DOI: 10.1111/j.1471-0528.2009.02160.x
www.blackwellpublishing.com/bjog

Occupational predictors of pregnancy outcomes in Irish working women in the Lifeways cohort

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Accepted 15 February 2009. Published Online 7 April 2009.

Objective The objective of this study was to explore the association between occupational factors and pregnancy outcomes in a prospective cohort of Irish pregnant women.

Design This study has a prospective design.

Population The Lifeways cohort included 1124 pregnant women, 676 of whom delivered a single baby and were working at their first prenatal care visit when they filled in a self-administered questionnaire.

Methods Occupational factors were measured using this questionnaire and included eight factors describing job and working conditions. Data including pregnancy outcomes were also obtained from clinical hospital records. Logistic regression analysis was used to adjust for well-known risk factors.

Main outcome measures Birthweight (≤3000 g and ≤2500 g), preterm delivery (<37 gestation weeks) and small-for-gestational-age.

Results Significant associations were found between physical work demands and low birthweight (≤2500 g) and working with between a temporary contract and preterm delivery. Trends were also observed between working 40 hours or more a week and shift work, and birthweight of 3000 g or less. The study of a cumulative index showed that being exposed to at least two of these occupational factors significantly predicted birthweight of ≤3000 g (OR = 2.44, 95% CI: 1.17–5.08) and of ≤2500 g (OR = 4.65, 95% CI: 1.08–20.07) and preterm delivery (OR = 5.18, 95% CI: 1.00–27.01).

Conclusions Our findings suggest that occupational factors may predict birthweight through their predictive effects on preterm delivery. This is one of the few prospective studies on pregnancy outcomes that include working conditions. As they may be modifiable, occupational factors deserve more attention in relation to birth outcomes.

Keywords Birthweight, occupational factors, pregnancy outcomes, preterm delivery, small-for-gestational-age.

Please cite this paper as: Niedhammer I, O'Mahony D, Daly S, Morrison J, Kelleher C. Occupational predictors of pregnancy outcomes in Irish working women in the Lifeways cohort. BJOG 2009;116:943–952.

Introduction

Pregnancy outcomes such as low birthweight and preterm delivery are considered to be major risk factors for subsequent morbidity and mortality of newborns.[1] Birthweight may be low either because of premature birth, because of intrauterine growth retardation or because of a combination of both. Life-course epidemiological evidence suggests that birthweight may be associated with longer-term risk of adult disease and this consequence is not confined to the clinically accepted cut-off point of 2500 g for obstetric outcomes.[2] Although these outcomes may be linked to different mechanisms, a certain number of risk factors of these pregnancy outcomes have been identified, such as those related to maternal risk factors (e.g. age, body mass index, behavioural factors, marital status, education) and obstetric risk factors (e.g. parity, complications, previous events). Nevertheless, it is likely that risk factors remain undiscovered.

As a growing percentage of women work outside home before, during and after pregnancy in most industrialised countries (in Ireland, the employment rate of women was 59.3% in 2006), work and its related occupational factors deserve to be studied in relation to pregnancy outcomes. Several published literature reviews and meta-analysis have pointed out that physical work demands, long working hours, shift work and/or measures of job stress may be associated with these outcomes.[3–5] However, most previous

studies were retrospective or case–control studies and may suffer from recall bias.[6–22] So far, there have been few prospective studies.[23–28] Furthermore, a large number of studies focused on the impact of occupation or job title on pregnancy outcomes,[6,18] or on a reduced number (a maximum of 3 or 4) of occupational factors,[7,9,15,22,23,25,26,28] or on occupational factors evaluated through a job-exposure matrix (i.e. derived from job titles) that may present several shortcomings in terms of exposure misclassification or underestimation of the actual risk.[7,15,17] Finally, most studies did not explore the effects of occupational factors on birthweight, preterm delivery and small-for-gestational-age simultaneously, but one or two outcomes only, making the interpretation of the results difficult to disentangle the respective contribution of premature birth and intrauterine growth retardation to birthweight. The aim of the present study was to respond to these limitations and provide the first answer to this issue for Irish working women.

The objective of this study was to examine the predictive effects of various occupational factors on the pregnancy outcomes of birthweight, preterm delivery and small-for-gestational-age in a prospective cohort of working women. This study included a careful consideration of other well-known risk factors.

Methods

The Lifeways cohort is a prospective study established in 2001.[29–31] It included a sample of 1124 pregnant women, who were recruited at their first maternity hospital booking visit, i.e. between 14 and 16 weeks of pregnancy. Women were selected randomly and all women were Irish-born (non-Irish women, because of anticipated small numbers in the sample, were excluded). Two regions were chosen, one urban, one rural and within those regions, two major hospitals providing maternity services were selected: University College Hospital Galway (West Ireland) and Coombe Women's Hospital in Dublin (East Ireland). These two hospitals are among the biggest units in Ireland. Comparison between the Lifeways sample and a nationally representative sample of women of the same ages (16–44) from the Irish SLAN national surveys in 2002[32] suggests a satisfactory representativeness of the Lifeways sample, on socio-demographic characteristics including employment situation.

Baseline data for mothers were collected using a self-completed questionnaire. This questionnaire included several sections relating to health, lifestyle behaviours and demographic, occupational and social characteristics. Hospital medical records provided information relating to mothers' health during pregnancy and pregnancy outcomes.

Four pregnancy outcomes derived from hospital records were studied: two outcomes of birthweight (≤3000 g and ≤2500 g) as general measures of adverse pregnancy outcome, preterm delivery (<37 gestation weeks) as a specific measure of prematurity and small-for-gestational-age. The threshold of ≤3000 g was included in addition to the one of ≤2500 g to give complementary results regarding birthweight especially in relatively small sample sizes[23] and because of its potential long-term association with adult chronic disease outcomes.[2] Gestational age at birth was calculated from the mother's expected delivery date recorded at the booking visit (that was derived from last menstrual period, and clinical examination, as well as in some cases from ultrasounds examination) and the baby's actual date of birth. Small-for-gestational-age (SGA) was defined by weight below the 10th percentile for gestational age on the basis of gender- and parity-specific standards. As no Irish standards were available, Scottish standards were used.[33]

Eight occupational factors were studied and were extracted from the self-completed questionnaire and were based on the following items: occupation coded using ISCO-08 (International Standard Classification of Occupations-2008), work contract: permanent/contract post, number of working hours per week, time schedules: no shift work, shift work without night shifts and shift work with night shifts, physical work demands: job very, fairly, not very or not at all physically active, job satisfaction: very dissatisfied, dissatisfied, neither satisfied nor dissatisfied, satisfied or very satisfied, job stress: work is a source of stress (frequently, sometimes, only occasionally, or never) and two items of job influence: level of influence in deciding what tasks to do and in deciding how to carry out the tasks (a great deal, a fair amount, a little or none). This variable was constructed by adding the two items. All variables (except occupation) were dichotomised.

Some well-known risk factors were derived from the self-completed questionnaire: maternal age, Body Mass Index (BMI) calculated from the formula: pre-pregnant weight in kilos/(height in metre)^2, smoking status: nonsmoker, ex-smoker, smoker, alcohol consumption calculated from number of days and number of drinks during a typical week, marital status and educational level as a marker of socio-economic status. The other risk factors were extracted from hospital records: planned pregnancy, parity, complications during pregnancy: bleeding and/or fetal problems and region: West/East.

The associations between occupational factors and pregnancy outcomes were studied using the Chi-square test or Fisher's exact test; the same tests were used to examine the associations between well-known risk factors and pregnancy outcomes. In a first step, logistic regression analysis was used to study simultaneously occupational factors and well-known risk factors as potential predictive factors of one of the four pregnancy outcomes. Note that parity was not included in the multivariate analysis of SGA, as parity was a criterion in the definition of SGA standards. In a second

step, a cumulative index of occupational factors was constructed to study the cumulative impact of occupational exposures on pregnancy outcomes and was examined as a potential predictor of pregnancy outcomes after adjustment for well-known risk factors using logistic regression analysis. The occupational factors included in the first logistic regression models were those associated with at least one pregnancy outcome at a *P*-value of <0.15 in the bivariate associations for beta error considerations and/or have already been observed in the literature as being significant risk factors of pregnancy outcomes. The construction of the cumulative index was also based on the selection of occupational factors that were associated with at least one pregnancy outcome at a *P*-value of <0.15 in the first logistic regression models. The choice was guided by two considerations; reducing the number of occupational factors in the multivariate analysis and not missing pertinent factors that would have not been associated with pregnancy outcomes at the conventional 5% level for power reasons. Such a strategy has already been used in other studies.[34,35] Odds-ratios (OR) and Wald 95% confidence intervals (CIs) were then calculated to characterise the significance, strength and precision of the associations. Statistical analysis was performed using SAS statistical software (SAS Institute Inc., Cary, NC, USA).

Results

The Lifeways cohort included initially a sample of 1124 pregnant women and 676 of them delivered a single baby and were working at their first prenatal care visit. Miscarriages, stillbirths, neonatal deaths and twins were excluded from the study.

The description of the sample studied for well-known risk factors and occupational factors is presented in Tables 1 and 2. The prevalences were 15.42% ($N = 101$) for birthweight of 3000 g or less, 3.21% ($N = 21$) for birthweight of 2500 g or less, 4.10% ($N = 24$) for preterm delivery and 6.53% ($N = 38$) for small-for-gestational-age in the total sample of the 676 working women. The associations between well-known risk factors and pregnancy outcomes are shown in Table 1. Complications during pregnancy such as bleeding or fetal problems increased the risk of all pregnancy outcomes. Smoking was associated with birthweight using both definitions (≤2500 g and ≤3000 g) and SGA. Nulliparity and alcohol consumption was associated with birthweight of 3000 g or less. Some trends were also observed for other variables: BMI, planned pregnancy and living in the East region.

The associations between occupational factors and pregnancy outcomes are presented in Table 2. Working 40 hours or more a week was found to be associated with the pregnancy outcomes of birthweight of 3000 g or less ($P < 0.01$), birthweight of 2500 g or less ($P = 0.15$) and preterm delivery ($P = 0.10$). Tendencies were observed between high physical work demands and birthweight of less or equal 3000 g ($P = 0.07$) and 2500 g ($P = 0.08$) and small-for-gestational age ($P = 0.13$). Temporary contract tended to predict preterm delivery ($P = 0.10$). The variables of work contract, working hours and physical demands, as well as shift work and job stress, that have been found to be risk factors in the literature, were retained in the multivariate analysis.

The results of the logistic regression analysis including the five occupational factors selected as well as well-known risk factors are presented in Table 3. Significant and strong predictive effects of physical work demands on birthweight of 2500 g or less (OR = 4.32, 95% CI: 1.24–15.00) and of temporary contract on preterm delivery (OR = 4.58, 95% CI: 1.09–19.22) were observed. Trends were also observed between long working hours ($P = 0.08$) and shift work ($P = 0.12$) and birthweight of 3000 g or less. Job stress was associated with no pregnancy outcome. The four variables of work contract, working hours, shift work and physical demands were used to construct a cumulative index. The description of this index and its bivariate associations with pregnancy outcomes are shown in Table 2. This index displayed a dose–response association with all pregnancy outcomes, but was not associated with small-for-gestational-age. This result was confirmed in logistic regression analysis (Table 4) that showed that being exposed to at least two of these four occupational factors increased the risk of birthweight of 3000 g or less (OR = 2.44, 95% CI: 1.17–5.08), birthweight of 2500 g or less (OR = 4.65, 95% CI: 1.08–20.07) and preterm delivery (OR = 5.18, 95% CI: 1.00–27.01).

Regarding well-known risk factors, logistic regression analysis (Tables 3 and 4) showed that complications during pregnancy predicted birthweight, preterm delivery and small-for-gestational age. Smoking predicted birthweight of 3000 g or less and of 2500 g or less. Higher age, nulliparity and high alcohol consumption (as well as no consumption at all) were predictive of birthweight of 3000 g or less.

Discussion

This prospective study showed that occupational factors played a substantial role in predicting pregnancy outcomes. These factors were temporary work contract, long working hours, shift work and physical demands. The study of a cumulative index showed that exposure to at least two of these factors increased the risk by 4.6 and 5.2 for birthweight of 2500 g or less and preterm delivery. Predictive effects were also observed for well-known risk factors that were nulliparity, complications during pregnancy, higher age, smoking and alcohol consumption.

Table 1. Well-known risk factors, birthweight, preterm delivery and small-for-gestational age (SGA)

	Women (N = 676)		Birthweight (≤3000 g)		Birthweight (≤2500 g)		Preterm delivery		SGA	
	N	%	No cases	%	No cases	%	No cases	%	No cases	%
Age (years)										
<25	119	17.60	20	17.09	5	4.27	5	5.26	8	8.42
25–29	190	28.11	26	13.83	8	4.26	10	5.88	8	4.76
30–34	224	33.14	33	15.28	5	2.31	6	3.06	13	6.67
≥35	143	21.15	22	16.42	3	2.24	3	2.42	9	7.26
Parity				**		*		*		
1+	309	46.61	36	11.92	6	1.99	7	2.55	18	6.59
0	354	53.39	64	18.29	15	4.29	17	5.50	20	6.51
Complications during pregnancy				****		***		***		***
No	551	81.66	69	12.95	12	2.25	14	2.92	25	5.23
Yes	124	18.34	32	26.23	9	7.38	10	9.52	13	12.50
BMI (kg/m^2)				*						
<20	68	11.33	16	24.24	1	1.52	2	3.64	4	7.27
20–24	364	60.67	48	13.56	10	2.82	12	3.73	21	6.54
≥25	168	28.00	25	15.43	8	4.94	7	4.86	9	6.29
Smoking				****		**				**
Nonsmoker	297	44.93	32	11.11	7	2.43	7	2.65	17	6.46
Smoker	121	18.31	34	28.57	8	6.72	5	5.26	11	11.58
Ex-smoker	243	36.76	32	13.62	5	2.13	10	4.67	8	3.77
Alcohol consumption (drinks/week)				***				*		
0	264	39.05	45	17.79	11	4.35	13	5.63	19	8.30
1–7	225	33.29	23	10.41	5	2.26	5	2.51	7	3.54
8–14	129	19.08	16	12.80	3	2.40	2	1.87	9	8.41
>14	58	8.58	17	30.36	2	3.57	4	8.33	3	6.25
Educational level										
Lower than secondary	70	10.36	14	21.54	1	1.54	3	5.26	6	10.53
Complete secondary	215	31.80	35	16.59	8	3.79	4	2.19	11	6.01
Higher than secondary	391	57.84	52	13.72	12	3.17	17	4.93	21	6.14
Marital status										
In couple	555	82.10	78	14.53	16	2.98	19	3.89	31	6.38
Alone	121	17.90	23	19.49	5	4.24	5	5.21	7	7.29
Planned pregnancy				*						*
Yes	480	71.01	64	13.91	13	2.83	16	3.78	23	5.48
No	196	28.99	37	18.97	8	4.10	8	4.94	15	9.26
Region				*						*
West	224	33.14	25	11.74	5	2.35	7	3.41	9	4.43
East	452	66.86	76	17.19	16	3.62	17	4.47	29	7.65

*P < 0.15, **P < 0.05, ***P < 0.01, ****P < 0.001.

Our results showed that four occupational factors may be associated with pregnancy outcomes; temporary work contract with preterm delivery and long working hours, shift work and physical demands with birthweight. Temporary contract may be considered as a marker of poor working conditions that may not have been evaluated *per se* in the present study, and may be associated with new challenges and adaptation to the job and may generate feelings of stress and anxiety to find another future job. This type of contract and perceived job insecurity have already been observed to be associated with other health outcomes.[36] To our knowledge, no previous study has already studied and found an association between temporary employment and pregnancy outcomes. The three last occupational factors that were long working hours, shift work and physical demands have more commonly been associated with pregnancy outcomes in the literature. Long working hours, especially more than 40 hours per week, have been observed to be associated with pregnancy outcomes,[10,12,16,19,20,23,27] with preterm delivery[12,16,19,20] and also with small-for-gestational-age.[10,27] The literature review by Bonzini *et al.*[3] confirmed that prolonged

Table 2. Occupational factors, birthweight, preterm delivery and small-for-gestational-age (SGA)

	Women (*N* = 676)		Birthweight (≤3000 g)		Birthweight (≤2500 g)		Preterm delivery		SGA	
	N	%	No cases	%	No cases	%	No cases	%	No cases	%
Occupational group (ISCO-08)										
Managers, professionals (1, 2)	143	21.70	21	14.89	6	4.26	7	5.47	6	4.72
Technicians, associate professionals (3)	203	30.81	26	13.61	4	2.09	6	3.37	15	8.43
Clerical support workers (4)	122	18.51	19	15.97	5	4.20	2	1.87	9	8.41
Service and sales workers (5)	128	19.42	21	16.67	3	2.38	6	5.94	5	5.00
Blue collar workers (6, 7, 8, 9)	63	9.56	12	19.67	2	3.28	2	3.64	3	5.56
Work contract								*		
Permanent post	586	88.39	88	15.52	18	3.17	18	3.59	34	6.81
Contract post	77	11.61	13	17.33	3	4.00	6	8.57	3	4.29
Working hours per week				***		*		*		
<40	499	75.26	65	13.46	13	2.69	14	3.24	26	6.05
≥40	164	24.74	35	22.01	8	5.03	9	6.38	12	8.57
Shift work										
No	529	79.91	75	14.65	16	3.13	17	3.70	28	6.13
Yes	133	20.09	24	18.60	5	3.88	6	5.36	9	8.04
Physical demands										
Fairly, or not very or not at all				*		*				*
physically active	550	81.85	76	14.29	14	2.63	20	4.17	28	5.86
Job very physically active	122	18.15	25	21.01	7	5.88	4	3.96	10	10.00
Job satisfaction										
High	492	73.43	70	14.55	15	3.12	17	3.96	28	6.56
Low	178	26.57	31	18.34	6	3.55	7	4.64	10	6.67
Job stress										
Low	299	44.43	45	15.46	9	3.09	10	3.85	18	7.00
High	374	55.57	56	15.51	12	3.32	14	4.35	20	6.21
Job influence										
High	312	46.71	48	15.84	10	3.30	14	5.15	16	5.93
Low	356	53.29	52	15.12	11	3.20	10	3.27	21	6.89
Cumulative index of occupational factors				***		**		*		
0	282	43.79	28	10.29	4	1.47	5	2.02	12	4.90
1	264	40.99	49	19.22	11	4.31	12	5.38	16	7.17
2 or more	98	15.22	21	21.88	6	6.25	5	5.88	8	9.52

Cumulative index based on the sum of the following items: work contract, working hours, shift work and physical demands.
*$P < 0.15$, **$P < 0.05$, ***$P < 0.01$, ****$P < 0.001$.

working hours may have a detrimental impact on pregnancy outcomes. Shift work, especially night work, has already been studied in several literature reviews and meta-analysis suggesting predictive effects on preterm delivery,[4,5] as demonstrated in several studies.[8,14,22,26,28] Various indicators of physical demands have already been found to predict birth outcomes,[7,12,13,16,17,21] especially preterm delivery.[7,12,13,16] The predictive role of physically demanding work has been confirmed by literature review and meta-analysis.[3,4] Several occupational factors were not found to be predictive factors of pregnancy outcomes in our study. This was especially the case for job stress that was found to be a risk factor in some other studies.[9,12,25] Finally, the cumulative index constructed using the four occupational factors described previously displayed strong predictive effects on low birthweight and preterm delivery with ORs reaching values of 4.6 and 5.2 for exposure to two occupational factors or more. Furthermore, this index showed dose–response relationships with these pregnancy outcomes. Other authors studied and found significant effects of similar indexes on preterm delivery, confirming the negative impact of the combination of several occupational factors on this outcome.[12] All these studies suggested that occupational factors may be more powerful

Table 3. Predictive factors of birthweight, preterm delivery and small-for-gestational-age (SGA): results from logistic regression analysis

	Birthweight (≤3000 g) *N* = 538		Birthweight (≤2500 g) *N* = 538		Preterm delivery *N* = 481		SGA *N* = 479	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age (years)								
<25	1		1		1		1	
25–29	1.20	0.48–3.00	1.05	0.23–4.86	0.91	0.14–5.86	0.74	0.17–3.13
30–34	1.70	0.67–4.32	0.63	0.11–3.57	0.53	0.07–4.30	1.28	0.32–5.14
≥35	2.67	0.96–7.42	0.91	0.14–5.82	0.88	0.10–8.20	1.25	0.28–5.67
Parity								
1+	1		1		1		-	
0	1.71	0.94–3.10	2.39	0.69–8.34	2.36	0.60–9.37		
Complications during pregnancy								
No	1		1		1		1	
Yes	2.24	1.24–4.04	5.77	1.89–17.68	6.97	2.20–22.09	2.51	1.07–5.86
BMI (kg/m^2)								
<20	1.63	0.76–3.52	0.38	0.04–3.69	1.20	0.22–6.67	1.13	0.29–4.45
20–24	1		1		1		1	
≥25	1.16	0.64–2.09	2.56	0.85–7.69	1.98	0.59–6.65	1.18	0.48–2.90
Smoking								
Nonsmoker	1		1		1		1	
Smoker	3.86	1.98–7.53	3.90	1.10–13.78	2.10	0.48–9.23	1.83	0.70–4.78
Ex-smoker	1.32	0.70–2.50	1.33	0.33–5.41	1.73	0.46–6.57	0.57	0.20–1.62
Alcohol consumption (drinks/week)								
0	2.20	1.14–4.23	1.42	0.40–5.00	1.97	0.52–7.53	2.46	0.82–7.40
1–7	1		1		1		1	
8–14	1.04	0.47–2.32	0.51	0.09–2.88	0.34	0.04–3.20	3.05	0.91–10.27
>14	2.86	1.16–7.05	0.73	0.10–5.33	1.06	0.17–6.68	2.18	0.44–10.87
Educational level								
Lower than secondary	0.90	0.36–2.25	0.35	0.03–4.04	1.38	0.21–9.23	1.04	0.28–3.84
Complete secondary	0.94	0.53–1.68	0.94	0.30–2.88	0.46	0.11–1.94	0.74	0.30–1.84
Higher than secondary	1		1		1		1	
Marital status								
In couple	1		1		1		1	
Alone	0.72	0.29–1.79	0.67	0.12–3.88	0.59	0.08–4.32	0.52	0.12–2.19
Planned pregnancy								
Yes	1		1		1		1	
No	1.19	0.60–2.36	0.66	0.15–2.97	0.63	0.13–3.11	1.62	0.62–4.21
Region								
West	0.78	0.44–1.39	0.86	0.27–2.76	0.56	0.15–2.08	0.55	0.22–1.39
East	1		1		1		1	
Work contract								
Permanent post	1		1		1		1	
Contract post	1.22	0.55–2.72	1.98	0.37–10.69	4.58	1.09–19.22	0.52	0.11–2.45
Working hours per week								
<40	1		1		1		1	
≥40	1.67	0.93–2.98	1.80	0.56–5.80	2.25	0.69–7.32	1.42	0.58–3.51
Shift work								
No	1		1		1		1	
Yes	1.63	0.88–3.02	0.92	0.26–3.26	1.68	0.44–6.34	1.32	0.50–3.46
Physical demands								
Fairly, or not very or not at all physically active	1		1		1		1	
Job very physically active	1.25	0.64–2.46	4.32	1.24–15.00	1.20	0.25–5.66	1.44	0.53–3.86
Job stress								
Low	1		1		1		1	
High	0.80	0.47–1.36	0.65	0.23–1.86	1.11	0.36–3.45	0.60	0.26–1.37

Table 4. Predictive factors of birthweight, preterm delivery and small-for-gestational-age (SGA): results from logistic regression analysis (use of a cumulative index of occupational factors)

	Birthweight (≤3000 g) *N* = 539		Birthweight (≤2500 g) *N* = 539		Preterm delivery *N* = 482		SGA *N* = 480	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age (years)								
<25	1		1		1		1	
25–29	1.21	0.48–3.03	0.92	0.20–4.20	0.94	0.16–5.58	0.73	0.17–3.08
30–34	1.72	0.68–4.34	0.60	0.11–3.44	0.54	0.07–3.96	1.32	0.34–5.19
≥35	2.81	1.02–7.74	0.97	0.15–6.22	0.92	0.11–7.96	1.35	0.30–6.00
Parity								
1+	1		1		1		-	
0	1.78	1.00–3.20	2.18	0.64–7.41	2.40	0.65–8.91		
Complications during pregnancy								
No	1		1		1		1	
Yes	2.23	1.24–4.00	5.53	1.86–16.47	6.02	1.97–18.38	2.61	1.14–6.00
BMI (kg/m^2)								
<20	1.59	0.73–3.45	0.41	0.04–3.77	1.06	0.19–5.95	1.00	0.25–3.91
20–24	1		1		1		1	
≥25	1.21	0.67–2.18	2.33	0.79–6.85	1.76	0.54–5.70	1.26	0.52–3.04
Smoking								
Nonsmoker	1		1		1		1	
Smoker	3.88	1.99–7.58	4.11	1.15–14.66	2.40	0.56–10.27	1.75	0.67–4.58
Ex-smoker	1.34	0.71–2.52	1.44	0.37–5.62	1.88	0.50–7.01	0.57	0.20–1.59
Alcohol consumption (drinks/week)								
0	2.25	1.18–4.30	1.81	0.52–6.24	2.02	0.53–7.68	2.57	0.86–7.66
1–7	1		1		1		1	
8–14	1.00	0.45–2.20	0.53	0.09–3.02	0.33	0.04–3.18	2.76	0.83–9.20
>14	2.76	1.12–6.78	0.75	0.11–5.17	1.32	0.22–7.71	1.91	0.38–9.58
Educational level								
Lower than secondary	0.89	0.36–2.25	0.35	0.03–4.14	1.14	0.16–7.89	1.19	0.33–4.26
Complete secondary	0.94	0.53–1.67	1.06	0.35–3.17	0.38	0.09–1.56	0.82	0.34–2.03
Higher than secondary	1		1		1		1	
Marital status								
In couple	1		1		1		1	
Alone	0.72	0.29–1.80	0.87	0.15–4.94	0.72	0.10–5.38	0.57	0.14–2.33
Planned pregnancy								
Yes	1		1		1		1	
No	1.17	0.59–2.34	0.62	0.14–2.83	0.52	0.10–2.66	1.64	0.63–4.28
Region								
West	0.80	0.45–1.42	1.01	0.32–3.21	0.69	0.19–2.44	0.56	0.22–1.41
East	1		1		1		1	
Cumulative index of occupational factors								
0	1		1		1		1	
1	2.08	1.15–3.76	3.59	0.94–13.78	4.11	0.99–17.04	1.55	0.63–3.82
2 or more	2.44	1.17–5.08	4.65	1.08–20.07	5.18	1.00–27.01	1.64	0.54–4.98

Cumulative index based on the sum of the following items: work contract, working hours, shift work and physical demands.

to predict preterm delivery than growth retardation, reinforcing our own findings.

This study also underlined the importance of health behaviours in pregnancy outcomes, smoking being a strong predictor of birthweight of 2500 g or less and of 3000 g or less and alcohol consumption a strong predictor of birthweight of 3000 g or less. We also found that no alcohol consumption at all was observed to predict birthweight of 3000 g or less, suggesting a J-shaped association. This result might be explained by at least two factors: a healthy drinker effect; women with health problems like chronic diseases or in the case of pregnancy, with history of adverse pregnancy outcomes, may be more likely to abstain from having alcoholic drinks during their pregnancy, and an

under-reporting of alcohol consumption and even a complete denial of consumption for the women who had the highest alcohol intakes.

Several studies pointed out that alcohol consumption, even moderate, may be associated with adverse birth outcomes[37] confirming our own findings. Our results are also in agreement with previous results from other studies showing that smoking is associated with pregnancy outcomes.[38,39]

Our study also found that age, complications during pregnancy and nulliparity were associated with pregnancy outcomes; these findings are in agreement with previous studies[7,12,16,19,21,26] and reinforced the validity of our own results.

This study has several major strengths: the selection process yielded a sample of women at baseline, whose social circumstances may be considered as broadly representative of Irish women. This is a prospective study; consequently, the evaluation of risk factors including occupational factors was performed at the beginning of pregnancy and thus before the pregnancy outcomes, which we are reporting, had actually occurred; consequently, there is no possibility of a recall bias. We studied the pregnancy outcomes of birthweight, preterm delivery and small-for-gestational-age simultaneously, which has seldom been carried out before in relation to working conditions,[7,8,10–12,24,27,28] and allow us to disentangle the respective contribution of premature birth and intrauterine growth retardation to birthweight. There is also no possibility of a reporting bias, as pregnancy outcomes were measured using hospital records, and thus independently of women' answers. This study included a large number of occupational factors and covered the main occupational factors that have previously been suspected to be risk factors. Evaluation of occupational factors was performed using a self-administrated questionnaire already used in Irish national surveys,[32] and consistent results were found regarding social gradients in these factors in Lifeways working women; women employed in low-skilled occupations were more likely to be exposed to shift work, high physical demands, low job satisfaction and low job influence, providing elements supporting the validity of the evaluation of working conditions. Furthermore, our study took into account education level (a marker of socio-economic status) in the multivariate analysis; consequently, the associations observed can be considered as independent of socio-economic status. This study included a large number of well-known risk factors of pregnancy outcomes allowing us to control adequately for potential confounding in our analyses.

This study also had some limitations. The cohort was designed for 5-year follow-up with power calculations to detect significant trends according to socio-economic status on outcome measures including annual rates of healthcare utilisation and vaccinations.[29] As the present analysis is confined to working mothers, sample size may be considered as relatively small with reduced statistical power to detect subtle differences. This is why we decided to retain variables associated with pregnancy outcomes at a *P*-value of <15% and not 5%, so as not miss some pertinent occupational factors. This selection process identified occupational factors that have already been found as risk factors in the literature (one exception was work contract), supporting the validity of our strategy. No data were available on whether, when and why women stopped working during their pregnancy or whether working conditions changed during pregnancy. This may have led to potential exposure misclassification that is likely to be nondifferential and that may have led to underestimation of risks. Gestational age was not routinely verified by ultrasound measures in the two hospitals at the time of recruitment, which may arguably have led to potential misclassifications. Overadjustment may be possible, as for example, we controlled for complications during pregnancy that may be a mediating variable between occupational factors and pregnancy outcomes. This may have led to underestimates of the predictive effects of occupational factors. However, excluding the variable of pregnancy complications in the multivariate analyses did not modify the results. Finally, as the analysis was restricted to four pregnancy outcomes and did not consider other outcomes, such as stillbirths and neonatal deaths, our findings may arguably have underestimated the effects of occupational factors. Given the very few numbers of stillbirths (5) and neonatal deaths (2) in the total Lifeways sample, the analysis of these outcomes was not possible.

Conclusion

This study is one of the rare prospective studies focusing on the predictive effects of occupational factors on pregnancy outcomes and the first one to be set up in Ireland. It urges further research effort on the subject of occupational predictors of pregnancy health and outcomes. As working conditions may be modifiable, intensifying research on this topic may have a substantial impact on the understanding of determinants of pregnancy outcomes and on prevention policies.

Disclosure of interests

No conflict of interest.

Contribution to authorship

I.N. wrote the study protocol in association with C.C.K., performed the analyses and wrote the first draft of the manuscript. D.O., S.D., J.J.M. and C.C.K. all made substantial contributions to the study design, interpretation of

results and manuscript revisions. S.D., J.J.M. and C.C.K. instigated the original cohort establishment and follow up. The Lifeways Cross-Generation Cohort Study Steering Group has overseeing responsibility for the project.

Details of ethics approval

Ethical approval was obtained both from the hospitals and from the Irish College of General Practitioners ethical committees. Consent was obtained from the pregnant women at recruitment when attending their first antenatal care visit at the maternity hospital.

Funding

The Lifeways cohort was funded by the Health Research Board, Ireland. ■

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