

RISKS FOR ADVERSE PREGNANCY OUTCOMES AND INFECTIONS IN DAYCARE WORKERS: AN OVERVIEW OF CURRENT EPIDEMIOLOGICAL EVIDENCE AND IMPLICATIONS FOR PRIMARY PREVENTION

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Abstract

Childcare providers are overwhelmingly women of childbearing age. Occupational risks in this sector include exposure to biological (infectious) or physical (standing, carrying loads) hazards, many of which are associated with adverse pregnancy outcomes such as children with congenital infections, low birth weight or prematurity. Here, the authors examined literature on pregnancy outcomes and infectious hazards related to employment in daycare settings. Overall, 33 original studies (10 reporting pregnancy issues, 23 focusing on infectious risks) published in 1980–2018 were retained following a Medline search. Pregnancy issues in daycare workers have rarely been studied, and inconsistent risks of spontaneous abortion, congenital malformations and fetal growth retardation have been reported. Literature pertaining to infectious risks in daycare settings is extensive. The risk of a primary cytomegalovirus infection during pregnancy was increased for daycare workers caring for >6 children and younger children, changing diapers ≥ 3 days/week, not wearing gloves when changing diapers, and having employment in daycare for ≤ 2 years. Personal factors (nulliparity, ethnicity) were also independent risk factors. Parvovirus B19 (B19V) infections appear to be related to employment in daycare, but also to having one's own children and an increased number of siblings. Consequently, the risk of a primary B19V infection during an outbreak is of most concern among younger nulliparous workers caring for large numbers of young infected children. Since the main occupational hazard is viral infection, feasible prevention strategies include improving workers' awareness, serological monitoring during pregnancy, educating on appropriate preventive measures, and ensuring age-appropriate immunization of children and staff in childcare facilities. *Int J Occup Med Environ Health*. 2020;33(6):733–56

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INTRODUCTION

In the last century, women's participation in the workforce of industrialized countries has risen substantially and, as a consequence, working during pregnancy has become more common [1]. Maternal employment in specific occupational groups may potentially affect all stages of pregnancy, with increased risks of fetal death, birth defects, preterm delivery, intrauterine growth restriction, as well as long-term effects in the offspring.

The numbers of female workers in the healthcare and daycare sectors are rapidly increasing worldwide, and childcare is a profession where women of reproductive age are more likely to be employed [1,2]. Although the risk of adverse reproductive outcomes has been extensively assessed among healthcare workers [3,4], few studies have reported on adverse pregnancy outcomes in daycare and nursery staff. Childcare workers are mainly exposed to biological, physical and chemical hazards in their workplaces as part of care, recreational and janitorial tasks. Since childcare workers are frequently exposed to numerous excreta-borne viruses, such as cytomegalovirus (CMV), parvovirus B19 (B19V), varicella-zoster virus (VZV), and rubella virus, most research conducted to date has examined the risks for pregnancy related to viral infections. Congenital infections may cause serious fetal diseases, such as cognitive and motor deficits, visual or hearing impairments, central nervous system diseases (CMV), fetal hydrops or fetal death (B19V), miscarriage or congenital abnormalities (VZV), deafness, cataracts, microcephaly and other congenital birth defects (rubella virus) [5,6].

Just as a point of interest, the risk of maternal infections with CMV during pregnancy has been reported to be increased among women employed in childcare centers, whereas CMV seronegative hospital workers caring for young children and infants are not at an increased risk [7].

Physical effort exerted by daycare staff may be designated as a "moderate" to "high" physical load [8] but, to the

best of the authors' knowledge, no published studies present the effects of physical demands on pregnancy issues specifically for daycare workers. Workers in the childcare sector are exposed to psychosocial factors, such as job stress [9], but no data about the effects of work-related stress on pregnancy outcomes in childcare staff have been reported.

The objective of this review was to give an overview of previously published literature on the risk of adverse pregnancy outcomes and infectious hazards related to maternal employment in daycare settings. Accordingly, some issues of interest, such as preventing infections and protecting pregnant caregivers, were discussed.

METHODS

Literature search strategy

Published literature was identified through a Medline database electronic search. Articles relating to adverse pregnancy outcomes and risks for infections in daycare settings were identified. The search was carried out according to PRISMA guidelines [10], and was restricted to the period of 1980–2018 and to articles published in English.

The search strategy was mainly constructed using MeSH terms and additional queries with freely-selected texts (without MeSH terms). The exposed population was identified through the following MeSH terms: "child day care centers" or "nurseries" associated with "occupational exposure" or "risk factors" or "maternal exposure" or "virus disease." The outcomes of interest were selected using the following MeSH terms: "pregnancy," "pregnancy outcome," "congenital abnormalities," "abortion, spontaneous," "fetal death," "stillbirth," "premature birth," and "infant, premature." Adverse effects on fertility and menstrual function were not addressed in this article.

Additional articles were searched using the following words as search terms: "working/employment/work activity/infection" in combination with "day care/child care/child day/ kindergarten/nursery" and with "pregnancy," "pregnancy/

reproductive outcome,” “reproductive risk,” “spontaneous/threatened abortion,” “miscarriages,” “stillbirths,” “fetal/infant death,” “embryonic/fetal/pregnancy loss,” “perinatal death,” “birth defects,” “congenital malformations/defects/anomalies,” “low birth weight,” “small/large for gestational age,” “preterm/premature birth/delivery/labor,” “post-term delivery,” “sex ratio,” “ratio of male/female births,” and “offspring.” Finally, some articles were identified from the reference lists of relevant articles.

Eligibility criteria

Article selection

Observational studies, such as cohort, case-control, and cross-sectional studies, as well as short communications focusing on pregnancy outcomes or occupational risks of infections in daycare, nursery and kindergarten staff, were included.

Study population

The exposed population had to be employed in daycare centers, kindergartens and nurseries, and clearly identified as female childcare providers. So, exposure was based on the job title within daycare settings. Most populations were pregnant women, with the exception of some research relating to occupational risks of infections (seroprevalence and seroconversion studies), in which all female daycare workers were included.

Occupational risk estimates

Only studies with reported risk estimates were retained: the ratio of observed to expected numbers of adverse issues (O/E), the relative risk (RR), the odds ratio (OR), the hazard ratio (HR), or the prevalence ratio (PR).

Quality assessment

Quality assessment of observational research was guided by the Strengthening and Reporting of Observational Studies in Epidemiology (STROBE) statement recom-

mendations [11], a checklist of 22 items required to assess the studies’ strengths and weaknesses. The items relate to the title, abstract, introduction, methods, results and funding sources. To be included in the overview, studies had to include at least 11 of the 22 items on the STROBE statement checklist.

Exclusion criteria

Factors other than work may affect the risk of adverse pregnancy outcomes [12]. These potential confounding factors are delivery age, infections and drug treatment during pregnancy, medical and obstetric history, smoking and drinking habits, education and family income, nutrition, etc. To minimize the risk of bias, these variables should be taken into account in statistical analyses whenever they are available. When factors related to mothers’ medical history and lifestyle are not available, the selection of a comparison group may control these potential confounders [13].

Studies not including non-occupational variables or a comparison group were excluded, with the exception of descriptive studies relating to the risks of infections based on seroprevalence/seroconversion rates during endemic/epidemic periods not requiring controls.

As the epidemiology of infectious risks differs between developed and developing countries, studies conducted in developing countries were also excluded [14].

Summary of a literature overview

The results presented in the studies reviewed are summarized in Tables 1, 2 and 3 listing the country of investigation, the study reference (first author, year), the study population, the type of study, the key adverse outcome(s), the occupational risk estimate, and comments on potential bias and weaknesses of the studies. Both authors examined these articles for items such as the study design, the study population, key outcomes, statistical analysis, covariates considered, and the quality of the study.

Table 1. Summary of studies conducted in developed countries (1987–2013) reporting pregnancy outcomes in daycare providers

Country	Reference	Study population	Type of study	Key adverse outcome(s)	Occupational risk estimate	Comments on potential bias and limitations
Canada	McDonald et al., 1987 [16]	childcare workers	hospital-based cohort	– adverse pregnancy outcomes	O/E congenital defects: 2.19 (p < 0.01)	– the participation rate not reported (“refusals were rare”) – current and previous pregnancies were combined (215 pregnancies), potentially inducing recall bias
Canada	McDonald et al., 1988 [15]	childcare workers	hospital-based cohort	– congenital defects	O/E congenital defects: 1.84 (n.s.)	– the study was probably underpowered to detect risk in this small occupational group (221 pregnancies)
Canada	McDonald et al., 1988 [17]	childcare workers	hospital-based cohort	– fetal death	O/E spontaneous abortion: <16 weeks: 0.88 (n.s.); O/E spontaneous abortion 16–28 weeks: 1.19 (n.s.) O/E stillbirths ≥28 weeks: 1.13 (n.s.)	– the study was probably underpowered to detect risk in this small occupational group (79 pregnancies)
Canada	McDonald et al., 1988 [18]	childcare workers	hospital-based cohort	– prematurity	O/E preterm births (<37 weeks): 1.32 (n.s.); O/E low birth weight (≤2500 g): 1.16 (n.s.)	– the study was probably underpowered to detect risk in this small occupational group (117 pregnancies)
Canada	Armstrong et al., 1989 [20]	childcare workers	hospital-based cohort	– predicted birth weight considering the following confounding variables: maternal age, gravidity, previous spontaneous abortion, ethnic group, height, education, tobacco and alcohol consumption	percent of predicted birth weight 96.7 (90% CI: 94.1–99.3) (p < 0.05)	– the mean indices of predicted birth weight are more difficult to directly interpret than estimates of risks of retarded fetal growth or short gestation
				– predicted birth weight accounting also for gestational age	percent of predicted birth weight 97.4 (90% CI: 94.9–99.9) (p < 0.05)	

Denmark	Olsen et al., 1991 [25]	childcare workers and kindergarten heads	population-based record-linkage case-control study	<ul style="list-style-type: none"> cancer in the offspring (before the age of 15) 	<p>OR for:</p> <ul style="list-style-type: none"> central nervous system cancer: 1.7 ($p < 0.05$); sympathetic nervous system cancer: 1.7 ($p < 0.05$) 	<ul style="list-style-type: none"> data from cancer register records; the reference group consisted in population controls (including non-working controls) of all mothers included in the analysis ($N = 1721$), 23 were childcare workers (central nervous system cancer) and 19 kindergarten heads (sympathetic nervous system cancer)
Sweden	Göthe et al., 1992 [22]	workers in day nurseries	cross-sectional retrospective day nursery population	<ul style="list-style-type: none"> spontaneous abortions 	<p>spontaneous abortion rate in exposed vs. unexposed pregnancies: 11.7% vs. 3.9% ($p < 0.05$); threatened abortions (extensive bleeding and/or strong uterine contractions) in exposed vs. unexposed pregnancies: RR = 2.5 (1.07–5.84) ($p = 0.03$)</p>	<ul style="list-style-type: none"> response rate: 78.4% (280/357 women) exposure was arbitrarily characterized by work as a child-minder in day nurseries; all pregnancies irrespective of whether the mothers worked in day nurseries were assessed (recall bias) case-control design with internal controls and statistical analyses examining pregnancies (exposed) rather than the mothers “cases” were pregnancies ending up in spontaneous abortions (27 exposed and 7 unexposed) and “controls” were all other pregnancies
Denmark	Hersoug et al., 2008 [26]	mothers employed in childcare institutions	prospective register-based cohort	<ul style="list-style-type: none"> infant wheeze in first born infants/infants with older siblings recurrent infant wheeze in first born infants/infants with older siblings atopic dermatitis in first born infants/infants with older siblings 	<p>RR (95% CI): 1.15 (0.96–1.37)/0.94 (0.82–1.09)</p> <p>RR (95% CI): 1.37 (1.05–1.77)/0.95 (0.78–1.16)</p> <p>RR (95% CI): 1.03 (0.81–1.31)/0.95 (0.77–1.19)</p>	<ul style="list-style-type: none"> the study group ($N = 2215$ infants) differed from the control group ($N = 29\,256$ infants) with regard to maternal parameters (atopic disease, income bracket) infants were followed up from birth to 18 months of age, thus long-term effects of maternal employment in childcare institutions on atopic diseases later in life could not be assessed no objective diagnosis of infant wheeze and atopic dermatitis was performed; however, atopic dermatitis was diagnosed using an algorithm based on a specialist evaluation

Table 1. Summary of studies conducted in developed countries (1987–2013) reporting pregnancy outcomes in daycare providers – cont.

Country	Reference	Study population	Type of study	Key adverse outcome(s)	Occupational risk estimate	Comments on potential bias and limitations
Finland	Riipinen et al., 2010 [23]	daycare workers	register-based cohort study	pregnancy outcomes	OR (95% CI) for: - preterm birth: 0.91 (0.79–1.06) (n.s.) - perinatal death: 0.91 (0.62–1.34) (n.s.) - small for gestational age: 1.01 (0.91–1.12) (n.s.) - congenital malformation: 1.10 (0.92–1.32) (n.s.)	- data from records (links to national registers): 13 299 and 12 182 singleton births in the study and reference group, respectively
USA	Lin et al., 2013 [24]	preschool teachers	population-based ongoing multicenter case-control study	major birth defects	OR (95% CI) determined by logistic regression for: - cataract: 3.44 (1.29–9.19) (p < 0.05) - cleft lip with/without cleft palate: 1.73 (1.02–2.94) (p < 0.05)	- response rate: 66% (69% cases, 65% controls) - recall bias as a telephone interview was conducted between 6 weeks and 2 years after the delivery date - for preschool teachers (N = 194), cataract (N = 5) and cleft lip (N = 21) were the major birth defects - Bayesian analysis was conducted to allow for further stability of the effect estimates showed no significant increased risk of cleft lip

HR – hazard ratio; PR – prevalence ratio; O/E – ratio of observed to expected numbers of adverse issues
 n.s. – not statistically significant.
 Threshold for statistical significance, p < 0.05.

Table 2. Summary of studies conducted in developed countries (1988–2016) reporting cytomegalovirus (CMV) infections in daycare center staff

Country	Reference	Study population	Type of study	Key adverse outcome(s)	Occupational risk estimate	Comments on potential biases and limitations
Italy	Volpi et al., 1988 [39]	female workers in daycare centers	cross-sectional study	CMV seroprevalence	CMV seropositivity rate: 96.4% in daycare workers comparable with the seropositivity rate in controls (85%)	- a relatively small sample size (N = 82 female educators) - the control group differed from the study group in terms of the socioeconomic status (housewives, female students)

USA	Adler, 1989 [14]	female workers in daycare centers	prospective study	CMV seropositivity and seroconversion	CMV seropositivity rate: 46% for women caring for children aged ≤ 2 years vs. 35% for women caring for children aged > 2 years (RR = 1.29 (1.05–1.57), $p < 0.02$); CMV seroconversion rate after 2 years: 11% vs. 2% (controls) (RR = 5 (2.4–10.5), $p < 0.02$)	<ul style="list-style-type: none"> the control (comparison) group of hospital workers with unspecified duties differed from daycare workers (N = 610) in terms of the socioeconomic category few confounding variables taken into account, no information about workers' own children; characteristics of individuals not available for follow-up
USA	Pass et al., 1990 [37]	childcare workers	prospective study	CMV seropositivity and seroconversion	CMV seropositivity rate: 62.5%; CMV seroconversion rate after 6 months: 20%, with the occupational risk factor being contact with children aged < 3 years for ≥ 20 h/week, $p = 0.03$	<ul style="list-style-type: none"> workers (N = 509) were employed in 32 daycare centers, and exhibited certain demographic differences, although statistical models were adjusted for some important confounders (age, ethnic background, gravidity)
USA	Murph et al., 1991 [36]	daycare providers in daycare centers	prospective study	CMV seropositivity and seroconversion	CMV seropositivity rate: 38%; CMV seroconversion rate: 7.9% annualized, 0–22% by 12 months, 0–40% by 16 months, but no occupational risk factors, but parallel CMV infections among children	<ul style="list-style-type: none"> among the 252 daycare providers included, 96 were seropositive; only 82 (53%) of the 156 seronegative workers were available for follow-up
Canada	Soto et al., 1994 [38]	female workers in daycare centers	prospective study	CMV prevalence and seroconversion	CMV seroprevalence rate: 47.3%, with the occupational risk factor being daycare employment continuing for > 5 years, $p < 0.05$; CMV seroconversion rate after 12 months: 23.8%, with the occupational risk factor being caring for children aged < 3 years vs. caring for children of other age groups (50% vs. 8%, $p < 0.05$)	<ul style="list-style-type: none"> a convenience sample of 166 educators were recruited from 29 daycare centers in Montreal, but educators born outside Canada (N = 18) were excluded from the analysis in addition, a high loss to follow-up limited generalizability of the results of this study

Table 2. Summary of studies conducted in developed countries (1988–2016) reporting cytomegalovirus (CMV) infections in daycare center staff – cont.

Country	Reference	Study population	Type of study	Key adverse outcome(s)	Occupational risk estimate	Comments on potential biases and limitations
Canada	Ford-Jones et al., 1996 [33]	daycare providers	prospective study	CMV seroprevalence and seroconversion	CMV seropositivity rate: 67%; CMV seroconversion rate: 12.5%, with the following occupational risk factors – never wore gloves for diaper changing and working with infants only, rather than with toddlers and infants, $p < 0.05$	– among the daycare providers (N = 206) included from 38 daycare centers in Toronto, 68 were seronegative and 56 were retested for seroconversion – high results variability between 2 large Canadian cities: Toronto and Montreal [38]
USA	Jackson et al., 1996 [34]	childcare providers	cross-sectional study	CMV seroprevalence	CMV seropositivity rate: 62%, with the occupational risk factor being changing diapers ≥ 3 days/week; RR = 1.8 (1.1–2.8), $p < 0.05$	– the study population included 560 educators, and the control group was representative of the general U.S. population, including unemployed people
Belgium	Kiss et al., 2002 [40]	kindergarten teachers working with children aged 2.5–6 years	cross-sectional study	CMV seroprevalence	overall (teachers and controls) CMV seropositivity rate: 16.4% in childless women, 33.7% in women with ≥ 1 child (raising one's own children is the major risk factor: OR = 2.25, $p < 0.05$); increased CMV seropositivity rate in teachers vs. controls: OR = 1.54, with non-significant influence of washing hands at school, the number and age of pupils, and seniority	– the study group consisted in teachers (N = 211) and the control group in administrative workers (N = 283) – children were aged 2.5–6 years; therefore, the study provided no data on work with infants and toddlers
Canada	Joseph et al., 2005 [35]	female educators in a daycare setting	cross-sectional study	CMV seroprevalence	CMV seroprevalence rate: 57%, with an occupational risk factor of a child to educator ratio $> 6:1$ for children aged 18–35 months; OR = 1.87 (1.25–2.81), $p < 0.05$	– a large sample size (N = 473 female educators), the random sample of daycare centers (N = 81) and multiple educator-level and daycare centre-level sociodemographic and professional variables taken into account strengthened the generalizability of the results, despite the limitations of the cross-sectional design

The Netherlands	Stelma et al., 2009 [41] female daycare staff	cross-sectional study	CMV seroprevalence	<p>CMV seroprevalence rate in daycare staff vs. controls: 50% vs. 31%, $p = 0.03$; risk of contracting a primary CMV infection vs. controls: OR = 2.19 (1.28–3.74), $p < 0.001$; OR = 3.80 (1.53–9.38), $p < 0.001$ during the first 2 years of daycare employment</p> <p>– the control group (N = 156) differed from the study group consisting of daycare workers (N = 313)</p>
France	Billette de Villemeur et al., 2011 [43] female childcare staff	cross-sectional study	CMV seroprevalence	<p>CMV seroprevalence: 69.4% for daycare staff vs. 41.1% for controls, PR = 1.43 (1.22–1.69), $p < 0.001$; occupational risk of CMV seropositivity: RR = 1.017 (1.005–1.092) per year of occupational exposure, $p < 0.001$; RR = 1.24 (1.06–1.46), $p = 0.009$ for work in a maternity hospital; RR = 1.23 (1.07–1.41), $p = 0.003$ for cleaning duties in the workplace</p> <p>– the control group (N = 382) differed from the study group (N = 395), as it was composed of women employed in 2 business organizations</p> <p>– participation rate: 63% for childcare staff and no information for controls</p>
The Netherlands	Van Rijkevorsel et al., 2012 [42] female daycare staff	cross-sectional study	CMV seroprevalence	<p>CMV seroprevalence: 73% similar to controls; 96% among workers born outside Europe vs. 57% among workers born in European countries, $p < 0.001$; 68% among daycare workers born in European countries vs. 42% among controls, PR = 1.7 (1.3–2.3), $p < 0.05$</p> <p>– controls (N = 298) were sociodemographically different from childcare workers (N = 242), since they came from the general population</p> <p>– moreover, serological sampling for controls and childcare workers was performed at different times (in 2004 and 2008, respectively)</p>

Table 2. Summary of studies conducted in developed countries (1988–2016) reporting cytomegalovirus (CMV) infections in daycare center staff – cont.

Country	Reference	Study population	Type of study	Key adverse outcome(s)	Occupational risk estimate	Comments on potential biases and limitations
Canada	Lamarre et al., 2016 [27]	pregnant women	prospective cohort	CMV seroprevalence and seroconversion	CMV seroprevalence: OR = 4.49 (1.57–12.82), $p < 0.05$ for working as a daycare educator; OR = 3.96 (1.31–11.97), $p < 0.05$ for women born in Canada or USA working as daycare educators	<ul style="list-style-type: none"> – a substudy (N = 1938) conducted in a large and heterogenic cohort of pregnant women (N = 2366) for whom serum samples were available for the first trimester and the third trimester/delivery. – consequently, the sociodemographic questionnaire was not specifically designed to monitor CMV seropositivity and seroconversion; the findings may not be generalizable
Germany	Stranzinger et al., 2016 [44]	pregnant daycare workers in daycare centers	cross-sectional study	CMV seroprevalence	CMV seroprevalence: 54.6% vs. 41.5% in controls (OR = 1.6 (1.3–1.9), $p < 0.05$), 54.6% vs. 53.9% in the control subgroup with ≥ 1 previous pregnancy, residing in Hamburg (OR = 0.9 (0.8–1.2))	<ul style="list-style-type: none"> – some confounding variables (one's own children, migration status) were not indicated – the control group (N = 14 358) composed of blood donors as a whole, residing in the same geographical region as pregnant daycare workers (N = 509); – when compared with a best-matching control subgroup, no significant difference in the prevalence was found

Abbreviations and explanations as in Table 1.

Table 3. Summary of studies conducted in developed countries (1990–2014) reporting parvovirus B19 (B19V) infections in daycare workers

Country	Reference	Study population	Type of study	Key adverse outcome(s)	Occupational risk estimate	Comments on potential biases and limitations
USA	Gillespie et al., 1990 [49]	school and daycare staff during an outbreak of erythema infectiosum	prospective study	B19V seroprevalence and seroconversion during an outbreak	B19V seropositivity rate: 58% seroconversion rate: 19%	<ul style="list-style-type: none"> – the study population (N = 571) included mixed school and daycare staff – participation rate: 90%

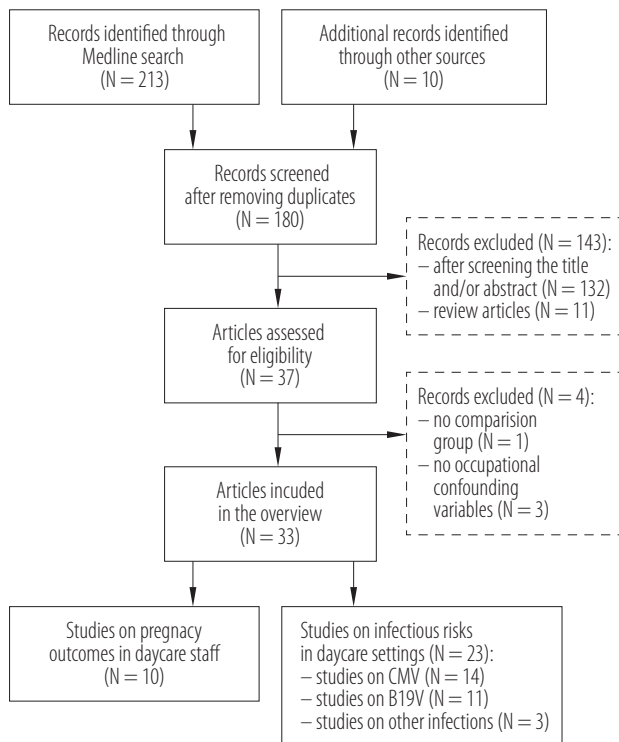
USA	Cartier et al., 1991 [50]	employed and home-working pregnant women during an outbreak	cross-sectional study	B19V infection rates during an outbreak	<ul style="list-style-type: none"> - seroprevalence rate in pregnant women with perceived exposure to B19: 53% previous infection, 6% recent infection - infection rates: 16% for school teachers, 9% for daycare workers, 9% for homeworkers, 4% for women working outside their home, but not in school or daycare settings 	<ul style="list-style-type: none"> - questionnaire response rate: 60% (479/796 pregnant women)
USA	Adler et al., 1993 [48]	hospital and school workers during the endemic period	prospective study	B19V seropositivity and seroconversion during an endemic period	<ul style="list-style-type: none"> - B19V seropositivity rate: 60% for all hospital and school workers; risk factors for seropositivity: contact with children aged 5–18 years (OR = 1.2, $p < 0.05$), employment in elementary schools (OR = 1.4, $p < 0.05$) - B19V seroconversion rate: 0.5% for hospital workers, 6.7% for school workers; risk factor for seroconversion: daily contact with school-age children in the workplace (OR = 5, $p < 0.05$) 	<ul style="list-style-type: none"> - the study sample consisted in 2730 school workers and 751 hospital workers - only age, race and gender were taken into account as confounders
USA	Harger et al., 1998 [54]	pregnant women exposed to B19V of various sources	prospective study	B19V seroprevalence and seroconversion	<ul style="list-style-type: none"> - B19V seroconversion occupational risk factors: no increase in risk for 8 categories of maternal occupation 	<ul style="list-style-type: none"> - the study population included 618 pregnant women known to be exposed to sources of B19V infections - serological evidence of contact was not available for all children (the testing rate of the source not reported) – in these cases, clinical diagnosis by a doctor of erythema infectiosum in the source was accepted

Table 3. Summary of studies conducted in developed countries (1990–2014) reporting parvovirus B19 (B19V) infections in daycare workers – cont.

Country	Reference	Study population	Type of study	Key adverse outcome(s)	Occupational risk estimate	Comments on potential biases and limitations
Denmark	Valeur-Jensen et al., 1999 [52]	pregnant women in epidemic and endemic situations	population-based cohort study	B19V seropositivity and seroconversion in endemic and epidemic	<ul style="list-style-type: none"> - B19V seropositivity rate: 65% for all pregnant women vs. 77% for nursery school teachers (OR = 1.83 (1.43–2.33)) and 75.2% for educated workers of an after-school club (OR = 1.65 (1.08–2.53), $p < 0.05$) - B19V seroconversion rate during a non-epidemic period: 1.5% for all pregnant women vs. 7.33% for nursery school teachers (OR = 3.07 (1.61–5.85)) and 7.41% for educated workers of an after-school club (OR = 3.36 (1.18–9.58), $p < 0.05$) 	<ul style="list-style-type: none"> - data obtained by linkage between different public registers for 30 946 pregnant women, including 390 nursery school teachers and 117 educated employees of an after-school club
Denmark	Jensen et al., 2000 [53]	pregnant women followed up from their first antenatal visit before 24 weeks of gestation until delivery	prospective cohort study	B19V seroprevalence and seroconversion	<ul style="list-style-type: none"> - B19V seropositivity rate: 66% for all pregnant women, and for women working with children (OR = 1.4 (1.1–1.9), $p < 0.05$) - B19V cumulative seroconversion rate: 10.3% (1.0% before and 13.5% during the epidemic) 	<ul style="list-style-type: none"> - the study population included 3596 pregnant women - participation rate: 80%
Canada	Gilbert et al., 2005 [47]	daycare educators	cross-sectional study	B19V seroprevalence	<ul style="list-style-type: none"> - B19V seroprevalence rate: 70% 	<ul style="list-style-type: none"> - the study population (N = 477 female educators), had an increased risk of seroprevalence depending on the age of children cared for (<18 months and ≥ 36 months); this difference was incompletely explained
The Netherlands	Stelma et al., 2009 [41]	female daycare staff	cross-sectional study	B19V seroprevalence	<ul style="list-style-type: none"> - B19V seroprevalence rate: 71% vs. 77% in controls, $p = 0.224$ 	<ul style="list-style-type: none"> - the control group composed of female students (N = 156) differed from the study group composed of daycare workers (N = 313)

France	Billette de Villemeur et al., 2011 [43]	female childcare staff	cross-sectional study	B19V seroprevalence	<ul style="list-style-type: none"> - B19V seroprevalence rate: 79.4% vs. 68% in controls, adjusted PR = 1.05 (0.94–1.16), p = 0.375 - participation rate: 63% for childcare staff and no information for the comparison group 	<ul style="list-style-type: none"> - the control group (N = 382) differed from the study group (N = 395), as it was composed of women employed in 2 business organizations
The Netherlands	Van Rijkevorsel et al., 2012 [42]	female daycare staff	cross-sectional study	B19V seroprevalence	<ul style="list-style-type: none"> - B19V seroprevalence rate: 73% vs. 60% in controls, PR = 1.2 (1.1–1.4), p = 0.003 	<ul style="list-style-type: none"> - controls (comparison group, N = 298) were sociodemographically different from childcare workers (N = 242), since they came from the general population - serological sampling for controls and childcare workers was performed at different times (in 2004 and 2008, respectively)
Finland	Riipinen et al., 2014 [51]	pregnant daycare and healthcare workers	cohort study	B19V seropositivity and seroconversion	<ul style="list-style-type: none"> - B19V seropositivity rate at baseline: 59% for daycare workers, 55% for healthcare workers - B19V seroconversion rate during pregnancy: 6.6% in daycare vs. 3.7% in healthcare workers [HR = 2.63 (1.27–5.46)] and among nulliparous women [HR = 5.59 (1.40–2.4), p < 0.05] 	<ul style="list-style-type: none"> - information relating to the occupation and employment status at baseline and during the follow-up was extracted from various registers for both daycare educators (N = 1966) and healthcare workers (N = 1744).

Abbreviations and explanations as in Table 1.



CMV – cytomegalovirus, B19V – parvovirus B19.

Articles were initially selected based on a literature search covering the period of 1980–2018. The remaining articles reported at least 11 of 22 STROBE statement items.

Figure 1. Studies included in and excluded from the review on pregnancy outcomes and infectious hazards related to employment in daycare settings

RESULTS

Overview of literature search results

The initial search of the database identified 223 records, 180 of which were selected to determine eligibility based on the study purpose and after removing duplicates. Figure 1 shows the flow diagram with numbers of articles identified and excluded at each selection step. Finally, 33 original studies were retained for the review: 10 studies related to pregnancy outcomes and 23 studies to infectious risks in daycare settings.

Studies on pregnancy outcomes in daycare staff

Literature reporting pregnancy issues in daycare workers is rather limited, and very few studies performed to date

have included pregnant childcare staff as an occupational group (Table 1).

Studies conducted in the early 1980s in Canada focused on occupation and pregnancy outcomes over a 2-year period (56 067 women, 104 649 pregnancies) and included childcare workers (6147 women, 221 pregnancies). Seven confounding variables (age, gravidity, pregnancy history-related variables, maternal education, smoking, alcohol consumption, ethnic group) were included in the models used to examine the association between work in the childcare sector and adverse pregnancy outcomes. Inconsistent associations between work in the childcare sector and congenital defects were reported [15,16]. No increase in the risk of fetal death [17], low birth weight (≤ 2500 g) or preterm birth (< 37 weeks) was found in this occupational group [18]. Nevertheless, workers in this sector were exposed to noise, heavy lifting and long work hours, all of which are known risk factors for prematurity and fetal growth retardation [8,19]. Because a reduced length of gestation is a cause of low birth weight, a closer reanalysis of birth weight data was adopted to permit gestational age to be taken into account [20]. The results showed that daycare workers were more likely to experience retarded fetal growth associated with lifting heavy weights > 15 times/day and high fatigue indexes previously reported [21].

A study conducted in Sweden in the early 1990s showed that working in day nurseries was associated with higher spontaneous abortion and threatened abortion risks, but not with prematurity or congenital malformations [22]. In contrast, a Finnish study conducted in 2010 found no increase in the risk for adverse pregnancy outcomes among daycare workers [23]. More recently, a U.S. study found that preschool teachers had a 3-fold higher risk of giving birth to children with cataract and cleft lip with/without cleft palate [24].

An increased risk of childhood tumors of the central and sympathetic nervous system were reported in a Danish

study examining the offspring of female childcare workers and kindergarten heads [25]. The authors pointed to infections during pregnancy as a potential risk factors for childhood cancer.

Finally, the possible protective effect of maternal microbial exposure at the time of conception and during pregnancy against infant wheeze and atopic dermatitis was not supported by the findings of a Danish study of mothers employed in childcare institutions [26].

In summary, studies evaluating the association between maternal daycare work and reproductive risks for pregnancy present inconstant results.

Studies on infectious risks in daycare settings

Although data reporting on problems in pregnancy are rare, literature pertaining to infectious risks in daycare settings is extensive.

Cytomegalovirus

Primary maternal infections with CMV during pregnancy result in viral transmissions to the fetus in up to 40% of cases [27]. In contrast, only 1% of CMV immune mothers who were already infected before pregnancy transmit the virus to the fetus, more often by reinfection than by reactivation of the latent virus [28]. Overall, about 10% of congenitally infected newborns have long-term sequelae, with the most frequent being hearing loss (50–59%), mental retardation (47–55%), cerebral palsy (49%), seizures (11–23%) and visual impairment (10–20%) [29,30]. Between 1–2% of seronegative women may contract a primary CMV infection during pregnancy, and seronegative women at high risk include daycare workers, who have a 10–20% annual infection rate [31]. Seroprevalence in adulthood may vary even between developed countries, and the occupational risk of contracting CMV in daycare centers varies accordingly [32]. Most CMV seroprevalence and seroconversion studies in daycare educators were performed in North America in the 1990s (Table 2). Seroprevalence in this occupational group is <70% (40–67%) in Canada and the USA [14,33–38], but >85% in Italy [39], which is similar to the seroprevalence for the Italian general population. The annual seroconversion rates in seronegative daycare educators were rather high in the USA and Canada (10–20%), whereas, in contrast, there is no evidence to suggest that CMV infection is a potential problem in British daycare settings [29]. North American daycare workers were shown to be at risk of CMV infections related to their work in daycare settings, and related to personal risk factors like older age, non-white race, foreign birth, birth in a low- or middle-income country, having children at home (≥ 2 children of their own, in particular children aged <5 years), living with ≥ 4 people, or having left school before the age of 15. The daycare-specific risk factors for CMV seropositivity and seroconversion, as shown in Table 2 (caring for >6 children and for children aged <2–3 years, changing diapers ≥ 3 times/week, not wearing gloves when changing diapers, employment in the daycare sector for >5 years), suggest that educators are at an increased risk of acquiring CMV from children in daycare settings. Indeed, infants shed viruses more often than toddlers (21% vs. 8%, average: 17%) [33], and viral DNA patterns were in most cases identical among children and workers who shed isolates of CMV in saliva or urine [14]. Moreover, poor hygiene practices and new CMV shedding in children were associated with a higher infection rate in daycare workers (0–22% by 12 months, average: 7.9%) [36]. However, a Belgian study conducted among kindergarten teachers found that washing hands at work, the number and age of school children, and the length of employment did not significantly influence seropositivity, while parenting their own children was the major risk factor for CMV seropositivity in this population [40]. Indeed, the CMV infection rate is 47% for parents of a CMV-shedding child aged 0–12 months, and 32% if the child is ≤ 18 months of age, compared to 7.9–20% in daycare workers [28].

Studies conducted in European countries showed a positive association between employment in daycare centers and CMV infections [41–43]. In the Netherlands, female daycare staff were at an increased occupational risk of a primary CMV infection, especially during the first 2 years of employment [41]. Having ≥ 1 child of their own, and having children in daycare or at school, did not correlate with CMV seroprevalence in adjusted models, whereas work seniority was associated only for the first 2 years of employment in the daycare sector. In another study conducted in the Netherlands, CMV seroprevalence was strongly related to the country of birth and was much higher among non-European women born in Africa, Asia, South or Central America [42]. Consequently, for daycare workers of European origin only, the CMV infection was associated with their workplace (the seroprevalence ratio = 1.7), and, in the same subgroup, with raising ≥ 1 own child (the seroprevalence ratio = 1.2).

French female childcare staff had an increased occupational risk of contracting CMV infections compared to a reference group (the seroprevalence ratio = 1.43) [43]. Notably, CMV seroprevalence increased with the duration of contact with children in the workplace, for workers performing cleaning tasks in childcare centers and for those who had previously worked in maternity hospitals, and was marginally higher in full-time childcare staff compared to drop-in childcare staff. However, the risk was not associated with the number of children cared for. Childless women or mothers of a single child had a higher risk of an occupation-related CMV infection compared to those who had ≥ 2 children of their own. Overall, the risk attributed to occupation was 30% for childcare staff, and a similar risk was calculated for some personal risk factors (the number of one's own children, in-home care for one's own child, one's own children attending a childcare facility, exposure through one's spouse) which ranged 14.5–32.4%.

Only 2 studies reported on pregnant women. In a cohort of 1938 pregnant women in the province of Quebec,

Canada, 58% of the subjects were seronegative during the first trimester of pregnancy, which placed them at risk of a primary CMV infection [27]. Higher seroprevalence was significantly more frequent in mothers working as daycare educators, but other factors were associated with previous CMV infections, such as having ≥ 1 child of their own, a low socioeconomic status, being born outside Canada or the USA, and having a first language other than French or English. The annual CMV seroconversion rate was 5.1% (95% CI: 3.2–7.7) and was not associated with any specific study population characteristics. In the region of Hamburg, Germany, the prevalence of anti-CMV IgG was significantly higher among pregnant daycare workers compared to female blood donors as a whole (55% vs. 42%) across all age groups. However, when compared to the subgroup of female blood donors matching best, based on past pregnancies and living in the city of Hamburg, the seroprevalence rates were similar among pregnant daycare workers and controls (54.6% vs. 53.9%) [44].

In summary, these findings suggest that employment in daycare facilities in developed countries is associated with an increased risk of CMV infections, although $>30\%$ of women remain seronegative and at risk of a primary infection during pregnancy. The main occupational risk factors are related to the high number and young age of children cared for, to changing diapers, to not using gloves, and to work seniority. The risk of seropositivity attributed to personal factors (older age, foreign birth, raising one's own children) is similar to, or even greater than, the occupational risk. Therefore, younger childless women employed in daycare centers are at the greatest risk for contracting a primary CMV infection during pregnancy, which raises concerns related to a vertical transmission of CMV and clinical outcomes of congenital infections.

Parvovirus B19

Parvovirus B19 infects 1–5% of pregnant women, and the transplacental transmission of B19V occurring in

25–33% of them may cause fetal loss or fetal damage, such as severe anemia, cardiac failure or brain anomalies [41,45]. In Europe, B19V-related fetal loss is underreported, and the occupational risk in pregnant women has yet to be fully addressed. For instance, in Northern Ireland, only 5% of the fetuses lost were tested for B19V, and only 52% of pregnancies were checked following occupational exposure to erythema infectiosum, mainly among teachers or daycare workers [46].

The authors identified 11 studies investigating the occupational risk of B19V infections in daycare staff (Table 3). The association between employment in daycare centers and B19V seropositivity was reported in some [42,47–49] but not in all studies [41,43]. Unlike CMV, B19V seropositivity does not seem to be linked to ethnic background. In a Dutch study, B19V seropositivity was independently associated with employment in daycare centers and with having one's own children, but not with the country of birth [42]. The risk of infection was high for pregnant women exposed during epidemics, and was associated with contact with children. During an outbreak of erythema infectiosum in Connecticut, 1 study reported a high infection rate with B19V for pregnant school teachers (16%), daycare workers (9%), and homemakers (9%), whereas women employed in other occupations outside their home had the lowest rate (4%) [50].

A cohort study compared B19V infections in pregnant daycare workers and healthcare workers with no occupational contact with children during a B19V epidemic in Finland [51]. A 3-fold increase in the risk was observed among daycare workers compared to women employed in healthcare, and the association was stronger among nulliparous women. Actually, the risk of seropositivity increased in relation to the number of one's own children (≥ 3) but was unrelated to age or job seniority. Similarly, in Denmark, pregnant nursery school teachers were at an increased risk of an acute infection compared to other pregnant women, but the population-attributable risk of

seroconversion was 55.4% for having one's own children and only 6% for occupational exposure to children [52], suggesting that most infections during pregnancy result from exposure through the woman's own children. The independent determinants for past infections were personal factors (an increased number of siblings, having siblings of similar age, the number of one's own children) and occupational exposure to children aged <7 years (nursery school teachers) or children aged 7–16 years (after-school clubs).

During a large B19V epidemic in Denmark, another study found no increase in the risk of an acute B19 infection during pregnancy among women working with children, but a trend for a higher prevalence of B19 IgG seropositivity was observed at the first antenatal visit among women working with children compared to women in other professions [53]. The higher level of immunity among women employed in this sector might explain the above-mentioned negative association. In all pregnant women combined, B19V infections during pregnancy were significantly associated with adverse pregnancy events (a 10-fold increase in late spontaneous abortions and stillbirths). Independent risk factors related to the increased risk of B19V infections during pregnancy were having children at home, suffering from a serious medical condition, and having a stressful job.

In the USA, during an endemic period, seropositivity for pregnant women in contact with cases of erythema infectiosum correlated weakly with employment as elementary school teachers (41 of 76 were immune) and as daycare workers (25 of 42 were immune) [48]. The risk of contracting B19 infections in seronegative elementary school teachers (23%) or seronegative daycare workers (24%) was somewhat higher than the overall 16.7% infection rate, but the difference was not statistically significant. A previous study conducted among pregnant women exposed to B19V found no increase in the risk of infections in 8 categories of maternal occupations involving contact

with children, but it did report a 3-fold higher risk if their own children were the source of infection [54].

Older studies showed that, among school and daycare staff, 58% had evidence of past infections, and 19% contracted a B19V infection during a large outbreak of erythema infectiosum in Connecticut [49]. The risk of seroconversion was increased for teachers and daycare providers in contact with a larger number of ill children, and with younger children.

In Montreal, B19V seroprevalence among daycare educators was 70% [47]. In daycare educators aged <40 years, a significant association with the length of employment in daycare centers was found. The risk of being seropositive depended on the age of children cared for, and was increased in educators in charge of children aged <18 months or ≥ 36 months compared to those working with children aged 18–36 months.

In summary, daycare workers exhibit a high rate of B19V seropositivity which is also related to personal factors – less to ethnic background than CMV, but strongly linked to having their own children and their number. The risk of seroconversion during an outbreak is thus mainly of concern among nulliparous younger daycare workers who are in contact with larger numbers of ill children and with younger children. This exposure is of greater concern as fetal loss due to a B19V infection seems to be underreported.

Other infectious risks

Very high rates of seroprevalence to rubella (98.7%) and varicella (100%) were observed in childcare staff and reference groups in France [43] and the Netherlands [42], and no occupational risks were found. In 2001, in Montreal, an overall seronegativity of 10.2% for rubella was found [55], and the most important predictors of rubella seronegativity for daycare educators were younger age, the lack of rubella vaccination and not having their own children.

Final remarks and practical implications for workers' health protection

This review of the available data suggests that daycare workers are faced with inconsistent reproductive risks for pregnancy problems including spontaneous abortion and congenital malformations. These risks are probably related to infectious agents excreted by children. In addition, a risk of retarded fetal growth could be related to physical constraints. Overall, women working in daycare settings have an increased risk of contracting CMV and B19V infections compared to reference groups, but personal characteristics are also independent determinants of seroprevalence and seroconversion in this occupational group.

Potential bias and limitations of the studies

Recall bias and low response rates were common among the studies, hinting that some bias may be present. Small study populations, particularly small numbers of exposed cases despite relatively large samples, justify multicenter studies to avoid underpowered epidemiological studies. Potential confounding non-occupational variables should be included when interpreting data such as the socioeconomic status, education, residence, family income, country of birth, delivery age, reproductive history, prenatal care, weight gain during pregnancy, nutrition, smoking, drinking, drugs consumption, etc. [56]. Unfortunately, confounding factors related to lifestyle and health are not available in historical cohort studies or birth certificates. Appropriate comparison groups should be used to control for confounding bias, but reproductive health should not be compared between employed vs. non-employed mothers. Thus, studies in which unexposed groups including employed women with comparable or similar occupations were used as comparison populations are less likely to be biased than where comparison groups included non-employed women or women with different occupations [13]. The relevant time window of exposure must be considered when examining pregnancy outcomes. Generally, the criti-

cal vulnerability window extends before and during pregnancy, from approximately 1 month before conception, and covers both the pregnancy and the breastfeeding periods. The most vulnerable period of fetal and newborn development is the first trimester, although some effects have been observed in the second and third trimesters. For instance, B19V may cause fetal loss especially in the second half of pregnancy, when other causes of fetal loss are rare [45].

The identification of pregnancy outcomes can be achieved from a variety of sources, such as birth certificates, death certificates, medical records, postal or interviewed questionnaires with parents, surveillance systems like registries, or health surveillance programs. Compared to the data collected by means of questionnaires, medical records and hospital information based on medical diagnoses and recordings at the time of the event afford more sound data [57].

The exposure assessment is an essential problem in occupational studies. In this overview, exposure was simply defined as being employed in a childcare setting and being identified as a childcare provider. Actually, the paucity of the research involving this occupational group did not allow for analyzing specific risk factors.

To avoid biases in future studies, prospective cohorts must be suitably designed to include a large-scale population and a narrow recall period, to improve the estimation of occupational exposures and the quality of outcome assessments, and to collect the potential confounding variables.

Preventing infections within childcare centers

Generally, 4 categories of preventive measures can be applied to prevent transmission of infections within a childcare center, i.e., antimicrobial treatment and/or prophylaxis; exclusion or quarantine of ill or infected children; infection prevention through age-appropriate immunization of both staff and children; and environmental controls with regard to hand hygiene, diaper changing practices, surfaces cleaning, or handling food [5]. Moreover, formal

written policies for infection control within childcare and repeated training for staff to prevent transmission of infections should be implemented.

The epidemiology of infections within daycare centers is driven by person-to-person contact, which is common and expected in these settings. Because CMV is transmitted during close contact with child's infected secretions and excretions, good personal hygiene should be practiced, especially by hand-washing after activities such as feeding, bathing, wiping drool or runny nose, or handling child's toys. To reduce the risk of infections, good hand hygiene should be applied to both the staff and children. Hands are best washed in warm, soapy water after removing rings and other jewelry. Alcohol-based hand rubs (hand sanitizers) appear safe to use among children and staff in daycare centers, since no evidence of elevated alcohol concentrations in alcometer readings for children were reported [58].

Diaper changing surfaces should be clearly separated from the food preparation area. Moreover, as much as possible, staff members who care for children using diapers should not be involved in food preparation [5]. Diaper changing surfaces should be non-porous and cleaned with a disinfectant after each change, together with other work surfaces that come in contact with urine or saliva, like toys or countertops.

Exposure to saliva allows direct transfer of the virus to mucous membranes. A simple surgical mask provides equivalent protection against exposure to saliva to an N95 mask, and is associated with better compliance as it does not cause skin irritation [59]. As a reminder, an N95 respirator is a respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles (the "N95" designation means that when subjected to careful testing, the respirator blocks $\geq 95\%$ of very small [$0.3 \mu\text{m}$] test particles).

Protective gloves should be worn during diaper changes and when manipulating children's unclean laundry.

Additional hygiene practices such as avoiding intimate contact with the child through kissing, on or near the mouth, sleeping together, sharing towels, washcloths and toothbrushes, and sharing food, drink, cups and plates can also reduce risk of CMV infection.

In summary, CMV transmission can be reduced by avoiding contact with children's excretions and secretions, restricting close contacts with children and washing hands both frequently and regularly.

Protection of pregnant workers

A pregnancy intention status is an important determinant of pregnancy-related health behavior and should be considered in prenatal programs. Women should be made aware that unplanned pregnancies are more likely to involve exposure to harmful occupational hazards during the critical vulnerability window for pregnancy outcome.

Daycare workers planning a pregnancy may need to be screened for the CMV status before conception. For seronegative workers, hygienic practices to reduce the risk of CMV infection, as washing hands after diaper changes and contact with respiratory secretions, is strongly recommended [30]. Hand-washing, using gloves, and restricting close contacts were successfully used to reduce CMV transmission to pregnant caregivers.

Regulations to reduce contamination levels and to protect women of childbearing age in occupational settings differ between countries and periods. In Germany, daycare providers have implemented working restrictions for pregnant CMV seronegative daycare workers, such as exclusion from professional activities with children aged <3 years [44].

It must be emphasized that there is currently no vaccine available for CMV and parvovirus infections. In contrast, vaccination should be strongly encouraged for women employed in the childcare sector who are not immunized against varicella or rubella [43], although immunization with live virus vaccines during pregnancy is not recom-

mended because of the risk of possible vertical transmission. For pregnant childcare staff, guidelines and recommendations relating to infectious diseases, stress and physical requirements have been reviewed elsewhere [6]. Ensuring, when available, age-appropriate vaccination of children and staff in childcare facilities, along with optimal ratios of children to caregivers, represent proven beneficial interventions to reduce infections [5]. It should, nevertheless, be noted that protection against infections does not eliminate other occupational risks for adverse pregnancy outcomes not addressed in this work, such as physical efforts and job stress for daycare providers.

Dealing with sick children

Updated guidelines on how to manage infectious diseases in childcare and schools provide the staff of childcare facilities with clear and easy-to-use information on the prevention and management of infectious diseases in daycare settings [60]. Childcare centers may thus provide care to healthy and mildly ill children. Sick children may be cared for within larger daycare centers or might be based in a separate facility specifically designed for mildly ill children who are ruled out from systematic childcare activities.

Exclusion as a means of reducing cross-infections has a limited effect as the shedding of infectious agents often precedes an illness and may persist for some time after its symptoms have resolved [5]. In addition, alternative care options for ill children may not always be available, or may be considerably more expensive. Nevertheless, when a child's illness restrains the child from participating in regular activities or requires a level of care that might be detrimental to the other childcare center attendees, an alternative mode of care outside the center appears appropriate. Moreover, certain symptoms displayed by a child, such as high fever, lethargy, difficulty breathing, rash with fever, repeated vomiting, increased production of infectious materials (diarrhea, drooling, conjunctivitis), etc., could be indications that the child has a serious sick-

ness or the likelihood of secondary transmission of infectious agents, requiring a level of observation not possible in a daycare center.

Specific diseases necessitating exclusion from a daycare facility and the duration of exclusion should be clearly guided by childcare centers policies. Immunocompetent children with B19V or CMV infections do not usually need to be excluded, all the more so CMV is generally clinically quiet in healthy children [28]. Compliance with daycare center policies tends to improve when written policies are individualized for each center [5], and communication between daycare providers and parents is an essential part of promoting these policies. Well-educated parents are thus less likely to bring ill children into the center, and information obtained from the parents (e.g., on how the weekend went) can help the staff to identify a possible problem.

CONCLUSIONS

Working in a daycare setting presents rare and inconsistent risks of adverse pregnancy outcomes. Few studies included the occupational group of daycare providers or tackled the risks for pregnancy in women of childbearing age.

Viral infections represent the most common risk for pregnancy issues in daycare centers. Workers generally exhibit a high rate of past infections, which is also strongly related to personal factors. Among daycare staff, young nulliparous women remain sensitive to infections and are at an increased risk of seroconversion during pregnancy.

Unplanned pregnancies are at a greater risk of exposure to occupational hazards.

Knowledge about the effects of infections, serological screening and monitoring during pregnancy could protect seronegative women from exposure and primary infections.

Vaccination, if applicable, and interventions to educate staff on hygiene measures in the workplace offer the best protection and represent easy-to-implement broad primary prevention strategies for women of childbearing age.

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