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Pregnancy, obstetrical and neonatal outcomes in women exposed to physician-related occupational hazards: a scoping review

Candace M Marsters,[1] Lenka Stafl,[2] Sarah Bugden,[3] Rita Gustainis,[4] Victoria Nkunu ,[5] Renee Reimer,[6] Sarah Fletcher,[6] Stephanie Smith,[7] Moss Bruton Joe,[8] Christine Hyde,[9] Erica Dance,[10] Shannon M Ruzycki [2,11]

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CMM and LS are joint first authors.

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For numbered affiliations see end of article.

Correspondence to
Dr Shannon M Ruzycki; shannon.ruzycki@ucalgary.ca

ABSTRACT

Objective Evidence is needed to guide organisational decision making about workplace accommodations for pregnant physicians. Our objective was to characterise the strengths and limitations of current research examining the association between physician-related occupational hazards with pregnancy, obstetrical and neonatal outcomes.

Design Scoping review.

Data sources MEDLINE/PubMed, EMBASE, CINAHL/EBSCO, SciVerse Scopus and Web of Science/Knowledge were searched from inception to 2 April 2020. A grey literature search was performed on 5 April 2020. The references of all included articles were hand searched for additional citations.

Eligibility criteria English language citations that studied employed pregnant people and any 'physician-related occupational hazards', meaning any relevant physical, infectious, chemical or psychological hazard, were included. Outcomes included any pregnancy, obstetrical or neonatal complication.

Data extraction and synthesis Physician-related occupational hazards included physician work, healthcare work, long work hours, 'demanding' work, disordered sleep, night shifts and exposure to radiation, chemotherapy, anaesthetic gases or infectious disease. Data were extracted independently in duplicate and reconciled through discussion.

Results Of the 316 included citations, 189 were original research studies. Most were retrospective, observational and included women in any occupation rather than healthcare workers. Methods for exposure and outcome ascertainment varied across studies and most studies had a high risk of bias in data ascertainment. Most exposures and outcomes were defined categorically and results from different studies could not be combined in a meta-analysis due to heterogeneity in how these categories were defined. Overall, some data suggested that healthcare workers may have an increased risk of miscarriage compared with other employed women. Long work hours may be associated with miscarriage and preterm birth.

Conclusions There are important limitations in the current evidence examining physician-related occupational hazards and adverse pregnancy, obstetrical and neonatal outcomes. It is not clear how the medical workplace should be accommodated to improve outcomes for pregnant physicians. High-quality studies are needed and likely feasible.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This scoping review included a range of occupations with physician-related occupational hazards.
⇒ Due to heterogeneous study populations and outcome and exposure definitions, we cannot make recommendations about how to adapt the physician workplace to reduce adverse pregnancy, birth and neonatal outcomes.
⇒ These results can inform the design of high-quality studies to measure an association between select adverse pregnancy, birth and neonatal outcomes with physician-related occupational hazards.

INTRODUCTION

The number of women physicians is rising in nearly every country[1–3] with a concomitant rise in the number of physicians mothers; about three-quarters of women physicians will become parents during training or practice.[4] This increasing demand has not been met with a similar rise in supports for physician mothers. Many medical organisations do not have parental[5 6] or pregnancy[7] policies to guide workplace adaptations for pregnant physicians and those returning to work after a parental leave. Due to this lack of systems-level guidance, the experiences of women physicians are variable both between and within organisations.[7] Pregnant physicians may experience a greater prevalence of complications than other groups,[8] including more frequent preterm labour[9–11] and pregnancy loss,[12] though the literature is conflicting.[13 14] Further, the relationship between modifiable aspects of physician work that contribute to these worse outcomes is not well described.

Despite the lack of clarity about which occupational hazards may contribute to worse outcomes for pregnant physicians, there is an urgent need for evidence-informed policies to guide workplace adaptations for physicians who are pregnant. The objective of this review was to characterise the extant literature examining pregnancy, obstetrical and neonatal outcomes associated with the physical, psychological, chemical and infectious hazards encountered by physicians at work. The aim was to use the currently available data to inform further study to better understand the relationship between physician work and adverse pregnancy outcomes and to provide interim guidance for pregnant physicians, especially those at greatest risk of complications.

METHODS

Study design

The review protocol used the framework outlined by the Joanna Briggs Institute methodology for scoping reviews because of the topic's complexity and anticipated heterogeneity in exposures and outcomes (online supplemental appendix 1).[15 16] This manuscript follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews guidelines.

Research question

The study population was employed pregnant people. Exposures were 'physician-related occupational hazards', meaning any relevant physical, infectious, chemical or psychological hazard. Outcomes were any pregnancy, obstetrical or neonatal complication. A list of potential exposures and outcomes was developed a priori by the study team and piloted using a subset of citations.

Data sources and search

The search strategy was codeveloped with a medical librarian (online supplemental appendix 2). Five electronic databases were searched from inception to 2 April 2020: MEDLINE/PubMed, EMBASE, CINAHL/ EBSCO, SciVerse Scopus, Web of Science/Knowledge. A grey literature search (5 April 2020) included a Google search,[17] handsearching the reference lists of included articles,[18] recommendations from content experts and review of PubMed's 'cited by' and 'similar articles'.

Study selection

There were no restrictions on publication date or study date. We included citations of any experimental or quasi-experimental study design as well as qualitative studies, systematic reviews and non-systematic reviews, letters, opinion papers, policy statements and published abstracts. Citations not available in English were excluded.

Included studies must have: (1) the population of interest (pregnant women, pregnant employed women, physicians, clinicians, resident physicians, medical students, nurses, healthcare personnel or healthcare professionals); (2) an exposure of interest (physician work, residency work, medical school, nursing work, general healthcare personnel work, shift work, working hours, physical workload, workplace stress or any type of medically hazardous exposures) and (3) an outcome of interest (any type of pregnancy, obstetrical or neonatal outcome). When data were reported in more than one publication, only the citation containing the most complete dataset or reporting was used.

Data extraction and quality assessment

Citations were imported into Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) and deduplicated. Two authors independently screened abstracts for eligibility and disagreements were resolved by a third reviewer. A data extraction form (online supplemental appendix 3) was pilot-tested on ten articles by two reviewers (CMM and SMR) for completeness, accuracy and ease of use. Data extraction was performed independently by two reviewers in duplicate and reconciled for accuracy. Disagreements were resolved by rereviewing the article or a third reviewer.

Data synthesis and analysis

Due to heterogeneity of the outcomes, methods and populations, meta-analysis was not performed. Instead, the 'direction' of effect for each exposure-and-outcome relationship (eg, increased risk, decreased risk, no association) was tabulated descriptively. When multiple levels of an outcome or an exposure were reported, (eg, standing less than 2 hours, between 2 and 6 hours, or more than 6 hours per day),[19] we extracted the strongest association to avoid missing a signal for harm in the data.

Patient and public involvement

None.

RESULTS

Study characteristics and limitations

The initial search strategies identified 6039 citations and 316 met inclusion criteria (figure 1). Most were original research articles (n=189, 59.8%). There were no intervention studies. Most original research articles were published prior to 2010 while non-systematic reviews, opinion articles, systematic reviews and meta-analyses were more common after 2010 (table 1; online supplemental efigure 1).

Most of the data on exposure to physician-related occupational hazards and pregnancy, obstetrical and neonatal outcomes examined employed women working in non-healthcare-related fields. Fewer than half of all citations examined healthcare workers and 22.2% reported outcomes specifically for physicians (n=42). These articles included a total 29 198 unique physician pregnancies (table 1).

Heterogeneity in outcome and exposure definition and potential bias in ascertainment limited our ability to synthesise the association between exposure

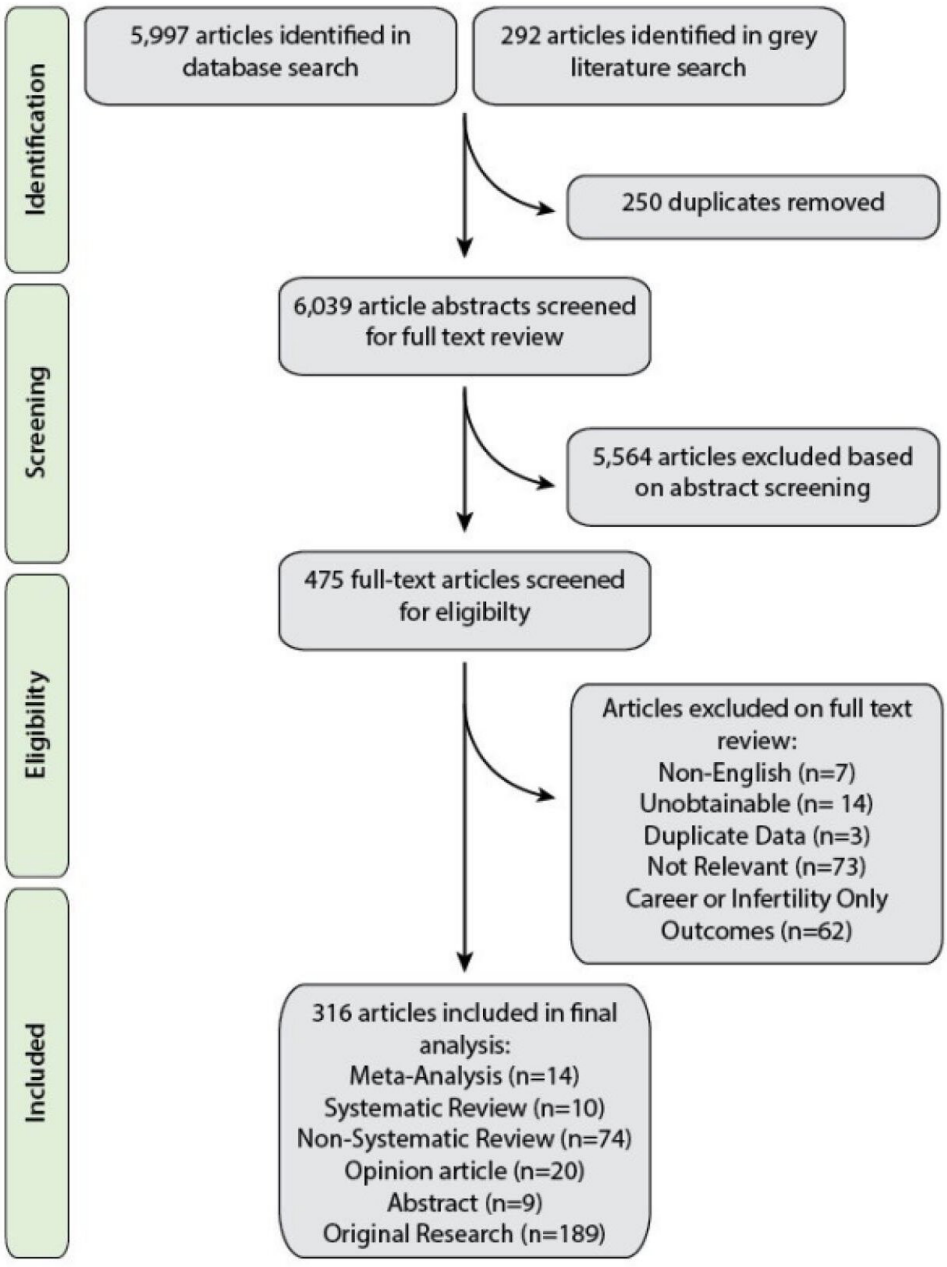

Figure 1 PRISMA flow chart of citations included and excluded in this scoping review. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

to physician-related occupational hazards and adverse outcomes (table 2). For example, included citations used a range of gestational lengths to define a spontaneous abortion or pregnancy loss and many studies combined preterm labour and preterm birth as a single outcome. There were few cases of pregnancy loss and preterm birth reported in most studies and so the relationship between these outcomes and many exposures cannot be well determined. Since most articles defined preterm birth, miscarriage and small- for-gestational age (SGA) as categorical rather than continuous variables, we were unable to combine data across studies (table 2).

Most exposures and outcomes data were collected by self-reported, retrospective surveys and were limited by small sample sizes, low response rates, recall bias, response bias and low numbers of the outcome (tables 1 and 2). Since many outcomes were ascertained by self-reported surveys or were uncommon, the sample sizes for these studies were small (eg, less than 1000). Birth weight was a notable exception; many studies used administrative data sets to collect birth weight data and sample sizes were therefore much larger. Unfortunately, these studies lacked granularity in exposure data and physicians were less commonly studied for this outcome.

With these limitations in mind, we identified 16 unique outcomes and 13 unique exposures in this scoping review (online supplemental etable 1). Preterm labour and/or birth ('preterm birth') was the most commonly reported

Table 1 Characteristics of the original research articles included in scoping review

Characteristic	No	Percentage
Total	189	–
Publication year		
<1990	40	21.2
1990–1999	55	29.1
2000–2009	37	19.6
2010–2019	56	29.6
2020	1	0.5
Study design type		
Case–control	42	22.2
Cohort	91	44.4
Cross-sectional	56	35.6
Study location		
North America	83	43.9
Europe	77	40.7
Asia	21	11.1
Africa	3	1.6
South America	2	1.1
Worldwide	1	0.5
Australia	1	0.5
Not stated	1	0.5
Study data source types		
Survey	102	54.0
Interview	67	35.4
Database	68	36.0
Direct observation or measurement	13	6.9
Unknown	4	2.1
Study population category		
Employed women	99	52.4
Healthcare workers	26	13.8
Nurses	20	10.6
Physicians and residents	42	22.2
Other	2	1.1
Female physicians studied (total*)	29 198	

*Included total number of participants or pregnancies.

outcome (n=223 unique outcomes), followed by 'miscarriage' (n=179) and birth weight (n=116) (figure 2A; online supplemental etable 1). The most common exposures were 'healthcare work' (n=185), 'physician work' (n=166) and work hours (n=150) (figure 2A; online supplemental etable 1).

Details about studies that examined the four most commonly studied outcomes are in table 3. Overall, about one-fifth of these studies did not have a comparison group and reported prevalence data only. In the remaining studies, the selected comparator population likely introduced important, unmeasured confounders and limited our ability to generalise these findings to physicians. For example, several studies compared physicians to unemployed women, which potentially introduces healthy worker bias. Notably, many studies compared their result to general population incidence data but used much lower incidence than typically reported, such as a prevalence of miscarriage of 4.2%.[20] Many studies compared healthcare workers or physicians to a specific other occupation, most often teachers or used the partners of men physicians as a comparator population to control for lifestyle or socioeconomic confounders. The comparator group with the lowest risk of unmeasured confounders were studies that compared physicians or healthcare workers with a specific exposure to the same population that did not have that exposure; for example, studies that compared physicians working in the operating room with physicians working on a medical inpatient unit to understand the risk of anaesthetic exposure on pregnancy outcomes.

The relationship between physician-related occupational hazards and pregnancy, birth and neonatal outcomes must be interpreted with the above limitations in mind. Due to the heterogeneity of the available studies, we have restricted the main text results to studies that focused on physicians and healthcare workers. Additional information for all identified studies is available in online supplemental efigure 2. The number of studies that included only physicians and healthcare workers, stratified by the direction of effect between exposure and outcome, are shown in figure 3, the prevalence of select outcomes among physicians and healthcare workers is shown in figure 4, and the effect sizes of the risk of miscarriage and preterm birth among healthcare workers are shown in figure 5.

Miscarriage

In this manuscript, we use the more general term 'miscarriage' rather than spontaneous abortion because included citations used varying definitions rather than the current accepted medical definition of spontaneous abortion. The data examining whether physicians and healthcare workers have increased risk of miscarriage compared with other workers or the general population were conflicting (figures 3A and 5A). When an increased risk was found, it was less than two times greater. Two studies reported a greater prevalence of miscarriage among physicians than the general population (11.8% vs 4.2%; p<0.001[20]; and 20.8% versus 14.2%; p<0.05[21] and two studies reported greater prevalence of miscarriage among healthcare workers compared with women in other occupations (OR 1.18 (95% CI 1.13 to 1.23) and 1.06 (95% CI 1.03 to 1.09) respectively).[22 23] However, three studies comparing physicians to the general population found no difference[12 24 25] and five studies comparing women physicians to workers in any occupation[12 21] or to the partners of men physicians[26–28] also reported no increased risk. Three studies including only healthcare workers reported increased risk

Table 2 The definitions and ascertainment of select exposures and outcomes for citations included in this scoping review were heterogeneous

Exposure/outcome	Example definitions and/or ascertainment methods
Pregnancy outcomes	
Threatened abortion	Bleeding in the first 22 weeks of pregnancy.[120]
Ectopic pregnancy	ICD-10 codes.[22] Self-reported.[74]
General pregnancy loss	Some studies defined separately from spontaneous abortion, as a fetal loss after 28 weeks.[24 121]
Miscarriage*	Pregnancy that ended before 20 weeks gestational age.[122] Pregnancy that ended before 22 weeks gestational age.[118] Pregnancy that ended before 26 weeks gestational age.[54] Pregnancy that ended before 28 weeks gestational age.[25] Pregnancy that ended before 29 weeks gestational age.[40]
Gestational hypertension	Self-reported, two or more measurements greater than 140/90 after 20 weeks gestational age.[123] Using administrative data, based on ICD-10 codes.[124] Using chart review, diastolic blood pressure >110 mm Hg.[125]
Preeclampsia	Self-reported, two or more measurements greater than 140/90 and albuminuria after 20 weeks gestational age.[123] Using chart review, proteinuria >300 mg in 24-hour collection.[125]
Mood disorder	Self-reported.
Gestational length	Gestational age.
Preterm labour and birth	Birth prior to 37 weeks gestational age.[13] Birth prior to 38 weeks gestational age.[74]
Neonatal outcomes	
Birth weight	Any birth weight less than 2500 g.[74,13]
SGA	Any birth weight less than the 10th centile for given gestational age.[68] Any birth weight less than the 5th centile for given gestational age.[126] Any birth weight less than the 2.5th centile for a given gestational age.[127]
IUGR	Any estimated fetal weight less than the 10th centile for given gestational age.[13]
Exposures	
Work hours	More than 40 hours per week.[31] More than 46 hours per week.[128] More than 100 hours per week.[9] More than 170 hours per month.[32]
Shift work	Two or more night shifts per week.[118] Rotating shifts.[129] 'Unfavourable' work hours.[119] Some studies stratified by work in different trimesters.
Physical work demands	Energy expenditure, estimated as percent increase above basal metabolic rate.[130] Mean energy expenditure per working hour.[131]
Healthcare work	Any study that compared healthcare workers to another group.
Physician-type work	Any study that compared physicians to another group.
Mental stress	Being very tired or extremely tired at the end of a typical work day.[132] In the 75th centile for rating their job as 'high psychological stress'.[29] Sum of skill factors, decision latitude and decision authority.[133]
Sleep	Self-reported.
Anaesthetic gas	Varied by year of study, varied by reports of safety or mitigating measures.
Chemotherapy drugs	Varied by year of study, dosage categories.
Infection	Varied by year of study, whether patient used PPE.
Medication exposures	Varied.
Chemical exposures	Varied by dose and categorisation.
Radiation	Variably characterised, included self-reported and direct observation.

*Miscarriage is used in this scoping review rather than spontaneous abortion to differentiate the varied definitions of pregnancy loss across studies from the current definition of spontaneous abortion (a nonviable intrauterine pregnancy up to 20 weeks gestational age).
ICD-10, 10th version of International Classification of Diseases; IUGR, intrauterine growth restriction; PPE, personal protective equipment; SGA, small-for-gestational age.

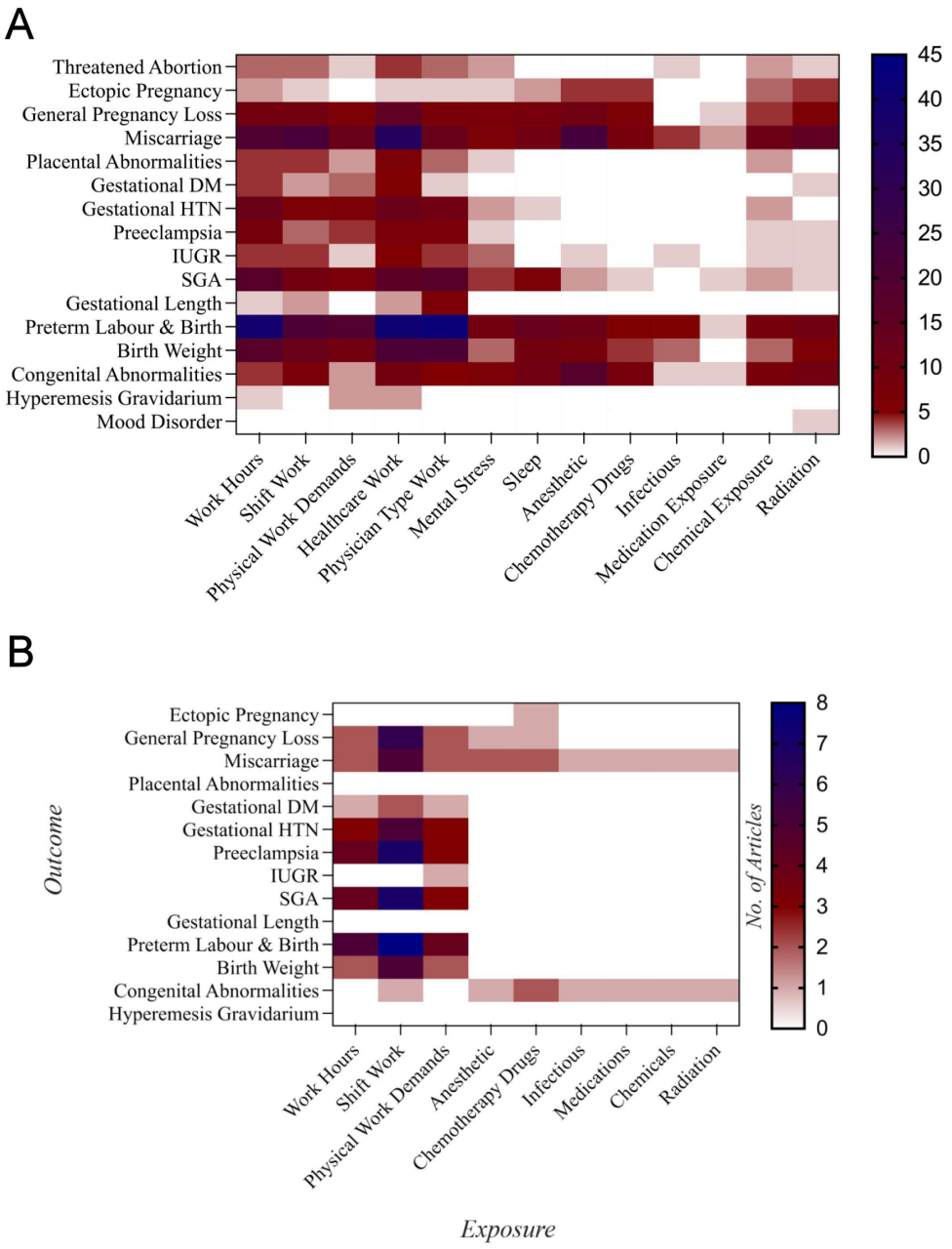

Figure 2 Heatmap representing the number of articles that refer to relevant occupational exposures related to physician-type work and pregnancy outcomes (A) Within the included original research articles and (B) within systematic review with meta-analysis articles. Miscarriage refers to a pregnancy loss that was classified as a spontaneous abortion and not a stillbirth or intrauterine fetal demise by the included citation. The gestational age used to define this outcome varied across studies and does not reflect the current definition of spontaneous abortion. IUGR, intrauterine growth restriction; SGA, small-for-gestational age. HTN, hypertension; DM, diabetes mellitus.

of miscarriage with increasing work hours (healthcare workers; adjusted OR, aOR 1.36,[24 29] nurses; relative risk 1.5 (95% CI 1.3 to 1.7)[30] and nurses or midwives (p=0.03).[31]

A case–control study found nurses who had a miscarriage were more likely to have worked more than 170 hours per month[32] and night shifts were associated with a greater risk of miscarriage among midwives (OR 3.33 (95% CI 1.13 to 9.87)).[33]

Pregnancy loss

There was variability in the definition of pregnancy loss and many studies combined stillbirth, intrauterine fetal demise and spontaneous abortion as a single outcome. We, therefore, use 'pregnancy loss' in this manuscript to refer to any fetal demise that was not characterised as a spontaneous abortion or miscarriage in the original citation. The prevalence of pregnancy loss among physicians ranged from 0%[10 11 34] to 1.7% (figure 4).[35] Two studies comparing women physicians to the partners of men physicians reported no increased risk of pregnancy loss (figure 3B).[27 36] Similarly, studies comparing physicians to other workers found no increased risk of pregnancy loss,[14 25 37–39] though one survey reported an unadjusted,

Table 3 Characteristics of original research studies that examined the four most commonly reported outcomes

Definition	Miscarriage* n (%) Categorical, varied by study	Pregnancy loss n (%) Categorical, varied by study	Preterm birth† n (%) Categorical, varied by study	Birth weight n (%) Continuous, numerical
No	91	89	101	41
Study design				
Cross-sectional	30 (33.0)	13 (14.6)	20 (19.9)	5 (12.2)
Survey	11 (12.1)	27 (30.3)	5 (5.0)	4 (9.8)
Cohort	34 (37.4)	33 (37.1)	57 (56.4)	24 (58.5)
Case control	16 (17.6)	16 (18.0)	19 (18.8)	8 (19.5)
Sample size‡ of the target population				
Median (IQR)	334 (165–1137)	334 (166–1284)	717 (230–2383)	1183 (343–4476)
<100	15 (16.5)	16 (18.0)	10 (9.9)	2 (4.9)
101–250	19 (20.9)	20 (22.5)	20 (19.9)	5 (12.2)
251–1000	31 (34.1)	29 (32.6)	29 (28.7)	12 (29.3)
>1001	22 (24.2)	24 (27.0)	40 (39.6)	21 (51.2)
Population				
Physicians	41 (45.1)	39 (43.8)	26 (25.7)	7 (17.1)
Women employed in healthcare	36 (39.6)	36 (40.4)	24 (23.8)	7 (17.1)
Other employed women	21 (23.1)	20 (22.5)	51 (50.5)	27 (65.9)
Comparison group				
None	16 (17.6)	16 (18.0)	18 (17.8)	6 (14.6)
Unemployed women	3 (3.4)	4 (4.5)	11 (10.9)	9 (22.0)
General population	6 (6.6)	4 (4.5)	2 (2.0)	1 (2.4)
Any employed women	9 (9.9)	7 (7.9)	48 (47.5)	20 (48.8)
Women in a specific other occupation	22 (24.2)	17 (19.1)	6 (5.9)	2 (4.9)
Partners of men physicians	11 (12.1)	11 (12.4)	5 (5.0)	3 (7.3)
Women in healthcare occupations without the exposure	26 (28.6)	28 (31.5)	14 (13.9)	2 (4.9)

*Miscarriage is used in this scoping review rather than spontaneous abortion to differentiate the varied definitions of pregnancy loss across studies from the current definition of spontaneous abortion (a nonviable intrauterine pregnancy up to 20 weeks gestational age).
†Note that the gestational age used to define preterm birth varied across studies and some studies combined preterm labour and preterm birth as a single outcome.
‡Studies defined the number of participants as unique pregnancies (including repeat pregnancies by the same female) or unique mothers (most recent or first pregnancy only).

10-fold greater prevalence among physicians when compared with the general population (3.2% compared with 0.37%; p<0.001).[12] Few studies examined the association between pregnancy loss and healthcare work (figure 3B).

Most citations examining exposure to anaesthetic gas,[24 27 39–47] antineoplastic medications,[40 41 47–50] or radiation[47 48 51 52] and pregnancy loss were performed prior to 2000 and their relevance given contemporary safety measures are unknown (online supplemental efigure 2). Of the six studies performed after 2000,[28 31 47 51 53] only one demonstrated an increased risk of pregnancy loss among healthcare workers exposed to radioisotopes.[54] Similarly, no contemporary citations identified a relationship between working with antineoplastic drugs and pregnancy loss.[31 55 56]

Birthweight and related outcomes

Three studies reported a greater risk of intrauterine growth restriction among pregnant women in healthcare-related fields compared with women in other occupations (figure 3C).[20 22 23] The increased risk ranged from an absolute risk that was 5.3% higher (p<0.001)[20] to an aOR of 1.30 (95% CI 1.15 to 1.47))[23] to 1.34 (95% CI 1.23 to 1.46).[22] The exact exposure, beyond healthcare work, was not isolated in these studies.

Preterm birth

Many studies combined preterm labour and preterm birth as a single outcome, and the gestational age used to define preterm varied across studies. For this reason, we use 'preterm birth' to refer to preterm labour or preterm birth as defined by the citation rather than the

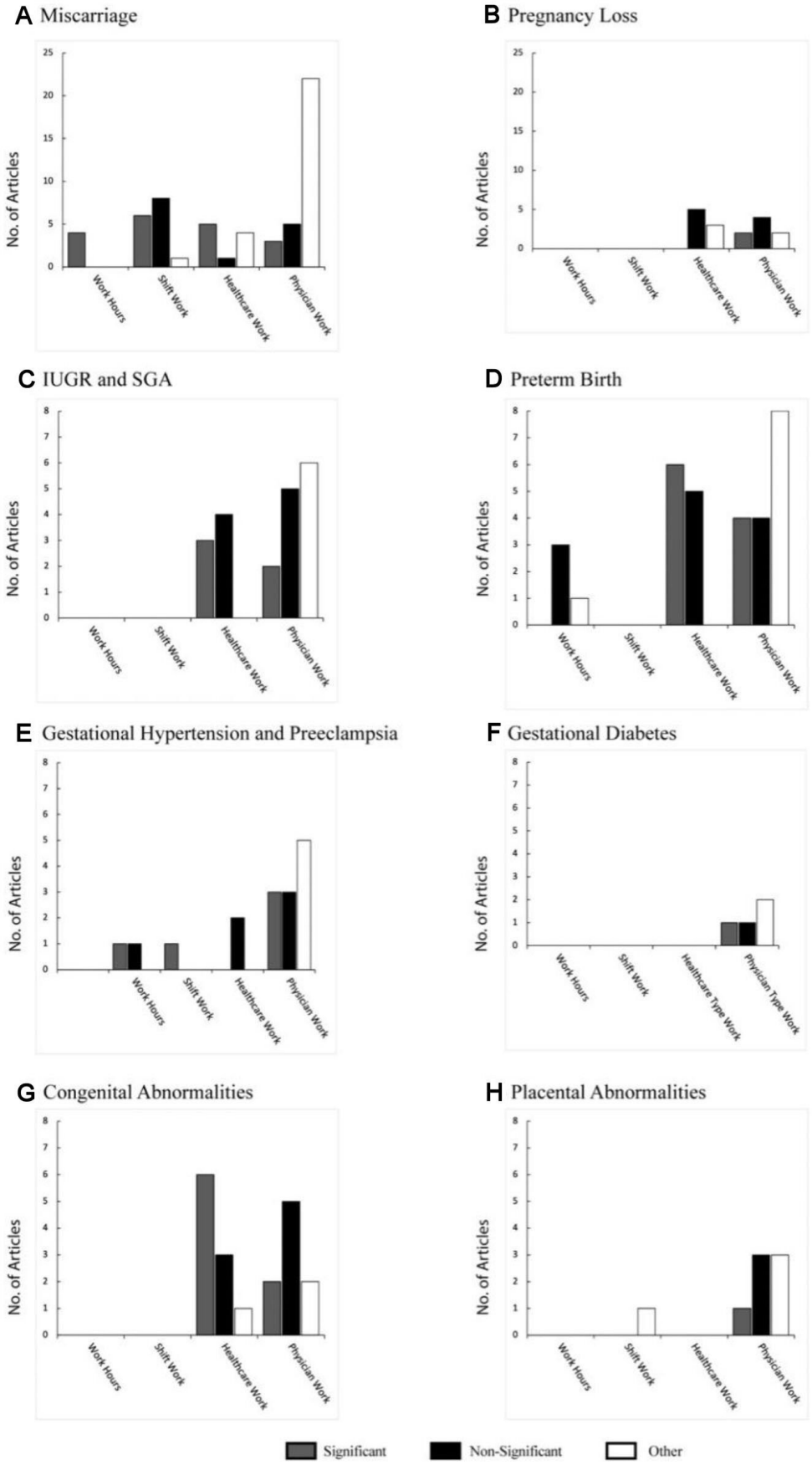

Figure 3 The number of original research studies focusing on physicians or healthcare workers that had a significant (gray) or non-significant (black) association between exposure and outcome (A–H). The number of studies that contained data with no relevant statistical comparison are also shown in white. IUGR, intrauterine growth restriction; SGA, small-for-gestational age.

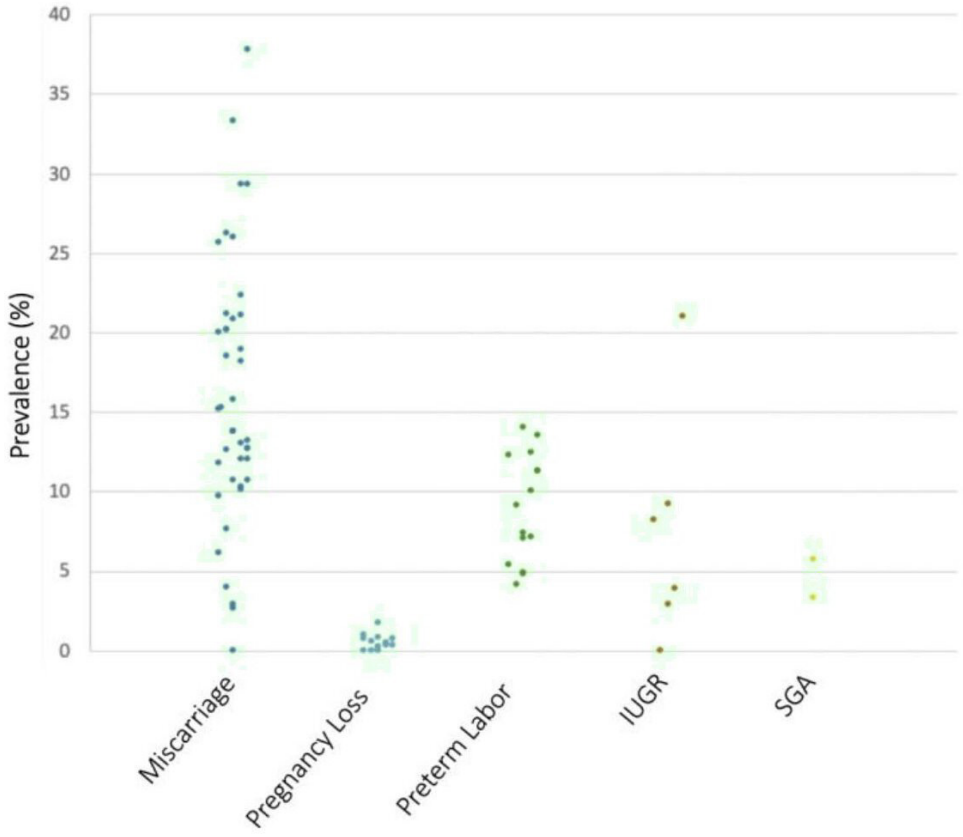

Figure 4 The reported prevalence of select study outcomes in physicians or medical trainees across included studies looking at pregnancy, birth and fetal outcomes. Each circle represents a study that reported a prevalence. Miscarriage refers to a pregnancy loss that was classified as a spontaneous abortion and not a stillbirth or intrauterine fetal demise by the included citation. The gestational age used to define this outcome varied across studies and does not reflect the current definition of spontaneous abortion. IUGR, intrauterine growth restriction; SGA, small-for-gestational age.

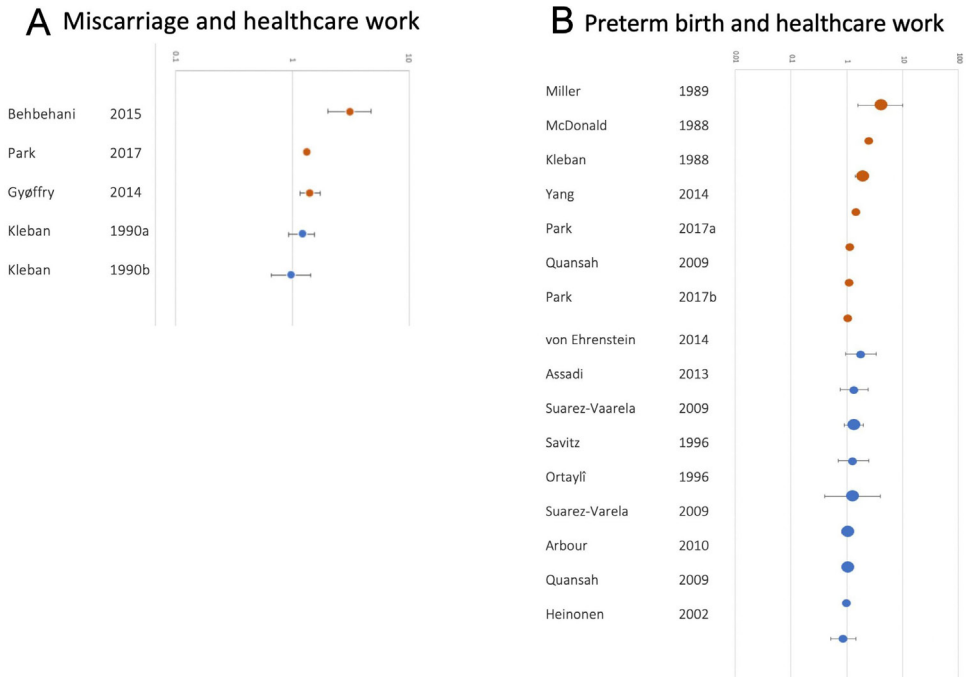

Figure 5 The magnitude of risk of miscarriage (A) and preterm birth (B), with 95% CIs, in included studies that focused on physicians and/or healthcare workers. Red circles indicate studies that reported an increased association and blue circles represent no association. Risks are reported as cute and adjusted ORs, and relative risks across studies.

contemporary medical definition. The range in prevalence for preterm birth among physicians was 4.1%[14] to 14.0%[57] (figure 4). Compared with workers in other occupations, nine studies report that physicians and nurses had a greater risk of preterm birth[9 10 12 14 22 23 58–60]; ranging from an absolute increase of 2.8%[58] to a 4-fold increase in risk (95% CI 1.57 to 10.1[10]; figures 3D and 5B). However, these studies had few participants, and several compared with the general population without adjustment for confounders such as smoking or socioeconomic status. Seven studies found no increased risk.[14 37 38 60–64]

There were no studies that examined an association between shift work and preterm birth that were performed in physicians. Four of the five studies performed in healthcare workers that examined for an association between prolonged standing and preterm birth demonstrated an association.[31 60 65–67] Preterm birth was not associated with anaesthetic gas,[31 46 65 68–70] antineoplastics[31 50 55 56 65] or radiation.[31 51 70 71]

Physician work characteristics

There were few studies that compared pregnancy outcomes between differing physician work characteristics, such as specialty, work hours, night shifts, overnight call and operating.[20 72] Among North American trainees, residents who operated fewer than 8 hours per week had significantly fewer complications compared with those who operated more than 8 hours per week and residents who performed less than six nights of call per month had fewer complications than those who performed more.[20] Similarly, residents who worked 100 or more hours per week in their first or third trimester had double the prevalence of preterm delivery with no change in birth weight compared with those who worked fewer than 100 hours per week in these trimesters.[9] This study[9] and others[27 73] found no difference between surgical and medical specialties for any outcome, though several studies performed in the 1970s reported increased adverse outcomes for working anaesthesiologists compared with not working or non-anaesthesiologist physicians.[45 46 50 54 68 74] A single contemporary study found that paediatric anaesthesiologists had greater prevalence of spontaneous abortion compared with adult anaesthesiologists.[69] In contrast, a German study found no association between the gestational age where a surgeon stopped work and a reduction in complications.[72] Children born to obstetricians during or after their residency had lower birth weights compared with those born before training, suggesting an adverse effect of residency training.[13]

Systematic reviews with and without meta-analysis

There were 24 systematic reviews with and without meta-analysis that met inclusion criteria (7%).[8 75–93] While 16 of the systematic reviews were published since 2010,[8 75 76 78–80 86 87 90–97] only 31.7% of the included references were published after the year 2000 (n=117) and 23.0% were from before 1990 (n=85) (online supplemental efigure 1). The most common outcome reported in systematic reviews was preterm birth, followed by pre-eclampsia and SGA (figure 2B, online supplemental etable 2). The most examined exposures were shift work, physical work demands and work hours. There were two systematic reviews that included only physicians[8 82] and five focused on healthcare workers.[81 87 88 93 98]

Most systematic reviews were unable to perform meta-analysis due to varying definitions of outcomes or exposures across studies. Five systematic reviews with meta-analysis found an association between preterm birth with increased work hours[8 77 92 94 95] and one found no association (online supplemental etable 3).[99] Two reported an association between miscarriage and work hours[86 95] and three found an association between miscarriage and night shifts.[75 86 95 100] There were conflicting conclusions for the association of most other outcome-and-exposure pairs (online supplemental etable 3).

Editorials, non-systematic reviews and opinion articles

Altogether, over one-quarter of citations were non-systematic reviews, editorials or opinion articles (n=96; 27.6%). Many of these citations advocated for interventions to prevent adverse outcomes among pregnant physicians, and often preferentially cited studies that demonstrated harm. For example, one editorial simply stated there is a 'higher rate of infant and maternal complications' for resident physicians[101] and another concluded '(psychological stress) is a significant cause of maternal and perinatal morbidity and mortality.'[102] Some articles concluded there was little evidence of harm from specific occupational hazards when appropriate precautions were taken.[85 103–111] Many contained anecdotal experiences of pregnancy during residency focusing on negative experiences.[112–115] The remaining reviews, editorials and opinion articles either reported a lack of adequate evidence to make conclusions, made suggestions on how study in this area could be improved, or reviewed how to perform an occupational assessment for healthcare workers.

DISCUSSION

This scoping review identified 316 citations examining physician-related work hazards and pregnancy, birth or neonatal outcomes. Due to heterogeneity between studies, we were unable to compare data across studies or combine formally in a meta-analysis. Study populations were also varied, with some studies comparing employed with unemployed women and others comparing physicians across different specialties. The body of literature on physician-related work hazards and adverse outcomes is further limited by study design; most reviews of this topic were non-systematic in nature, there were no intervention studies, and data ascertainment was mostly retrospective and self-reported. Future studies in this area should address the limitations of the described literature. High-quality, prospective studies using consistent exposure and outcome definitions, that carefully consider a

comparison population, and that report continuous data where possible, are urgently needed to inform workplace adaptations for pregnant physicians. Future studies should focus on the most important, modifiable associations that can inform policy decisions, such as number of work hours and on-call shifts with preterm birth and spontaneous abortion.

Investigators should carefully consider their comparison population. Many studies used a comparator population that introduced healthy worker bias, such as unemployed women or the general population. Healthy worker bias refers to the bias that people who work (and those who work in healthcare-related fields) are different than those who do not work (or work in non-healthcare-related fields). For example, pregnant people who have had multiple health issues are more likely to stop working during pregnancy while those with fewer comorbidities may be more likely to continue working. This bias likely explains the protective association of longer work hours and standing at work with preterm birth seen in some studies.[116 117] In addition, comparisons between pregnant physicians and other occupations may be limited by important but unmeasured confounders, including smoking, substance use, socioeconomic status and social supports.

Retrospective exposure ascertainment is an important limitation of the current literature and may bias studies to over-report an association between physician-related occupational hazards and adverse outcomes. Similarly, response bias in survey studies likely overcounts physicians who have experienced adverse outcomes and may be more likely to respond to survey invitations. Researchers could consider other study designs, such as cluster randomised trials, to evaluate the influence of workplace protections for pregnant physicians on adverse outcomes. This may generate more reliable data to guide decisions in this important area.

Current data on the risks of working as a physician on pregnancy, obstetrical and neonatal outcomes should be interpreted cautiously given the limitations of this evidence. When statistically significant, most increases in risk were small and may not be meaningful given the risk of bias and confounding in the majority of studies. Rather, the available data may guide outcome and/or exposure selection for future studies. In particular, the association between increasing work hours[24 29–31] and night shifts[24 30 31 117–119] among healthcare workers with spontaneous abortion and between work hours[8 9 82 120] and preterm birth[9 10 12 14 22 23 58–60] among physicians warrants in-depth study.

CONCLUSION

The extant literature describing the risk of physician-related occupational hazards for pregnant physicians is heterogeneous, at high risk of bias and often based on older data. Despite these limitations, guidance for pregnant physicians is needed. Based on available literature from all occupations, increased work hours and increased number of night shifts may be associated with an increased risk of miscarriage and preterm birth. Pregnancy policies for medical organisations could consider limiting work hours and forgoing night shifts in early pregnancy while high-quality studies are underway, particularly for pregnant physicians with other risk factors for preterm birth, such as multiple-gestation or previous preterm labour or birth. Pregnant physicians should receive institutional-level support to attend prenatal appointments, and additional accommodations based on the clinical judgement of their obstetrical provider should be incorporated into individual workplace adaptations. Well-designed studies to examine these relationships in physicians are needed and likely feasible, given the increasing number of women in medicine.

Author affiliations
[1]Department of Neurology, University of Alberta Faculty of Medicine & Dentistry, Edmonton, Alberta, Canada
[2]Department of Medicine, University of Calgary, Calgary, Alberta, Canada
[3]Memorial University of Newfoundland, St. John's, Newfoundland, Canada
[4]University of Toronto, Toronto, Ontario, Canada
[5]Department of Medicine, University of Alberta Faculty of Medicine & Dentistry, Edmonton, Alberta, Canada
[6]University of British Columbia, Vancouver, British Columbia, Canada
[7]Department of Family Medicine, University of Calgary, Calgary, Alberta, Canada
[8]Department of Medicine, University of British Columbia, Vancouver, British Columbia, Canada
[9]Department of Pediatrics, University of Alberta Faculty of Medicine & Dentistry, Edmonton, Alberta, Canada
[10]Department of Emergency Medicine, University of Alberta, Edmonton, Alberta, Canada
[11]Department of Community Health Sciences, University of Calgary, Calgary, Alberta, Canada

Twitter Shannon M Ruzycki @ShannonRuzycki

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ORCID iDs
Victoria Nkunu http://orcid.org/0000-0002-8508-6282
Shannon M Ruzycki http://orcid.org/0000-0002-8122-2910

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