriction
Strand (1997)[155]	Norway	1989	Cross-sectional	Physical effort Lifting Working hours Work schedules	Questionnaire after delivery in hospital	Sick certification
Teitelman (1990)[159]	USA	1980–2	Prospective cohort	Standing	Interview using a standard questionnaire in first trimester (and further 20%) by 20 weeks	IUGR Preterm birth
Tuntiseranee (1998)[161]	Thailand	1994–5	Prospective cohort	Working hours Lifting	Interviews at weeks 17 and 32	Small-for-gestational-age Low birth weight Preterm delivery
Wergeland (1997)[165]	Norway	1989	Retrospective cohort	Lifting Work above shoulder level Shift work	Questionnaire completed after delivery	Pre-eclampsia
Xu (1994)[169]	China	1992	Retrospective cohort	Shift work	Standardised questionnaire	Preterm birth Low birth weight
Zhang (1996)[170]	Connecticut, USA	1988–91	Prospective cohort	Manual handling – reaching above shoulders Standing	Home interview between 5 and 16 weeks gestation	Spontaneous abortion
Zhu (2004)[172]	Denmark	1998–2001	Prospective cohort	Shift work	Computer assisted telephone interviews twice during pregnancy and twice after delivery. Face-to-face interview post delivery	Duration of pregnancy
Zhu (2004)[171]	Denmark	1998–2001	Prospective cohort	Shift work	Telephone interviews between 11 and 25 weeks, again around 30 weeks, and post delivery	Spontaneous miscarriage

OR = odds ratio; RR = relative risk

Evidence table 2 Preterm birth/threatened preterm labour

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Lifting						
Systematic review						
Bonzini (2007)[27]	Association between lifting and preterm birth studied in 12 papers	Substantial difference in definitions of exposure. RR ≤1.35 in 11 of 12 studies, RR ≥1.5 in none of the 12 studies	See previous column	Various, mainly first trimester	Judged low risk of confounding in 10 of 12 studies	1++
Prospective cohort						
Ahlborg (1990)[9]	All pregnant women in antenatal care centres in Örebro county in the study period (1980–3) who worked during pregnancy, n=3906 (based on the number of subjects in the final analysis)	No significant risk associated with heavy lifting and preterm birth.	Adjusted OR 1.29 (0.69–2.4) (Table 4)	12 kg or more for more than 50 times per week (heaviest exposure) vs none first trimester. Exposure data were collected during early pregnancy, (from the time of LMP until first visit to antenatal care.	Age, parity, sex of infant, educational level, smoking and frequency of alcohol use	2+
Retrospective cohort						
McDonald (1988)[108]	Women attending 11 obstetrical units in Montreal from 1982–4, n=51,885, n=56,067 inter-viewed for the study. Results based upon n=2,2761	Significant association between lifting heavy weights and preterm birth	O/E 1.26 p<0.01	Lifting heavy weights ≥15 vs <15 times per day. Timing not noted	Age, gravidity, previous spontaneous abortion, ethnic group, height, educational level, cigarette smoking and alcohol consumption	2++

continued

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Manual handling						
Prospective cohort						
Tuntiseranee (1998)[161]	Pregnant women attending routine antenatal care at the dept of Obstetrics in 2 Thai hospitals from 1994–1995, n=1821	No significant risk of preterm delivery associated with lifting	RR 0.9 (0.4–2.1)	Lifting >12 kg 1–10 times per day vs none. Timing 15–28 weeks	Parity, maternal height, maternal age, obstetrical complications, baby sex, number of antenatal visits, maternal weight at delivery	2+
Physical activity						
Prospective cohort						
Koemeester (1995)[83]	Nurses working in 12 hospitals between 1989–90 who worked for at least the first 12 weeks of pregnancy, n=116 (number in the study)	There was a significant association between gestational age at delivery and duration of high physical workload. After stepwise multiple regression analysis on nurses without extra risks in pregnancy, the daily duration of tasks with a high physical workload, was significantly correlated with shorter gestational age at delivery	p=0.01 p=0.004	Daily duration of tasks with high physical workload in 3 categories (<2 hours, 2–4 hours, >4 hours). Timing not noted	Smoking, drinking, parity, age, sporting activities, non-physical occupational factors, work hours per week, frequency of stooping per day, frequency of lifting per day, frequency of standing per day duration of tasks with physical workload (stepwise multiple regression analysis)	2+
Retrospective survey						
Saurel-Cubizolles (1991)[141]	Random sample of births in four public maternity units in France between April 1987 and May 1988, n=1949 interviewed final sample from which results obtained n=875	Significant difference in preterm births between different occupations. There was a difference in the physical working conditions of different occupations. However there was no significant difference in preterm births according to working conditions Of note: women with strenuous working conditions reported more often that they had changed their working conditions. These women also stopped work before 28 weeks	RR 1.31 (0.64–2.58)	Lifting heavy loads often/always vs none/sometimes. Timing not noted	Age, nationality, education level, gravidity, previous preterm birth, maternity centre	2+

continued

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Physical activity – *continued*						
Case-control						
Ritsmitchai (1997)[133]	Mothers from Hat Yak regional hospital in 1993 Cases: spontaneously born singleton preterm infants delivered between 28 and 37 weeks, n=223 Controls: the first mothers of singleton infants delivered at over 37 weeks after each case – matched, n=223	Significant risk of preterm birth if physical exertion throughout pregnancy	Adjusted OR 2.91 95% CI 1.29–6.58	All pregnancy	Pregnancy complications, previous preterm birth, physical exertion, physical exercise. Did not adjust for coffee, alcohol, smoking, because small numbers exposed	2+
Cross-sectional from a national survey						
Saurel-Cubizolles (1987)[138]	Randomly sampled women who delivered in French maternity units in 1981 n=5508 interviewed study based upon n=2387	Higher rate of preterm birth among women who had to make considerable physical effort, and women who cumulated >2 strenuous working conditions. Not significant after adjustment for occupation. (note – is appropriately in table 4 as well) Significant increase in preterm delivery if undertaking 1 or 2 of the strenuous working conditions	p=0.05	Heavy load carrying yes vs no. Considerable physical effort yes vs no Timing: first trimester. The proportion of women who did not work in the third trimester was higher when the work was strenuous. Also more likely to change jobs	Parity, smoking, preterm delivery	2+
Standing						
Systematic review						
Bonzini (2007)[27]	20 papers considered standing and preterm birth	'High' exposure was defined as >3 hours in 12 studies. RR>1.5 in seven studies, less clearly positive in the rest. Meta-analysis RR=1.28	Pooled estimate for 12 studies RR 1.28 95% CI 1.11–1.47	See references in review	See references in review	1++

continued

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Standing – *continued*						
Prospective cohort						
Teitelman (1990)[159]	Eligible women who sought care from various health care providers in New Haven, expected to deliver at Yale-New Haven hospital and were pregnant, between 1980 and 1982; n=6219 introduced to the study; n=4186 completed valid interviews; final analysis based upon n=1,206	Significant risk of preterm delivery in those standing >3 hours/day, compared with sedentary and active jobs	Adjusted OR 2.72 95% CI 1.24–5.95	Not noted	Parity, smoking, education, caffeine use, illicit drug use, gestational age at interview and marital status	2+
Retrospective cohort						
Mamelle (1984)[98]	Women giving birth in 2 hospitals between 1977–8, analysis based upon n=1928 working women	Significantly increased risk if standing >3 hours	RR 1.6 95% CI 1.1–2.3	Not noted	Low socio-economic level, unmarried mother, low maternal education level, low maternal age, primiparity, previous prematurity, obstetric pathology	2++
Case-control						
Ritsmitchai (1997)[133]	Mothers from Hat Yai regional hospital in 1993 Cases: spontaneously born singleton preterm infants delivered between 28 and 37 weeks n=223 Controls: the first mothers of singleton infants delivered at over 37 weeks after each case – matched, n=223	Cases were more likely than controls to have been exposed to prolonged standing in all three trimesters. Significant risk of preterm birth if standing >3 hours/day throughout pregnancy	Adjusted OR 4.10 95% CI 1.29–13.10 p=0.001	Not noted	Pregnancy complications, previous preterm birth, physical exertion, physical exercise. Did not adjust for coffee, alcohol, smoking, because small numbers exposed	2+

continued

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Standing – *continued*						
Case-control – continued						
Saurel-Cubizolles (2004)[140]	Cases: Consecutive singleton pre-term births in 17 countries between 1994–1997, working after 3rd month of pregnancy n=2369 Controls randomly selected (not matched) n=4098	Significantly higher risk of preterm birth if standing >6 hours/day	Adjusted OR 1.26 95% CI 1.1–1.5 In A2 countries: Adjusted OR 1.38 95% CI 1.1–1.7 In B countries: Adjusted OR 1.55 95% CI 1.1–2.3	Not noted	Maternal age, women's educational level, marital status, obstetric history	2++
Standing and walking						
Prospective cohort						
Henriksen (1995)[65]	Women attending for antenatal care at Aarhus university hospital from 1989–91, analysis based upon n=4259	Significantly greater risk of preterm delivery if walking and standing for >5 hours/day (does not distinguish between the two), compared with 2 hours or less. Majority still working after 30 weeks, but a significant number were either off sick or no longer employed	Adjusted RR 3.3 95% CI 1.4–8.0	More women who reported jobs involving long hours of standing and walking at 16 weeks, were no longer employed by the 30th week. Those who left jobs involving standing or walking prior to 30 weeks had the same risk of preterm deliveries as women with the same exposure in the 16th week who kept working through the third trimester	Parity, maternal height, smoking, leisure time activities, partner's social class	2+
Working hours						
Systematic review						
Bonzini (2007)[27]	16 papers considering the relationship between working hours and preterm delivery	Moderate associations were reported. RR >1.5 in four studies, but some limitations. Lower RR in the larger studies	Eight studies pooled estimate: RR 1.31 95% CI 1.16–1.47	See references in review	See references in review	1++

continued

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Working hours – *continued*						
Retrospective cohort						
Klebanoff (1990)[81]	Women who graduated from medical school in 1985 and a random sample of male physician spouses Final study population: 989 residents, 1239 spouses	Residents worked >64 hours/week compared with <37 hours/week in spouses. Twice as many women residents going in to threatened preterm labour requiring bed rest or hospitalisation	p<0.001	Not noted	Parity, age at delivery, height, pre-pregnancy weight and race or ethnic group	2+
Mamelle (1984)[98]	Women giving birth in 2 hospitals between 1977–8, analysis based upon n=1928 working women	Significantly increased risk of prematurity if working >41 hours/week. Note, increasing % of prematurity with increasing hours worked	RR 1.7 95% CI 1.1–2.5	Not noted	Low socio-economic level, unmarried mother, low maternal education level, low maternal age, primiparity, previous prematurity, obstetric pathology	2++
McDonald (1988)[108]	Women attending 11 obstetrical units in Montreal from 1982–4, n=56067 interviewed for the study. Results based upon n=22761	Significant association between working >46 hours/week and preterm birth	O/E 1.24 p=0.03	Not noted	Age, gravidity, previous spontaneous abortion, ethnic group, height, educational level, cigarette smoking and alcohol consumption	2++
Case-control						
Luke (1995)[88]	Cases: Nurses whose infants were delivered preterm (<37 weeks) in 1991 with current membership of The Association of Women's Health, Obstetrics and Neonatal Nurses (AWHONN), n=210 Controls: nurses whose infants were delivered at term (>37 weeks), n=1260	Significantly increased risk of preterm birth if working >36 hours/week, compared with ≤36 hours/week	Adjusted OR 1.6 95% CI 1.1–2.2 p=0.006	Not noted	Young maternal age, non-white race, unmarried status, low educational level, pregnancy complications	2++

continued

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Working hours – *continued*						
Case-control						
Saurel-Cubizolles (2004)[140]	Cases: Consecutive singleton preterm births in 17 countries between 1994–7, working after 3rd month of pregnancy n=2369 Controls randomly selected (not matched) n=4098	Significantly higher risk of preterm birth if working >43 hours/week	Adjusted OR 1.33 95% CI 1.1–1.6	Not noted	Maternal age, women's educational level, marital status, obstetric history	2++
Shift work						
Systematic review						
Bonzini (2007)[27]	14 studies considered the association between preterm delivery and shift work	In 7 studies the RR was close to unity; in 6 studies the RR was >1.5. Two studies found risks >2.0. Meta-analysis RR=1.2	Pooled estimates of risk in 13 studies: RR 1.20 95% CI 1.01–1.42	See references in review	See references in review	1++
Retrospective Cohort						
Bodin (1999)[25]	Female members of the Swedish Midwives Association in 1989; pregnancies between 1980–1987, n=1244 number included in analysis	Significant association between night work and preterm birth	Adjusted OR 5.6 95% CI 1.9–16.4	Not noted	Maternal age, parity, employment, work schedule, N2O use	2+
Fortier (1995)[49]	Women in 6 community health departments in Quebec city who gave birth to a live singleton in 1989 Analysis based upon n=4390	For women working regular evening or night work compared with women always working days, the adjusted OR of preterm birth was 1.45x higher, however, not statistically significant	See previous column	Not noted	Age, parity, history of low birth weight or preterm delivery, education, family income, pre-pregnancy weight, height, alcohol and caffeine intake, active and passive smoking, and energy expenditure in non-occupational activities	2++

continued

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Shift work – *continued*						
Retrospective Cohort						
Xu (1994)[169]	Married women working in textile mills in China. Analysis based upon n=887 live births. Married, educated, non-smokers, non-alcohol drinkers	Significant increase in prevalence of preterm birth of all live births associated with rotating shifts.	Adjusted OR 2.0 95% CI 1.1–3.4 p=0.02	Not noted	Mill location, maternal age at pregnancy, job title, time and duration of leave from the job since pregnancy, order of live births, exposure to dust/gases/fumes, physical activity and position while working, stress at work and use of coal stove for heating at home	2+
Occupational fatigue						
Prospective cohort						
Newman (2001)[116]	Cohort of 2929 singleton pregnancies part of the multicentre preterm prediction study. Analysis based upon this number	Each of the 5 sources of occupational fatigue were associated with a significant increased risk of preterm premature rupture of membranes in nulliparous women. Significant linear trend (p=0.002) between risk of preterm premature rupture of membranes in nulliparous women and increasing occupational fatigue index. Significant association between hours worked per week and preterm premature rupture of membranes (p=0.01). With multivariate logistic regression, the adjusted odds ratio showed significant association of each individual source of occupational fatigue and overall occupational fatigue score for preterm premature rupture of membranes in nulliparous women	Posture adjusted OR 1.69 95% CI 1.20–2.38 Physical exertion OR 1.72 95% CI 1.16–2.23	Not noted	Contractions, cervical length, BMI, race, living with another adult, education, private insurance, smoking during pregnancy, alcohol use during pregnancy, drug use during pregnancy, vaginal bleeding	2+

continued

Author	Study population	Main results	Effect measure	Exposure comparison and timing in pregnancy	Confounders	Sign grade
Occupational fatigue – *continued*						
Retrospective cohort						
Mamelle (1984)[98]	Women giving birth in two hospitals between 1977–8, analysis based upon n=1928 working women	Risk of prematurity increases when a woman accumulates two or more sources of occupational fatigue	High fatigue score with no medical factor present: RR 2.1 95% CI 1.3–3.5 With medical factor present RR 2.8 95% CI 1.8–4.9	Not noted	Low socio-economic level, unmarried mother, low maternal education level, low maternal age, primiparity, previous prematurity, obstetric pathology	
Case-control						
Luke (1995)[88]	Cases: nurses whose infants were delivered preterm (<37 weeks) in 1991 with current membership of AWHONN, n=210 Controls: nurses whose infants were delivered at term (>37 weeks), n=1260	Significantly increased risk of preterm birth if occupational fatigue score ≥3. Dose response relationship between increasing fatigue score and increasing hours of work. Note the higher the occupational fatigue score, the more tired the nurse at the end of the shift. Highest fatigue scores in acute clinical areas	Adjusted OR 1.4 95% CI 1.1 –1.9 p=0.023 Cumulative effect: Adjusted OR 2.2	Not noted	Young maternal age, non-white race, unmarried status, low educational level, pregnancy complications	2++

OR = odds ratio; RR = relative risk

Evidence table 3 Spontaneous miscarriage/perinatal mortality

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Lifting						
Prospective cohort						
Ahlborg (1990)[9]	All pregnant women in antenatal care centres in Örebro county in the study period (1980–3) who worked during pregnancy, n=3906 the number used in the final analysis	No significant risk associated with heavy lifting and fetal death. The heaviest work categorised as >12 kg >50 times a week	Adjusted OR 1.06 95% CI 0.62–1.81	Lifting in first trimester	Age, parity, sex of infant, educational level, smoking and frequency of alcohol use	2+
Retrospective cohort						
McDonald (1986)[104]	Women attending 11 obstetrical units in Montreal from 1982–4, n=56,012 interviewed n=4127 + 10,910 met the criteria for spontaneous abortion	Ratios of O/E miscarriages significantly raised for early, mid and late miscarriages if lifting heavy weights >15 times daily. Significant increase in spontaneous miscarriage if lifting heavy weights in various occupational sectors (Table 2 of paper). A significant trend of increasing risk of spontaneous miscarriage with increasing amount of heavy lifting, for current pregnancies ($p<0.01$) and previous pregnancies ($p<0.01$)	Heavy lifting >15 times: RR 2.00 95% CI 1.5–2.5	Not noted	Maternal age, parity, history of previous abortion, smoking habit, highest education level reached	2+
McDonald (1988)[107]	Women attending 11 obstetrical units in Montreal from 1982–4; n=56067 interviewed n=22,613 previous pregnancies meeting criteria, therefore number used in analysis	Significantly increased risk of spontaneous miscarriage before 28 weeks associated with lifting heavy weights >15 times a day. For heavy lifting the O/E ratio increased with increasing grade of the factor	RR 2.0 90% CI 1.5–2.5 $p<0.01$ ($p<0.01$)	Not noted	Age, gravidity, previous spontaneous abortion, ethnic group, height, educational level, cigarette smoking and alcohol consumption	2+

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Lifting – *continued*						
Case-control						
Eskenazi (1994)[42]	Cases: pregnant women in Santa Clara County who had spontaneous miscarriage before 20 weeks gestation, from 1986–7, n=434 (working) Controls: two per case randomly selected from a matched group, n=910 (working)	No evidence of association with spontaneous miscarriage and frequently lifting >15 lbs	Adjusted OR 1.1 95% CI 0.6–2.0	Not noted	Race, maternal age history of spontaneous miscarriage, cigarette smoking, alcohol, caffeine consumption, tap water consumption, marital status, parity, level of education and nausea	2+
Manual handling						
Prospective cohort						
Zhang (1996)[170]	Women receiving prenatal care in organizations in Connecticut (Oct 1988–Dec 1991) who had a singleton live birth or a spontaneous abortion, n=2849 number used in analysis	Significant risk if arrying loads >9 kg once or more a day. Reaching over the shoulders once or more a day	Adjusted RR 1.71 95% CI 1.25–2.32 Adjusted OR 1.75 95% CI 1.13–2.71 Adjusted RR 1.35 95% CI 1.02–1.78	First trimester	Those considered – not all used at every stage: maternal age, marital status, mother's height, smoking, illicit drug use, chronic medical problems, use of birth control, number of pregnancies, induced abortion, spontaneous miscarriage, education, race, stopped smoking before pregnancy, infertility, stillbirth, ectopic pregnancy	2+
Physical activity						
Retrospective cohort						
McDonald (1988)[107]	Women attending 11 obstetrical units in Montreal from 1982–4; n=56,067 interviewed; n=22,613 previous pregnancies meeting criteria, therefore number used in analysis	Significantly increased risk of spontaneous miscarriage before 28 weeks associated with physical effort. For physical effort O/E ratio increased with increasing grade of the factor	RR 1.87 90% CI 1.4–2.3 p<0.01 (p<0.01)	Not noted	Age, gravidity, previous spontaneous miscarriage, ethnic group, height, educational level, cigarette smoking and alcohol consumption	2++

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Standing						
Retrospective cohort						
McDonald (1986)[104]	Women attending 11 obstetrical units in Montreal from 1982–4, n=56,012 interviewed n=4127 + 10,910 met the criteria for spontaneous abortion	Ratios of O/E miscarriages significantly raised for early, mid and late miscarriages if standing >8 hours daily; significantly greater O/E ratio for stillbirths if standing >8 hours daily	Standing >8 hours daily: RR 1.32 95% CI 1.1–3.5	Not noted	Maternal age, parity, history of previous miscarriage, smoking habit, highest education level reached	2+
McDonald (1988)[107]	Women attending 11 obstetrical units in Montreal from 1982–4; n=56067 interviewed n=22,613 previous pregnancies meeting criteria, therefore number used in analysis	Significantly increased risk of spontaneous miscarriage before 28 weeks associated with standing >8 hours/day: (See Table 5 for break-down by early, mid and late miscarriage.) Significant risk of stillbirth (>28 weeks) with standing >8 hours daily	RR 1.32 90% CI 1.1–3.5 p<0.01	Not noted	Age, gravidity, previous spontaneous miscarriage, ethnic group, height, educational level, cigarette smoking and alcohol consumption	2++
Case-control						
Eskenazi (1994)[42]	Cases: pregnant women in Santa Clara County who had spontaneous miscarriage before 20 weeks gestation, from 1986–7, n=434 (working) Controls: two per case randomly selected from a matched group, n=910 (working)	There is a significant association between standing >8 hours/day at work and spontaneous miscarriage. In second trimester: risk is much greater if there is a history of spontaneous miscarriage.	Adjusted OR 1.6 95% CI 1.1–2.3 Adjusted OR 2.1 95% CI 1.2–3.5	Not noted	Race, maternal age history of spontaneous miscarriage, cigarette smoking, alcohol, caffeine consumption, tap water consumption, marital status, parity, level of education and nausea	2+
Fenster (1997)[46]	Eligible members of prepaid healthcare plan in three areas of California, from 1990–1, n=5342 interviewed Working: n=4064 Numbers used in analysis	Significant increased risk of spontaneous miscarriage if standing for >7 hours in women with a history of >2 previous spontaneous miscarriages	Adjusted OR 4.32 95% CI 1.59–11.72	Not noted	Maternal age, gestational age at interview, pregnancy history, smoking, alcohol and caffeine consumption and marital status	2+

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Standing – *continued*						
Case-control						
Ali (2002)[11]	Cases: working mothers experiencing perinatal death. n=78 Controls: working mothers with a live baby, not resulting in early neonatal death, n=78	Prolonged standing >3 hours is significantly associated with perinatal mortality	OR 3.3 95% CI 1.7–6.5 p=0.001 Adjusted OR 3.5 95% CI 1.4–8.3	Not noted	Father's smoking status, birth weight of baby, baby's maturity at birth, past history of preterm delivery, mother's condition at work in relation to perinatal death. Maternal age, gravidity, antenatal care, previous obstetric history, medical complications, baby's gender, shift work, total hours of work per week, workplace hazards	2+
Working hours						
Case-control						
Eskenazi (1994)[42]	Cases: pregnant women in Santa Clara County who had spontaneous abortion before 20 weeks gestation, from 1986–1987, n=434 (working) Controls: two per case randomly selected from a matched group, n=910 (working)	No evidence of association with spontaneous miscarriage and working >40 hours/week	Adjusted OR 1.2 95% CI 0.8–1.9	Not noted	Race, maternal age history of spontaneous miscarriage, cigarette smoking, alcohol, caffeine consumption, tap water consumption, marital status, parity, level of education and nausea	2+
Retrospective cohort						
McDonald (1986)[104]	Women attending 11 obstetrical units in Montreal from 1982–4, n=56,012 interviewed n=4127 + 10,910 met the criteria for spontaneous miscarriage	A significant trend of increasing risk of spontaneous miscarriage with working >40 hours/week in previous pregnancies	(p<0.01)	Not noted	Maternal age, parity, history of previous miscarriage, smoking habit, highest education level reached	2+

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Working hours – *continued*						
Retrospective cohort						
McDonald (1988)[107]	Women attending 11 obstetrical units in Montreal from 1982–1984; n=56067 interviewed; n=22,613 previous pregnancies meeting criteria, therefore number used in analysis	For long hours of work, the O/E ratio increased with increasing grade of the factor	(p<0.01)	Not noted	Age, gravidity, previous spontaneous miscarriage, ethnic group, height, educational level, cigarette smoking and alcohol consumption	2++
Shift work						
Prospective cohort						
Zhu (2004)[171]	The Danish National Birth Cohort – all pregnant women who spoke Danish well enough; 1998–2001, initial n=54,954 enrolled n=42,687 with a job and work schedule	Increased risk of late fetal loss with fixed night work, but not significant	Adjusted hazard ratio 1.81 95% CI 0.88–3.72	Not noted	Maternal age, gravidity, history of spontaneous miscarriage, smoking, pre-pregnancy BMI, occupation, working posture, working hours per week, heavy lifting, perceived physically strenuous work, support from co-workers	2+
Retrospective cohort						
Axelsson (1996)[15]	Female members of the Swedish Midwives Association in 1989; pregnancies during which the woman worked as a midwife, n=1717 number used in analysis	When looking at first pregnancies only (n=428), there is a significantly increased risk of spontaneous miscarriage for night-work, and two-shift schedules Significantly increased risk of late spontaneous abortion with night work	Adjusted OR 6.89 95% CI 1.43–33.3 Adjusted OR 2.70 95% CI 1.09–6.72 Adjusted OR 3.33 95% CI 1.13–9.87	Exposure in first trimester only	Calendar year, age, previous spontaneous miscarriage, infection, full-time work, working time, use of N2O, shortage of staff	2+
McDonald (1986)[104]	Women attending 11 obstetrical units in Montreal from 1982–4, n=56,012 interviewed n=4127 + 10,910 met the criteria for spontaneous abortion	Greater O/E ratio of early and mid abortions if changing shift pattern. Significant increase in spontaneous miscarriage if rotating shift work, in various occupational sectors (Table 2 of paper)	(Table 2 of paper)	Not noted	Maternal age, parity, history of previous abortion, smoking habit, highest education level reached	2+

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Shift work – *continued*						
Case-control						
Infante-Rivard (1993)[74]	Women attending a particular hospital with a diagnosis of spontaneous miscarriage or fetal death from 1987–1989; matched controls Cases n=331 Controls n=993	Significantly increased risk of pregnancy loss if work fixed evening shift. Majority ≤17 weeks gestation. 26% >17 weeks	Adjusted OR 4.17 95% CI 2.19–7.92	Not noted	Age, level of schooling, presence of children at home, coffee drinking and uterine anatomical abnormality	2+

OR = odds ratio; RR = relative risk

Evidence table 4 Low birth weight

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Lifting						
Prospective cohort						
Ahlborg (1990)[9]	All pregnant women in antenatal care centres in Örebro county in the study period (1980–3) who worked during pregnancy, n=3906 the number used in the final analysis	Indication that heavy lifting might affect weight, but not conclusive, if woman continued to work at least until the 32nd week of pregnancy. Lifting weights and frequencies were defined	Adjusted OR 0.65 95% CI 0.24–1.77 for heaviest lifting category	Lifting in first trimester	Age, parity, sex of infant, educational level, smoking and frequency of alcohol use	2+
Tuntiseranee (1998)[161]	Pregnant women attending routine antenatal care at the dept of Obstetrics in 2 Thai hospitals from 1994–5, n=1821 number analysed in study n=2084 initially recruited	Significantly increased risk of low birth weight if lifting at chest level	Adjusted OR 3.5 95% CI 1.4–8.3	Reduced physical activity if at work at 32 weeks	Parity, maternal height, maternal age, obstetrical complications, baby sex, number of antenatal visits, maternal weight at delivery. Not necessarily applicable to UK context	2+
Retrospective cohort						
Armstrong (1989)[14]	Women attending 11 obstetrical units in Montreal from 1982–4, n=22,404 number in analysis. Further analysis from a previous study	Lifting heavy weights more than 15 times a day was significantly associated with low birth weight before and after accounting for gestational age	Mean per cent predicted birth weight for age 99.1% 90% CI: 98.3–99.9 p<0.05	Not noted	In previous paper, and then adjusted for occupational sector	2+
McDonald (1988)[108]	Women attending 11 obstetrical units in Montreal from 1982–4, n=56,067 interviewed for the study. Results based upon n=22,761	Significant association between lifting heavy weights and low birth weights	O/E 1.25 p<0.01	Not noted	Age, gravidity, previous spontaneous miscarriage, ethnic group, height, educational level, cigarette smoking and alcohol consumption	2++

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Physical activity						
Retrospective cohort						
Lima (1999)[86]	Women with low-income, with babies born April–December 1992 in NE Brazil; n=958 number in analysis	Significant reduction in birth weight if did heavy agricultural work for nine months of pregnancy	Adjusted effect: 117 g lower than un-exposed. p=0.05	Duration of pregnancy	Family income, maternal height, cigarette smoking, maternal age, parity, child care, antenatal care, child's sex. Not comparable to UK	2+
Cross-sectional						
Saurel-Cubizolles (1987)[138]	Randomly sampled women who delivered in French maternity units in 1981; n=5508 interviewed, analysis based upon n=2387	Higher rate of low birth weight among women who had to make considerable physical effort, and women who cumulated >2 strenuous working conditions	3.6% with birth weight <2500 g p=0.05	The proportion of women who did not work in the third trimester was higher when the work was strenuous (standing, heavy load carrying, assembly line work, considerable physical effort, p=0.001)	Parity, smoking, preterm delivery	2+
Standing						
Prospective Cohort						
Ha (2002)[58]	Eligible women who were current employees from 1996–1998 in a petrochemical corporation in Beijing, n=1222 number used in analysis	Standing for >3 hours/day is significantly associated with reduced birth weight	p=0.01	Not noted	Infant gender, maternal age, maternal BMI, maternal education, paternal education maternal organic solvent exposure	2+
Teitelman (1990)[159]	Eligible women who sought care from various healthcare providers in New Haven, expected to deliver at Yale-New Haven hospital and were pregnant, between 1980 and 1982; n=6219 introduced to the study; n=4186 completed valid interviews; final analysis based upon n=1,206	Mean birth weight lower in those standing, but not significantly. Low birth weight rate was moderately higher, but not statistically significant in those standing	p=0.182 RR 1.40 95% CI 0.64–3.03	Not noted	Parity, smoking, education, caffeine use, illicit drug use, gestational age at interview and marital status	2+

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Standing and walking						
Prospective cohort						
Henriksen (1995)[65]	Women attending for antenatal care at Aarhus university hospital from 1989–91, analysis based upon n=4259	Significantly greater risk of preterm delivery if walking and standing for >5 hours/day (does not distinguish between the two), compared with 2 hours or less	Adjusted RR 3.3 95% CI 1.4–8.0	Majority still working after 30 weeks, but a significant number either were off sick or no longer employed. More women who reported jobs involving long hours of standing and walking at 16 weeks, were no longer employed by the 30th week	Parity, maternal height, smoking, leisure time activities, partner's social class	2+
Working hours						
Prospective cohort						
Tuntiseranee (1998)[161]	Pregnant women attending routine antenatal care at the dept of Obstetrics in 2 Thai hospitals from 1994–5, n=1821 number analysed in study n=2084 initially recruited	Significantly increased risk of low birth weight if working 51–60 hours (note unusual trend for >61 hours)	Adjusted OR 2.4 95% CI 1.3–4.4	Not noted	Parity, maternal height, maternal age, obstetrical complications, baby sex, number of antenatal visits, maternal weight at delivery. Not necessarily applicable to UK context	2+
Retrospective cohort						
McDonald (1988)[108]	Women attending 11 obstetrical units in Montreal from 1982–4, n=56,067 interviewed for the study. Results based upon n=22,761	Significant association between working >46 hours/week and low birth weight	O/E 1.34 p<0.01	Not noted	Age, gravidity, previous spontaneous miscarriage, ethnic group, height, educational level, cigarette smoking and alcohol consumption	2++

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Shift work						
Retrospective cohort						
Armstrong (1989)[14]	Women attending 11 obstetrical units in Montreal from 1982–4, n=22,404 number in analysis Further analysis from a previous study	Changing shift work significantly associated with low birth weight before and after accounting for gestational age	Mean per cent predicted birth weight for age 98.2 % 90% CI: 97.2–99.2 p<0.01	Not noted	In previous paper, and then adjusted for occupational sector	2+
Bodin (1999)[25]	Female members of the Swedish Midwives Association in 1989; pregnancies between 1980–7, n=1244 number included in analysis	Significant association between night work and preterm birth	Adjusted OR 5.6 95% CI 1.9–16.4	Not noted	Maternal age, parity, employment, work schedule, N2O use	2+
Xu (1994)[169]	Married women working in textile mills in China. Analysis based upon n=887 live births Married, educated, non-smokers, non-alcohol drinkers.	Significant increase in prevalence of low birth weight of all live births associated with rotating shifts Significant association of low birth weight for first live births only and rotating shift work	Adjusted OR 2.1 95% CI 1.1–4.1 p=0.03 Adjusted OR 2.5 95% CI 1.2–5.4 p=0.02	Not noted	Mill location, maternal age at pregnancy, job title, time and duration of leave from the job since pregnancy, order of live births, exposure to dust/gases/fumes, physical activity and position while working, stress at work and use of coal stove for heating at home	2+
Cross-sectional						
Axelsson (1989)[17]	Women who had worked in a particular hospital in Sweden between 1980 and 1984 (previous pregnancies included). Those working nights permanently were selected and a random selection of those not working nights. n=807 sent the questionnaire, analysis based upon n=948 pregnancies	Significantly lower birth weight of second child in non-smoking women working irregular hours, always evenings and rotating shifts.	Irregular hours (p<0.01), always evenings (p<0.01) and rotating shifts (p<0.05)	In the second and third trimester	Not clear, although some results given are 'adjusted'	2+

OR = odds ratio; RR = relative risk

Evidence table 5 **Pre-eclampsia**

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Lifting						
Systematic review						
Bonzini (2007)[27]	Two studies considered the association between lifting and pre-eclampsia	One study found a positive association between lifting heavy loads and pre-eclampsia	See references in paper	See references in paper	See references in paper	1++
Retrospective cohort						
Wergeland (1997)[165]	Women who gave birth in a 6-week period in 1989 in Norway; singleton pregnancies, n=5438. Analysis based upon n=5388. 3321 in paid work beyond 3rd month of pregnancy	Significant association with lifting heavy loads (10–20 kg) in early pregnancy, compared with not lifting and pre-eclampsia. Significant association with lifting heavy loads >20 times weekly in early pregnancy and pre-eclampsia	Adjusted OR 1.7 95% CI 1.2–2.5 p<0.01 Adjusted OR 2.0 95% CI 1.2–3.2	Early pregnancy	Age, parity, height, BMI, education, smoking, coffee consumption, paid work	2+
Manual handling						
Retrospective cohort						
Wergeland (1997)[165]	Women who gave birth in a 6-week period in 1989 in Norway; singleton pregnancies, n=5438. Analysis based upon n=5388 3321 in paid work beyond 3rd month of pregnancy	Significant association with work with hands above shoulder level for more than half the day in early pregnancy and pre-eclampsia	Adjusted OR 2.3 95% CI 1.4–3.7	Early pregnancy	Age, parity, height, BMI, education, smoking, coffee consumption, paid work	2+
Working hours						
Systematic review						
Bonzini (2007)[27]	Two papers studied the association between working hours and pre-eclampsia	No results given	See references in paper	See references in paper	See references in paper	1++

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Working hours – *continued*						
Retrospective cohort						
Klebanoff (1990)[81]	Women who graduated from medical school in 1985 and a random sample of male physician spouses Final study population: 989 residents, 1239 spouses. Analysis based upon these numbers.	Residents worked 64 hours/week compared with <37 hours/week in spouses. Twice as many women residents developing pre-eclampsia or eclampsia, compared with spouses	p<0.001	Not noted	Parity, age at delivery, height, pre-pregnancy weight and race or ethnic group	2+
Shift work						
Systematic review						
Bonzini (2007)[27]	Two papers studied the association between shift work and pre-eclampsia	No results given	See references in paper	See references in paper	See references in paper	1++
Retrospective cohort						
Wergeland (1997)[165]	Women who gave birth in a 6-week period in 1989 in Norway; singleton pregnancies, n=5438. Analysis based upon n=5388 3321 in paid work beyond 3rd month of pregnancy.	Increased prevalence of pre-eclampsia in parous women doing shift work, however, adjusted OR not significant	Adjusted OR 1.3 95% CI 0.8–1.9 Note: OR 2.0 95% CI 1.1–3.6 for parous women working shifts, compared to women with other schedules.	Work beyond the 3rd month of pregnancy	Age, parity, height, BMI, education, smoking, coffee consumption, paid work	2+
Standing						
Systematic review						
Bonzini (2007)[27]	Four papers looked at the association between standing and pre-eclampsia	No results given	See references in paper	See references in paper	See references in paper	1++

OR = odds ratio; RR = relative risk

Evidence table 6 Small for gestational age/ intra-uterine growth restriction

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Lifting						
Systematic review						
Bonzini (2007)[27]	5 studies considered SGA and lifting	No significant positive or negative findings	NA	See references in paper	See references in paper	1++
Physical activity						
Case-control						
Spinillo (1996)[152]	Cases: Live born singleton infants with a diagnosis of fetal growth restriction delivered in the institution in the study period (1989–94) n=349 Controls: two nulliparous women with appropriate fetal growth during pregnancy, singleton infant born immediately after each case n=698	Increased risk of fetal growth restriction if performing moderate to heavy physical work, compared with light work. Intensity of work based upon type of physical effort (carrying heavy loads, performing heavy cleaning tasks, sweating while on physical exertion). Manual workers and healthcare workers have a significantly higher risk of IUGR	Adjusted OR 2.4 95% CI 1.36–4.21 Adjusted OR 1.81, 1.73 respectively 95% CI 1.15–2.85; 1.06–2.81 respectively	Not noted	Partner's social class, time of stopping work, smoking, alcohol use, illicit drug use, hypertension, maternal age, education, pre-pregnancy BMI, maternal weight gain per week	2+
Standing						
Systematic review						
Bonzini (2007)[27]	Association between standing and SGA considered in 8 studies	Majority of risk estimates were <1.5	NA	See references in paper	See references in paper	1++
Prospective cohort						
Teitleman (1990)[159]	Eligible women who sought care from various healthcare providers in New Haven, expected to deliver at Yale-New Haven hospital and were pregnant, between 1980 and 1982; n=6219 introduced to the study n=4186 completed valid interviews; final analysis based upon n=1,206	Rohrer's Index [(birth weight/length^3) x 100] for fetal growth was lower for those with standing jobs, compared with sedentary jobs, however this was not significant	p=0.27	Not noted	Parity, smoking, education, caffeine use, illicit drug use, gestational age at interview and marital status	2+

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Standing – *continued*						
Retrospective cohort						
Fortier (1995)[49]	Women in 6 community health departments in Quebec city who gave birth to a live singleton in 1989. Analysis based upon n=4390	Significant risk of SGA baby if standing ≥6 hours/day. Risk increases with increasing amount of standing. Significant risk of SGA if works at least 24 weeks and stood for ≥6 hours/day	Adjusted OR 1.42 CI 1.02–1.95 Significance of trend p=0.04	Not noted	Age, parity, history of low birth weight or preterm delivery, education, family income, pre-pregnancy weight, height, alcohol and caffeine intake, active and passive smoking, and energy expenditure in non-occupational activities	2++
Working hours						
Systematic review						
Bonzini (2007)[27]	Association between working hours and SGA considered in 7 studies	The largest study found an OR of 1.59. 95% CI 1.14–2.22. Most of the rest were close to unity	NA	See references in paper	See references in paper	1++
Prospective cohort						
Tuntiseranee (1998)[161]	Pregnant women attending routine antenatal care at the dept of Obstetrics in 2 Thai hospitals from 1994–5, n=1821 number analysed in study; n=2084 initially recruited	Significantly increased risk of small-for-gestational-age if working 51–60 hours (note unusual trend for >61 hours)	Adjusted OR 8.7 95% CI 3.1–24.2	Increased risk of SGA if at 32 weeks continued working >40 hours/week. However small numbers and wide confidence interval	Parity, maternal height, maternal age, obstetrical complications, baby sex, number of antenatal visits, maternal weight at delivery. Not necessarily applicable to UK context	2+
Shift work						
Systematic review						
Bonzini (2007)[27]	Association between shift work and SGA considered in 6 studies	In one the RR was 1.5 95% CI 1.0–2.4	Pooled estimate from 6 studies was 1.07 95% CI 0.96–1.19	See references in paper	See references in paper	1++

OR = odds ratio; RR = relative risk

Evidence table 7 Sick leave/sick certification

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Lifting						
Retrospective cohort						
Kaerlev (2004)[77]	Women employees aged 20–45 years, in a hospital from 1995–1999 who had a pregnancy. Analysis based upon n=655	Lifting heavy weights significantly associated with >10% sick leave of scheduled working time	Adjusted OR 1.9 CI 1.3–2.9	Lower absence at beginning of pregnancy – increased with gestation. If there was a need for change in work tasks, more sick leave	Age, occupation, full-time or part-time work and previous sickness absence	2+
Cross-sectional						
Strand (1997)[155]	Selection from a population of women in Norway who stayed in the same job during pregnancy and for whom data on leaving work was known Analysis based upon n=2,713	Significant number left work >3 weeks before delivery if lifting heavy loads (10–20 kg)	Adjusted OR 1.48 CI 1.22–1.80	Not noted	Age, education, children <16 years, housework, sick listed in the year prior to pregnancy	2+
Manual handling						
Retrospective cohort						
Kaerlev (2004)[77]	Women employees aged 20–45 years, in a hospital from 1995–9 who had a pregnancy. Analysis based upon n=655	Physically demanding jobs significantly associated with sick leave, eg launderers, nursing aides or hospital orderlies and nurses	Not clear if OR are adjusted	Lower absence at beginning of pregnancy – increased with gestation. If there was a need for change in work tasks, more sick leave	Age, occupation, full-time or part-time work and previous sickness absence	2+

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Manual handling – *continued*						
Cross-sectional						
Strand (1997)[155]	Selection from a population of women in Norway who stayed in the same job during pregnancy and for whom data on leaving work was known. Analysis based upon n=2,713	Significant number left work >3 weeks before delivery if twisting and bending, or working with hands above shoulders; significant number left >8 weeks before delivery if twisting and bending, or working with hands above shoulders. Sick certification increased with increasing level of strain	LSC >3 weeks T + B: Adjusted OR 1.46 CI 1.21–1.76 Hands above shoulder: Adjusted OR: 1.55 CI 1.22–1.95 LSC >8 weeks: T + B: Adjusted OR 1.32 CI 1.05–1.66 Hands above shoulders: Adjusted OR 1.36 CI 1.06–1.74	Not noted	Age, education, children <16 years, housework, sick listed in the year prior to pregnancy	2+
Cross-sectional study taken from a national survey						
Saurel-Cubizolles (1987)[138]	Randomly sampled women who delivered in French maternity units in 1981. n=5508 interviewed, analysis based upon n=2387	The proportion of women who did not work in the third trimester was higher when the work was strenuous (standing, heavy load carrying, assembly line work, considerable physical effort). More frequent sick leave if work was strenuous. Also more likely to change jobs	p=0.001 p=0.01 and p=0.001	Greater proportion took sick leave or did not work in the 3rd trimester if working conditions were tiring. If working conditions were not modified, there was a higher rate of sick leave, or woman more likely to stop working	Parity, smoking, preterm delivery	2+
Standing						
Cross-sectional						
Strand (1997)[155]	A selection from a population of women in Norway who stayed in the same job during pregnancy and for whom data on leaving work was known Analysis based upon n=2,713	Significant number left >8 weeks before delivery if standing with their back bent forwards	Adjusted OR 1.30 CI 1.02–1.65	Not noted	Age, education, children <16 years, housework, sick listed in the year prior to pregnancy	2+

continued

Author	Study population	Main results	Effect measure	Timing in pregnancy	Confounders	Sign grade
Standing and walking						
Retrospective cohort						
Kaerlev (2004)[77]	Women employees aged 20–45 years, in a hospital from 1995–9 who had a pregnancy. Analysis based upon n=655	Standing or walking at work significantly associated with sick leave.	Adjusted OR 3.4 CI 1.9–5.8	Lower absence at beginning of pregnancy – increased with gestation. If there was a need for change in work tasks, more sick leave	Age, occupation, full-time or part-time work and previous sickness absence	2+
Working hours						
Retrospective cohort						
Kaerlev (2004)[77]	Women employees aged 20–45 years, in a hospital from 1995–9 who had a pregnancy. Analysis based upon n=655	Long working days significantly associated with sick leave	Adjusted OR 3.3 CI 2.2– 4.9	Lower absence at beginning of pregnancy – increased with gestation. If there was a need for change in work tasks, more sick leave	Age, occupation, full-time or part-time work and previous sickness absence	2+
Shift work						
Retrospective cohort						
Kaerlev (2004)[77]	Women employees aged 20–45 years, in a hospital from 1995–9 who had a pregnancy. Analysis based upon n=655	Night or shift work not significantly associated with sick leave	Adjusted OR 1.4 95 % CI 1.0–1.9	Lower absence at beginning of pregnancy – increased with gestation. If there was a need for change in work tasks, more sick leave	Age, occupation, full-time or part-time work and previous sickness absence	2+
Cross-sectional						
Strand (1997)[155]	Selection from a population of women in Norway who stayed in the same job during pregnancy and for whom data on leaving work was known. Analysis based upon n=2,713	Significant number left work >3 weeks before delivery if doing shift work	Adjusted OR 1.51 CI 1.19–1.93	Not noted	Age, education, children <16 years, housework, sick listed in the year prior to pregnancy	2+

OR = odds ratio; RR = relative risk

Appendix 1 Search strategy

June 1980 – present

1. (pregnant or pregnancy) and work*
2. (pregnant or pregnancy) and employ*
3. (pregnant or pregnancy) and occupation*
4. (pregnant or pregnancy) and manual
5. (expect* mother*) and work*
6. (expect* mother*) and employ*
7. (expect* mother*) and occupation*
8. (expect* mother*) and manual
9. (childbirth) and work*
10. (childbirth) and employ*
11. (childbirth) and occupation*
12. (childbirth) and manual

The above terms were searched with the following words/phrases:

stand*
prolonged standing
morbid*
hypertension
blood pressure
diabet*
premature
preterm
sick*
absenc*
abort*
spontaneous abortion
miscarriage
birth weight
growth retard*
shift*
hour*
excessive hours
nightshift
long hours/long day
bleed*
pain/abdominal
lower back
risk factors

1975 – present

rupture of membranes/preterm rupture of membranes
thrombo-embolic disease/thrombo-embolic disease

Databases and journals searched

BNI
CINAHL
Cochrane Library
Embase
Evidence Based Periodicals Database (*BMJ*)
Health Periodicals Database
HSE Line
Medline
New England Journal of Medicine
Psychinfo
Scisearch

Appendix 2 Critical appraisal form

Reviewer(s): _____

Author, title: _____

Study type (tick all that apply)

Randomised controlled trial	❑
Systematic review	❑
Meta-analysis	❑
Qualitative research	❑
Literature review	❑
Case-control study	❑
Longitudinal/cohort study	❑
Other	❑

(Please describe)

Initial comments: _____

SCREENING QUESTIONS

1. Does the paper have a clearly focused aim or research question?

Yes ❑ No ❑ Can't tell ❑

Consider:
1. population studied
2. interventions delivered
3. outcomes

2. Is the chosen method appropriate?

Yes ❑ No ❑ Can't tell ❑

Consider whether:
1. the authors explain their research design
2. the chosen method address the research question

Is it worth continuing?

Yes ❑ No ❑

Please explain _____

Detailed questions

3. Has the research been conducted rigorously?

Yes ❑ No ❑ Can't tell ❑

Consider:
1. search strategy described
2. inclusions and exclusions
3. more than one researcher
4. resolving issues of bias

4. Is it clear how data has been analysed?

Yes ❑ No ❑ Can't tell ❑

Consider:
1. were study results combined
2. if so was this reasonable
3. in-depth description of the analysis process
4. all participants accounted for
5. contradictory findings explained

5. Is there a clear statement of findings?

Yes ❑ No ❑ Can't tell ❑

Consider:
1. sufficient evidence to support conclusions
2. do findings support the research question
3. precision of results
4. all important variables considered

6. How are the results presented?

Consider:
1. are the results presented numerically, i.e. p-value, OR (odds ratio)
2. are the results presented narratively

7. What is the main result?

Consider:
1. how large is the size of the result
2. how meaningful is the result
3. how would you sum up the bottom-line result in one sentence

8. Are there limitations to the research?

Yes ❑ No ❑ Can't tell ❑

Consider:
1. was the sample size large enough
2. were all important outcomes considered
3. was the intervention process adequately described
4. was there any follow-up data
5. do the authors acknowledge weaknesses

9. Can the results be applied to a UK context?

Yes ❑ No ❑ Can't tell ❑

Consider:
1. any discussion on how the findings can be used
2. findings considered in relation to current practice
3. estimation of benefits and costs

Accept for inclusion as evidence Yes ❑ No ❑ Can't tell ❑

Refer to guideline leader Yes ❑ No ❑

Guideline leader's notes

Any references to be followed up from this article?

Please attach this form to your recording sheet for appraising and grading and return to guideline leader

Appendix 3 **SIGN grading**

Levels of evidence	
1++	High quality meta-analyses, systematic reviews of randomised controlled trials (RCTs) , or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias
1–	Meta-analyses, systematic reviews of RCTs, or RCTs with a high risk of bias
2++	High quality systematic reviews of case-control or cohort studies High quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal
2+	Well conducted case-control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2–	Case-control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal
3	Non-analytic studies, eg case reports, case series
4	Expert opinion

Appendix 4 Grading system for recommendations

Grades of recommendation	
A	At least one meta-analysis, systematic review, or RCT rated as 1++, and directly applicable to the target population; *or* A systematic review of RCTs or a body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and demonstrating overall consistency of results
B	A body of evidence including studies rated as 2++, directly applicable to the target population, and demonstrating overall consistency of results; *or* Extrapolated evidence from studies rated as 1++ or 1+
C	A body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results; *or* Extrapolated evidence from studies rated as 2++
D	Evidence level 3 or 4; *or* Extrapolated evidence from studies rated as 2+

Good Practice Points

Guideline development groups may find that there is an important practical point that they wish to emphasise but for which there is not, nor is there likely to be, any research evidence. For example, some aspect of management or treatment that is regarded as such sound clinical practice that nobody is likely to question it. These may be marked in the guideline as Good Practice Points. These will not be alternatives to evidence-based recommendations, and will only be used where there is no other way of highlighting the issue.

Appendix 5 Score per paper

Journal: British Journal of Obstetrics and Gynaecology
Title: Standing at work and preterm delivery[65]
Authors: Henriksen TB, Hedegaard M, Secher NJ, Wilcox AJ.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaire: QBasic, Q16, Q30. All completed at home		
Outcome assessment	Ultrasound (82%), LMP or gestational age (9%), birth certificate (9%)		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2+

Journal: Occupational & Environmental Medicine
Title: Physical work load and gestational age at delivery[83]
Authors: Koemeester AP, Broersen JP, Treffers PE.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	
	>400	2	
	100–399	1	✓
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaire @ 15 weeks.		
	Interview + Questionnaire @ 20 wks		
Outcome assessment	Notes, US (80%) – LMP (20%)		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: American Journal of Epidemiology
Title: Prematurity and occupational activity during pregnancy[98]
Authors: Mamelle N, Laumon B, Lazar P.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaire post-delivery		
Outcome assessment	Medicine notes, LMP and Dubowitz score		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2+

Journal: International Journal of Epidemiology
Title: Heavy lifting during pregnancy – a hazard to the fetus? A prospective study[9]
Authors: Ahlborg G Jr, Bodin L, Hogstedt C.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	
	Mostly clear, some information unclear/missing	1	✓
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaire in early pregnancy prospective, interview post delivery		
Outcome assessment	Delivery records		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: Acta Obstetrica et Gynecology Scandinavia
Title: Standing and walking at work and birthweight[64]
Authors: Henriksen TB, Hedegaard M, Secher NJ.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	QBasic, Q16 at 16 weeks, and Q30 at 30 weeks		
Outcome assessment	Midwife + Hospital Records		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2+

Journal: Epidemiology
Title: Physical exertion as a risk factor for spontaneous abortion[42]
Authors: Eskenazi B, Fenster L, Wight S, English P, *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaire months post delivery		
	Computer assisted on telephone		
Outcome assessment	Cases: ?pathology specimen received in path lab.		
	Controls: birth certificates		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2+

Journal: Epidemiology
Title: Pregnancy loss and work schedule during pregnancy[74]
Authors: Infante-Rivard C, David M, Gauthier R, Rivard GE.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Face to face interview in hospital		
Outcome assessment	Not clear in this paper, but does refer reader to another paper for more details		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2+

Journal: Epidemiology
Title: A prospective study of work-related physical exertion and spontaneous abortion[46]
Authors: Fenster L, Hubbard AE, Windham GC, Waller KO, Swan SH.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interview 1st trimester – computer assessment telephone interview		
Outcome assessment	Computerised hospital records, medical records/phone some follow-up interviews		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			13
SIGN grade			2+

Journal: British Journal of Industrial Medicine
Title: Outcome of pregnancy in relation to irregular and inconvenient work schedules[17]
Authors: Axelsson G, Rylander R, Molin I.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	
	>400	2	✓
	100–399	1	
	<100	0	
Response rate	>85%	3	
	75–84%	2	✓
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Mailed questionnaire		
Outcome assessment	Mailed questionnaire + verification from hospital records		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			9
SIGN grade			2+

Journal: Journal of Occupational Health
Title: Prolonged standing and physical exertion at work during pregnancy increases the risk of preterm birth for Thai mothers[133]
Authors: Ritsmitchai S, Geater AF, Chonsuviwatvong V.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	
	>400	2	✓
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interviewed by trained interviewers, questionnaires post delivery, for each trimester		
Outcome assessment	Case: Spontaneous preterm abortion,		
	Control: birth at ≥37 weeks		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: American Journal of Obstetrics & Gynaecology
Title: The association between occupational factors and preterm birth: a United States nurses' study. Research Committee of the Association of Women's Health, Obstetric, and Neonatal Nurses[88]
Authors: Luke B, Mamelle N, Keith L, Munoz F, *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	✓
Exposure assessment	Mailed survey; structured questionnaire,		
Outcome assessment	LMP, actual delivery date/EDD		
	<37 weeks – cases		
	>37 weeks – controls		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total	Low score because of low percentage response rate, however, total population response was 7,250		9
SIGN grade			2++

Journal: PhD
Title: Perinatal deaths and maternal occupational risk factors in Peninsula Malaysia[11]
Author: Ali R.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	
	>400	2	
	100–399	1	✓
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment			
Outcome assessment			
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			10
SIGN grade			2+

Journal: Occupational & Environmental Medicine
Title: Shift work, nitrous oxide exposure, and spontaneous abortion among Swedish midwives[15]
Authors: Axelsson G, Ahlborg G Jr, Bodin L.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	
	75–84%	2	✓
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaire sent at set point to capture previous 10 years of pregnancies.		
	1st, 2nd, & 3rd trimester information		
Outcome assessment	Reported by woman that was diagnosed as pregnant, or preceded by the pregnancy test		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			10
SIGN grade			2+

Journal: Epidemiology
Title: The association of shift work and nitrous oxide exposure in pregnancy with birth weight and gestational age[25]
Authors: Bodin L, Axelsson G, Ahlborg G Jr.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	
	75–84%	2	✓
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	E-mailed questionnaire		
Outcome assessment	Questionnaire + Register		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			10
SIGN grade			2+

Journal: American Journal of Obstetrics & Gynaecology
Title: Occupational fatigue and preterm premature rupture of membranes. National Institute of Child Health and Human Development Maternal-Fetal Medicine, Units Network[116]
Authors: Newman RB, Goldenberg RL, Moawad AH, Iams JD, *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Nurse administered questionnaires at enrolment (22–4 weeks). Another questionnaire at 27–31 weeks, but no recheck of fatigue		
Outcome assessment	US/LMP/Algorithm used for gestational age		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			13
SIGN grade			2+

Journal: British Journal of Industrial Medicine
Title: Prematurity and work in pregnancy[108]
Authors: McDonald AD, McDonald JC, Armstrong B, Cherry NM *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interviews soon after delivery		
Outcome assessment	Hospital records		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2++

Journal: British Journal of Industrial Medicine
Title: Fetal death and work in pregnancy[107]
Authors: McDonald AD, Armstrong B, Cherry NM, Cote R, *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interviews immediately after delivery		
Outcome assessment	Women and hospital records		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2++

Journal: Journal of Occupational Medicine
Title: Spontaneous abortion and occupation[104]
Authors: McDonald AD,Armstrong B, Cherry NM, Delorme C *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interview post delivery		
Outcome assessment	Outcome assessment + medical records		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	
	no	0	
Total			12
SIGN grade			2+

Journal: Acta Obstetrics & Gynaecology Scandinavia
Title: The effect of work activity in pregnancy on the risk of fetal growth retardation[152]
Authors: Spinillo A, Capuzzo E, Baltaro F, Piazza G, *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Structured interview at birth		
Outcome assessment	US measurements		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	
	no	0	
Total			12
SIGN grade			2+

Journal: Occupational & Environmental Medicine
Title: Association of rotating shiftwork with preterm births and low birth weight among never smoking women textile workers in China[169]
Authors: Xu X, Ding M, Li B, Christiani DC.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	
	Mostly clear, some information unclear/missing (*refers to another paper)*	1	✓
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Standardised questionnaire, but not clear at what point is pregnancy		
Outcome assessment	Not clear, but refers to another paper		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: Journal of Epidemiology & Community Health
Title: Employment, working conditions, and preterm birth: results from the Europop case-control survey[140]
Authors: Saurel-Cubizolles MJ, Zeitlin J, Lelong N, Papiernik E *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interviews after delivery		
Outcome assessment	Medical records		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	All confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2++

Journal: American Journal of Obstetrics & Gynaecology
Title: Shift work, duration of pregnancy, and birth weight: the National Birth Cohort in Denmark[172]
Authors: Zhu JL, Hjollund NH, Olsen J.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	1st Interviews ≥11–25 weeks		
	2nd Interviews – 27–37 weeks		
Outcome assessment	LMP at prenatal visit, EDD at 2nd interviews; US measurement		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			13
SIGN grade			2++

Journal: The New England Journal of Medicine
Title: Outcomes of pregnancy in a national sample of resident physicians[81]
Author: Klebanoff MA, Shiono PH, Rhoads GG.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	
	Mostly clear, some information unclear/missing	1	✓
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaire at what point?		
	Implied post delivery		
Outcome assessment	Not clear – but was asked in questionnaire		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			10
SIGN grade			2+

Journal: American Journal of Epidemiology
Title: Tree based, Two-stage Risk factor analysis for spontaneous abortion[170]
Authors: Zhang H, Bracken MB

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	
	Mostly clear, some information unclear/missing	1	✓
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Home interviews 5–16 weeks		
Outcome assessment	Details in: Bracken MB, Belanger K, Hellenbrand K *et al.**		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2+

*Details in: Bracken MB, Belanger K, Hellenbrand K *et al.* Exposure to electromagnetic fields during pregnancy with emphasis on electrically heated beds: association with birth weight and intra-uterine growth retardation. *Epidemiology* 1995;6:263–70.

Journal: British Journal of Industrial Medicine
Title: Work in pregnancy and birth weight for gestational age[14]
Authors: Armstrong BG, Nolin AD, McDonald AD.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	
	Mostly clear, some information unclear/missing	1	✓
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interview using questionnaire soon after delivery		
Outcome assessment			
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: Journal of Occupational & Environmental Medicine
Title: Does standing at work during pregnancy result in reduced infant birth weight?[58]
Authors: Ha E, Cho SI, Park H, Chen D *et al.*

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	
	Mostly clear, some information unclear/missing	1	✓
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Administered questionnaire but not clear when		
Outcome assessment	Hospital delivery records		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: Journal of Occupational and Environmental Medicine
Title: Shift work, job stress, and late fetal loss: The National Birth Cohort in Denmark[171]
Authors: Zhu JL, Hjollund NH, Andersen AM, Olsen, J.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	1st interviews 11–25 weeks		
	2nd interviews		
Outcome assessment	LMP, EDD and register		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			13
SIGN grade			2+

Journal: Scandinavian Journal of Public Health
Title: Long-term sick leave and its risk factors during pregnancy among Danish hospital employees[77]
Authors: Kaerlev L, Jacobsen LB, Olsen J, Bonde JP.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	
	>400	2	✓
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	From hospital roster, questionnaire considered changes during pregnancy		
Outcome assessment	Register date, roster		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			10
SIGN grade			2+

Journal: Journal of Epidemiology and Community Health
Title: Is preterm delivery still related to physical working conditions in pregnancy?[141]
Authors: Saurel-Cubizolles MJ, Subtil D, Kaminski M.

Points to score	Conditions	Score	Points
Points to score	**Conditions**	**Score**	**Points**
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Structured questionnaire after delivery in hospital		
Outcome assessment	LMP, obstetric staff estimates		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: Scand Journal of Social Medicine
Title: Work load, job control and risk of leaving work by sickness certification before delivery, Norway 1989[155]
Authors: Strand K, Wergeland E, Bjerkedal T.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaire after delivery in hospital		
Outcome assessment	Questionnaire answers + some checking with a database		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2+

Journal: American Journal of Epidemiology
Title: Effect of maternal work activity on preterm birth and low birth weight[159]
Authors: Teitelman AM, Welch LS, Hellenbrand KG, Bracken MB.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interviewed using a standard questionnaire in 1st or 2nd trimester		
Outcome assessment	Hospital records or medical provider		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			13
SIGN grade			2+

Journal: Journal of Occupational & Environmental Medicine
Title: The effect of heavy maternal workload on fetal growth retardation and preterm delivery. A study among southern Thai women[161]
Authors: Tuntiseranee P, Geater A, Chongsuvivatwong V, Kor-anantakul O.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Q17, Q32 – interviews by trained interviewers		
Outcome assessment	From obstetric notes after delivery		
Inflationary bias	Low	2	✓
	Possible	1	
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			13
SIGN grade			2+

Journal: International Journal of Epidemiology
Title: Influence of heavy agricultural work during pregnancy on birthweight in northeast Brazil[86]
Authors: Lima M, Ismail S, Ashworth A, Morris SS.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	
	>400	2	✓
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Hospital based interviews 12–48 hours post delivery – trained interviewers		
Outcome assessment	'Antropometric' measures		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: British Journal of Industrial Medicine
Title: Pregnant women's working conditions and their changes during pregnancy: a national study in France[138]
Authors: Saurel-Cubizolles MJ, Kaminski M.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Interviews within 6 days of delivery, standard questionnaire, 1st trimester + modifications		
Outcome assessment	Preterm <37 weeks, low <2500g		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	
	A few confounders considered	1	✓
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2+

Journal: International Journal of Gynaecology & Obstetrics
Title: Working conditions and prevalence of pre-eclampsia, Norway 1989[165]
Authors: Wergeland E, Strand K.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	✓
	Mostly clear, some information unclear/missing	1	
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Questionnaires post delivery		
Outcome assessment	Report by women possibly cross-referenced with medical notes, but not clear		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	Most confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			12
SIGN grade			2+

Journal: Scandinavian Journal of Work Environmental Health
Title: Maternal work during pregnancy and the risks of delivering a small-for-gestational-age or preterm infant[49]
Authors: Fortier I, Marcoux S, Brisson J.

Points to score	Conditions	Score	Points
Sampling	Defined population, representative, clear procedures, all accounted for	2	
	Mostly clear, some information unclear/missing	1	✓
	Mostly unclear, difficult to track or unmentioned	0	
Power	>1000	3	✓
	>400	2	
	100–399	1	
	<100	0	
Response rate	>85%	3	✓
	75–84%	2	
	50–74%	1	
	<50% or unclear	0	
Exposure assessment	Telephone interviews post delivery		
Outcome assessment	Birth weight from birth certificate.		
	Gestational age from US/LMP/birth certificate		
Inflationary bias	Low	2	
	Possible	1	✓
Confounding	All confounders considered	2	✓
	A few confounders considered	1	
	None considered	0	
Statistics	OR/95%/p-value included: yes	1	✓
	no	0	
Total			11
SIGN grade			2++

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