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The Pregnancy and Work Questionnaire: A Self-Administered Screening Tool for the OB-GYN Clinic

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A Self-Administered Screening Tool for the OB-GYN Clinic

by

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Glossary of Terms

Reproductive age, as defined by the U.S. Census, is ages fifteen to forty-nine.

Reproductive toxicity refers to the adverse effects of environmental agents on the reproductive system. These effects may be manifested as damage to reproductive organs, alteration of related endocrine systems, or diminished capacity to successfully reproduce, up to the point of carrying a fetus to term.

Developmental toxicity refers to the adverse effects of environmental agents on the developing organism. Developmental toxicity is manifested as structural or functional abnormalities in the offspring. Exposures resulting in developmental toxicity may occur before conception (in the parental generation), during development, or in the postnatal period, up to the time of sexual maturation. Effects of developmental toxicity may be detected at any time during the organism's lifespan.

Spontaneous abortion, commonly referred to as miscarriage, is the loss of a fetus before 20 weeks' gestation (by last menstrual period calculation method). Intrauterine fetal demise, or stillbirth, is the loss of a fetus after 20 weeks' gestation.

Pre-term delivery is delivery before 37 weeks' gestation.

Reduced fetal growth is assessed by measures such as 'small for gestational age' (birth weight, length, or head circumference below the 10th percentile for race, gender, and gestational age), 'low birth weight' (birth weight less than 2500 grams), or 'intrauterine/fetal growth restriction' (fetal weight below 10th percentile for gestational age).

Teratogens are agents or conditions capable of producing birth defects.

Birth defects, also called congenital anomalies, are abnormalities of structure, function, or body metabolism present at birth that result in physical or mental disability, or death. Many birth defects are not apparent at birth and are only recognized later.

Congenital malformations are a subset of birth defects manifested as structural abnormalities.

Functional deficits are a subset of birth defects typically manifested as neurological or behavioral deficits, but may encompass any physiological system.

An Introduction to Pregnancy and Work

Public Health Context

In the United States today, more than half of children are born to working mothers (U.S. Census Bureau, 2008). Pregnant women who work represent a potentially at-risk population, as job duties may result in exposure to chemical, biological, physical, or psychosocial factors capable of adversely affecting pregnancy and the health of the developing fetus. Increasingly, the workplace is being recognized as the principal site of population exposure to environmental reproductive and developmental toxicants (McDiarmid, Gardiner, & Jack, 2008).

Attention to healthy pregnancy and development has long been a key component of environmental health practice, particularly in the workplace setting. In fact, concerns about workplace risks to a woman's ability to bear healthy children played a central role in the genesis of the modern occupational health movement in the United States in the early 20th Century (Hepler, 2000). These efforts culminated in the passage of the Occupational Safety and Health Act in 1970, which led to the creation of the Occupational Safety and Health Administration (OSHA), the regulatory agency charged with protecting worker health, and the National Institute for Occupational Safety and Health (NIOSH), which provides research and advice to inform OSHA regulations.

In parallel to public health's focus on these issues, the medical community has also placed increasing attention on environmental and occupational exposures and their

relationship to pregnancy and fetal development. As "front line" practitioners, clinicians have been essential in the recognition and reporting of environmentally-mediated epidemics, as in the cases of rubella and congenital cataracts, or thalidomide and congenital limb defects (Lawson et al., 2003). An early formal alignment between the clinical world and the field of occupational reproductive health was the 1977 publication by the American Congress of Obstetricians and Gynecologists (ACOG) entitled, "Guidelines on Pregnancy and Work." The need for this report came out of the recognition of three concomitant trends: growing scientific knowledge of environmental and occupational toxicants, increasing numbers of women in the workforce, and social policies guaranteeing equal employment opportunity, regardless of gender. Accordingly, ACOG, one of the major professional organizations for women's health physicians, with the support of NIOSH, developed guidelines to help physicians advise pregnant patients on the safety of working while pregnant (ACOG, 1977).

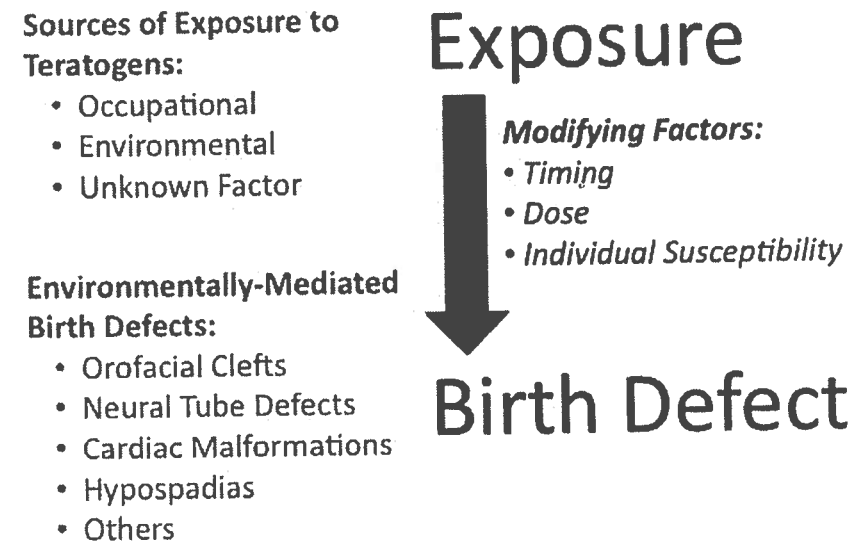
Workplace Threats to Healthy Reproduction and Development

Exposures of concern to the pregnant woman and her physician include reproductive toxicants, capable of causing spontaneous abortion, stillbirth, pre-term delivery, reduced fetal growth, and developmental toxicants, which can cause birth defects, including congenital malformations and functional deficits (Burdorf, Figà-Talamanca, Jensen, & Thulstrup, 2006). In addition, there is mounting evidence that some environmental exposures encountered by pregnant women increase the risk of cancer in her offspring (e.g., pesticides and certain childhood cancers, including leukemia, lymphoma, brain cancers, and others; see Wigle et al., 2008). The notion that prenatal exposure can

cause cancer in offspring years later became widely known following the experience with diethylstilbestrol (DES), a drug prescribed for miscarriage prophylaxis that was found to increase the risk of reproductive tract cancers and malformations in the offspring of mothers who took it while pregnant (Genuis, 2006).

Birth defects are the best-studied adverse developmental outcome, and their public health impact is significant. Not only are birth defects the leading cause of infant mortality, responsible for one in five infant deaths, they account for more than 20% of all childhood deaths, mostly due to cardiovascular malformations (TFA, 2002). While the cause of most birth defects is unknown, many of the known etiologies involve environmental factors (Grajewski, Coble, Frazier, & McDiarmid, 2005). Ten percent of all birth defects are attributable to specific teratogens, and an additional 40% are caused by the complex interplay of genetic and environmental factors (Buczynska & Tarkarkowski, 2005). Further, it is thought that occupational exposure to toxicants may be responsible for up to one half of all birth defects of unknown etiology (Grajewski et al., 2005). Specific birth defects with strong evidence of environmental etiology include anencephaly, spina bifida, orofacial clefts, atrial and ventricular septal defects, tetralogy of Fallot, transposition of the great vessels, gastroschisis, hypospadia and epispadia (TFA, 2002). A given birth defect may be caused by many different types of exposures, and a particular exposure can cause different outcomes depending on timing of exposure, dose, and individual susceptibility (Fawcett & Brent, 2006).

Figure 1: Environmental Teratogenesis



While this paper focuses on the effects of maternal exposures, it should be noted that paternal exposures can also contribute to adverse reproductive and developmental outcomes (Silbergeld & Patrick, 2005). Further, most exposures associated with reproductive and developmental toxicity are also associated with infertility (Burdorf et al., 2006; Winker & Rüdiger, 2006). A detailed discussion of these topics is beyond the scope of this paper.

The Evidence Base of Occupational Reproductive Health

Hundreds of environmental agents, including many encountered in the workplace, are known to cause reproductive and developmental toxicity. Known toxicants represent only a fraction of the 84,000 chemicals currently used in occupational settings, and new chemicals are being introduced into commerce by the thousands annually (Grajewski et al.,

2005). There is therefore a substantial knowledge gap in the scientific understanding of occupational risks to worker health, including workers' ability to bear healthy children.

Those agents that have been identified as reproductive and developmental toxicants have been consistently demonstrated to cause adverse effects in epidemiologic studies in human populations, as well as in animal toxicologic experiments. The limitations of each of these study types restrict scientific understanding of the true magnitude of risk posed by toxic exposures in the workplace.

Environmental-Occupational Epidemiology

The practice of occupational health, and its inquiry into work-related causes of adverse reproductive and developmental outcomes, relies on a substantial body of epidemiologic literature based on workplace studies of exposures and outcomes. Environmental epidemiologic studies of populations exposed to the same toxicants outside the workplace can provide additional evidence that an exposure and outcome are linked (Figà-Talamanca, 2006).

When numerous epidemiologic studies of sufficient quality consistently demonstrate an effect between exposure and outcome, causal inference may be made. An individual study cannot provide cause-effect information in and of itself. As valuable as epidemiologic studies are for understanding the relationship between exposures and adverse reproductive and developmental outcomes, they do suffer from limitations that decrease study power and may lead to conflicting conclusions about the risks of various exposures. Exposure misclassification is a major concern in occupational epidemiology because exposure status is typically ascertained by subjective rather than objective means

(e.g., self-report or assignment of exposure status by job title rather than physical sampling of the environment or of biological samples from workers; Grajewski et al., 2005). Studies comparing self-report to biomonitoring have found various degrees of agreement between the two measures, but under-reporting appears to be a more significant source of bias in self-report as compared with over-reporting (Hemminki, Lindbohm, & Kyyrönen, 1995).

The problem of mixtures is an important epidemiological issue. Certain occupations are known to increase the risk of adverse reproductive or developmental outcomes, yet because workers are exposed to a mixture of agents, it is not always possible to identify a specific exposure as a causal factor. Examples include hairdressers, who may be exposed to mixtures of solvents, and greenhouse workers who are exposed to numerous pesticides (Burdorf et al., 2006).

In the study of occupational and reproductive toxicity, the relationship between timing of exposure and outcome can complicate study design and limit the ability of an outcome to be detected. Some outcomes only result when exposures occur during a very narrow developmental period (Burdorf et al., 2006); others manifest years or decades after exposure (Genuis, 2006). Further complicating the effort to attribute outcomes to specific agents are exposures from persistent chemicals (e.g., lead, dioxin, organochlorine pesticides) that the mother may have encountered long before conception (Mattison, 2010).

The rarity of certain outcomes (e.g., birth defects, which occur in about 3% of all live births) can translate into inadequate study power. As noted earlier, birth defects are the most well studied adverse developmental outcome due to the existence of surveillance

mechanisms and registries in most states. However, the quality of these registries varies tremendously, and 25% of U.S. births occur in areas not under surveillance (TFA, 2002).

The difficulty of detecting other outcomes, such as spontaneous abortion before a woman knows she is pregnant, or subtle functional deficits that go unrecognized, dilutes the ability to detect true associations which may be present (Silbergeld & Patrick, 2005). As a result of subtle or latent presentation of developmental toxicity, the majority of structural and functional abnormalities are missed in newborn screening (Mattison, 2010).

Reproductive epidemiologic studies suffer from the same biases as other types of epidemiologic studies, including recall bias, selection bias (e.g., women with live-born children may leave the workforce and women with spontaneous abortions may be more likely to remain at work, or women with children who have birth defects or severe health effects might be most likely to quit work), confounding and interaction (synergy/antagonism, gene-environment) ((Fedoruk, 1996; Feinberg & Kelley, 1998)).

Animal Toxicology

Associations from occupational epidemiology are supported by data from animal toxicologic studies, which are conducted under experimental conditions to minimize bias. Animal studies may also provide insight into the physiological mechanisms underlying toxicity.

Only a small fraction of chemicals currently on the market have been tested for toxicity (Genuis, 2006). Among those chemicals that have undergone such testing, reproductive and developmental endpoints have not always been included in the battery of tests (Fedoruk, 1996). (It should be noted this is quite different from pharmaceuticals,

which must undergo extensive pre-market toxicology testing to examine safety and potential to cause reproductive and developmental harm (Genuis, 2006)).

When reproductive and developmental toxicity testing is performed, the ability to identify which substances are truly harmful is limited by interspecies differences and a lack of information about the effects of low doses. With respect to the former, physiological differences between humans and animals may mean that an adverse effect will not be observed in toxicologic studies, akin to a false negative (Fawcett & Brent, 2006). Probably the most famous instance of this phenomenon was the use of thalidomide in Europe in the 1960s. In that case, a drug indicated for morning sickness in pregnant women was found to be teratogenic only after it had been widely prescribed and resulted in thousands of cases of congenital limb deformities. Thalidomide evaded detection by animal toxicologic testing because the experimental species used, mouse and rat, were virtually insensitive to the drug, unlike humans (Winker & Rüdiger, 2006). As a general principle, developmental toxicity tests are inefficient at eliciting the types of congenital malformations a toxicant may cause in conditions of human exposure, but they do tend to reveal gross markers of developmental toxicity, such as decreased growth and survival (Fawcett & Brent, 2006).

The second problem with using toxicologic studies to predict effects in humans, i.e., the lack of information about low-dose exposures, is a function of standard toxicology study design, which was developed prior to the era of concern about endocrine-disrupting chemicals (EDCs). Chemical perturbation of the endocrine system is a major mechanism of reproductive and developmental toxicity, and exposures capable of disrupting the endocrine system typically do so at very low doses, orders of magnitude below the range normally tested in toxicology studies. A desire to extrapolate from higher dose studies is

complicated by the fact that EDCs often exhibit idiosyncratic patterns of toxicity, such as having greater effects or even fundamentally different effects at low doses as compared with high doses. In summary, standard (not low-dose) toxicologic studies provide only limited, and in some cases perhaps incorrect, information with which to draw conclusions about reproductive and developmental toxicity (Hanke & Jurewicz, 2004).

The Biology of Reproductive and Developmental Toxicogenesis

Fetal Exposure to Toxicants

Environmental toxicants reach the fetus through the placenta, an incomplete barrier that slows but does not block the passage of some substances (those that are polar, highly charged, or have a large molecular weight) while allowing many others to pass through without hindrance. Many reproductive toxicants, such as pesticides and organic solvents, are highly lipophilic and easily traverse the placenta to reach the fetus. Exposure to physical agents such as ionizing radiation is not at all limited by the placenta (Fawcett & Brent, 2006).

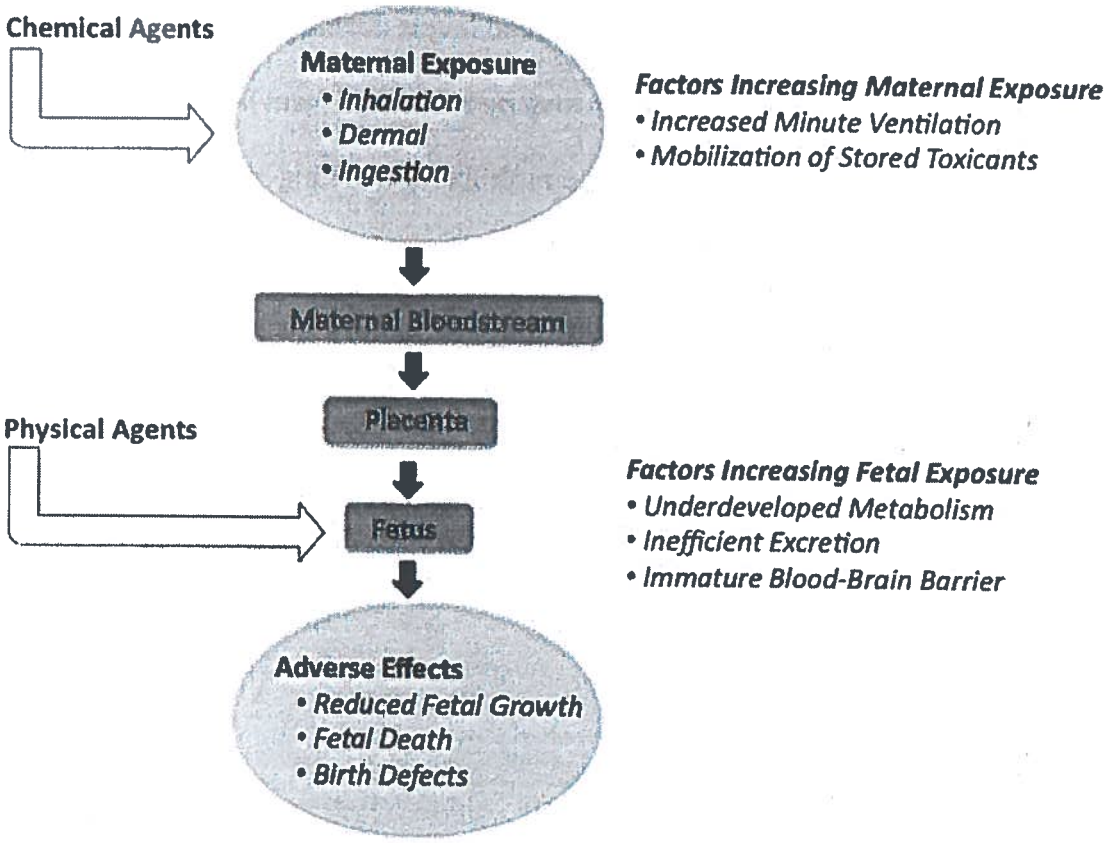
The fetus is highly vulnerable to the effects of toxicants. Besides undergoing extensive developmental processes, which may be disrupted by environmental agents, the fetal liver is less efficient at metabolizing toxicants. This means that substances passing through the placenta may rapidly accumulate in the fetus. Fetal excretion pathways are also inefficient, because toxicants excreted in fetal urine get reabsorbed with amniotic fluid through the nose and mouth. In addition, the fetal blood-brain-barrier is not fully developed and is more permeable than the corresponding structure in children or adults.

These facets of fetal physiology translate to toxicants having a longer half-life, greater tissue dose, and greater access to the central nervous system in the fetus (Genuis, 2006).

Certain physiological changes associated with pregnancy contribute to increased maternal and fetal exposures. Pregnant women's greater breathing rate and tidal volume (i.e., increased minute ventilation) may increase their exposure to inhaled toxicants. In addition, toxicants stored in the bone, such as lead and cadmium, are mobilized to the blood during pregnancy, early in pregnancy with maternal blood volume expansion, and later in pregnancy, as the fetal skeleton develops. Bone lead stores in particular may contribute up to one-third of maternal blood lead levels during pregnancy. Similarly, lipophilic chemicals stored in body fat can also be mobilized from fat to blood during pregnancy (Silbergeld & Patrick, 2005). The mobilization of long-stored toxicants means that the fetus may be exposed even at times when the mother does not appear to be exposed based on her occupational or environmental history (Grason & Misra, 2009).

Figure 2: Fetal Exposure Pathways

Fetal exposures to chemical toxicants occur via maternal exposure to an exogenous source (through inhalation, dermal contact, or ingestion) or via mobilization of tissue stores. In either case, toxicants in maternal circulation must pass through the placenta in order to reach the fetus. Lipophilic substances cross the placenta more readily than those that are hydrophilic. Fetal exposure to physical agents, such as ionizing radiation, is not at all hindered by the placenta.



Toxic Effects of Fetal Exposure

While the specific pathogenesis of many environmentally-mediated disease has not been elucidated, in general, environmental toxicants act through direct cell killing, altering cell-cell interactions, decreasing the synthesis of important biological molecules, impairing cells' ability to migrate during embryogenesis, or decreasing cellular proliferation (Fawcett & Brent, 2006). Physiologic alterations originating from prenatal exposures may be passed on to successive generations if toxicant exposure leads to DNA mutation or epigenetic modification (Silbergeld & Patrick, 2005; Woodruff, Carlson, Schwartz, & Giudice, 2008).

As mentioned earlier, timing of exposure plays a major role in determining which types of adverse outcomes will occur, or whether they will occur at all. "Critical windows of susceptibility" are particular times during development when exposures to environmental toxicants can affect the physiology of a cell, tissue, or organ. These windows correspond to times of extensive growth and development, particularly before and around the time of conception, during gestation, infancy, childhood, and puberty. Exposures during these periods can result in permanent, lifelong, or even intergenerational adverse effects (Woodruff et al., 2008). Within these larger critical windows, the period of sensitivity for a given agent and outcome may be narrow or broad. In general, the more specific the actions of a toxicant, the narrower the susceptible period (Fawcett & Brent, 2006).

Exposures during pregnancy tend to result in somewhat characteristic patterns of outcomes depending on gestational age (see Figure 3). There is a so-called "all-or-none phenomenon" in the early embryonic period, approximately the first two weeks after fertilization. During this period, toxic assaults usually cause significant cell loss or

chromosomal abnormalities that are likely to kill the embryo. If, however, the embryo survives, the remaining pluripotent cells may allow for normal development (Fawcett & Brent, 2006). The three to eight weeks after fertilization are a period of rapid cell division and tissue differentiation as the embryo's organs form. This period of organogenesis, corresponding to five to ten weeks' gestational age by last menstrual period, is the time during which the embryo is at the greatest risk for congenital malformations due to environmental exposures (Fawcett & Brent, 2006). Exposures resulting in doses too small to cause malformations may still cause functional deficits, including impaired intelligence and reproductive capacity (Silbergeld & Patrick, 2005). Exposures occurring during the second and third trimester are more likely to lead to pre-term birth and diminished growth, but malformations and subtle functional deficits may also occur (Fawcett & Brent, 2006).

Figure 3: Fetal Timeline

PERIOD	FIRST TRIMESTER			SECOND TRIMESTER	THIRD TRIMESTER
	Weeks 1-2	Weeks 3-8	Weeks 9-12	Weeks 13-28	Weeks 29-38
	Implantation	Embryonic Period (Organogenesis)	Fetal Period (Growth and Development)		
MAJOR ADVERSE OUTCOMES	Prenatal death	Major morphological abnormalities	Reduced fetal growth Pre-term birth Functional abnormalities Minor morphological abnormalities		

Specific Exposures and Their Effects

Maternal occupational exposures demonstrated to cause reproductive and developmental toxicity include pesticides, organic solvents, metals, chemical and biological agents encountered in healthcare work, physical agents, and ergonomic factors.

Pesticides

Pesticides, defined by the U.S. Environmental Protection Agency as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest," include herbicides, insecticides, rodenticides, and fungicides. Agricultural applications represent more than three-quarters of pesticide use in the U.S., thus workers

in this industry have a great potential for exposure (Stillerman, Mattison, Giudice, & Woodruff, 2008). Workers engaged in pesticide manufacturing and landscaping are also at risk for exposure (Figà-Talamanca, 2006; Kumar, 2004). Greenhouse workers are known to have particularly high exposures due to factors such as lack of ventilation, high humidity and high temperature (Figà-Talamanca, 2006; Hanke & Jurewicz, 2004). Exposure to pesticides occurs mainly through the dermal route, although inhalation and ingestion exposures also contribute. Most insecticides, including the organophosphates, carbamates, and organochlorines, are highly lipophilic and thus penetrate the skin easily (Hanke & Jurewicz, 2004); this lipophilicity also renders the placenta highly permeable.

Maternal occupational exposure to pesticides as a class has been associated with spontaneous abortion, pre-term birth, and multiple congenital anomalies, particularly orofacial clefts (Buczynska & Tarkarkowski, 2005; Figà-Talamanca, 2006; Hanke & Jurewicz, 2004). The human epidemiologic literature has not shown consistent associations between these outcomes and specific pesticides; however, there is toxicologic evidence that each of the major classes of pesticides contains agents capable of causing adverse reproductive and developmental outcomes (Frazier, 2007; Weselak, Arbuckle, & Foster, 2007). In addition to having the potential to cause these gross effects, many pesticides act as endocrine disrupters at very low doses. For example, pesticides like amitrole, inoxynil, and the dithiocarbamates interfere with thyroid hormone function, which is crucial for normal brain development (Hanke & Jurewicz, 2004).

Organic Solvents

Exposure to organic solvents occurs in a wide variety of industrial settings, including manufacturing, printing, dry cleaning, laboratories, cleaning, construction, and craft and trade work (Ahmed & Jaakkola, 2007; Khattak et al., 1999). Solvents are used to clean or remove grease, mix or thin paints, extract substances from natural sources, and synthesize other chemicals; they are a component of paints, paint thinners, lacquers, and glues (Kumar, 2004; Seedorff & Olsen, 1990). Organic solvents are volatile and lipophilic, and exposure occurs through dermal or inhalation routes. Most solvents cross the placenta (Kumar, 2004). Maternal occupational exposure is associated with spontaneous abortion, pre-term birth, and congenital malformations (Burdorf et al., 2006; Figà-Talamanca, 2006; Khattak et al., 1999; Stillerman et al., 2008).

Metals

Exposures to metals occur across a variety of industries, including manufacturing, smelting and refining, welding, construction, municipal waste handling, and others (Figà-Talamanca, 2006; Kumar, 2004; McDiarmid et al., 2008). Maternal occupational exposure to toxic metals is associated with increased risk of spontaneous abortion, congenital anomalies, and pre-term birth (Figà-Talamanca, 2006). The occupational epidemiologic literature provides the strongest evidence for the toxicity of lead and mercury, but other metals, including cadmium, chromium, nickel, and manganese, have been demonstrated to cause reproductive and developmental toxicity in animal studies (Kumar, 2004). Maternal occupational lead exposure is associated with low birth weight (Kumar, 2004), neural tube defects (Burdorf et al., 2006) and impaired cognitive development (Feinberg & Kelley,

1998), and women exposed to lead through their environment have higher rates of spontaneous abortion and pre-term birth (Figà-Talamanca, 2006). Exposure to mercury is associated with spontaneous abortion (Figà-Talamanca, 2006) and altered neurodevelopment, producing cognitive, attention, behavioral, and motor abnormalities in exposed offspring (Mattison, 2010).

Exposures in the Healthcare Industry

Many substances encountered by workers in the healthcare industry have the potential to cause reproductive and developmental toxicity. Environmental monitoring of hospitals has revealed widespread work area contamination by toxic chemicals, such as sterilizing agents, anesthetics, and chemotherapeutic drugs (McDiarmid, 2006), and several infectious agents that may be encountered by healthcare workers can cause adverse reproductive and developmental outcomes. Ethylene oxide is a disinfectant gas used in hospitals and other healthcare settings to sterilize heat-sensitive equipment. Occupational exposure increases the risk of pre-term birth, spontaneous abortion, and orofacial clefts (Burdorf et al., 2006; Figà-Talamanca, 2006). Anesthetic gases and chemotherapeutic drugs are associated with increased risk of spontaneous abortion in women occupationally exposed (Burdorf et al., 2006; Figà-Talamanca, 2006). Infectious agents such as cytomegalovirus, parvovirus B19, and rubella are associated with congenital defects and spontaneous abortion (Feinberg & Kelley, 1998).

Physical Agents

Physical factors such as ionizing radiation and noise can act as reproductive and developmental toxicants. Occupational exposure to ionizing radiation occurs mainly in the

healthcare (imaging and nuclear medicine) and aviation industries, and maternal exposure increases the risk of spontaneous abortion, congenital anomalies (Burdorf et al., 2006; Figà-Talamanca, 2006), cognitive defects, and childhood leukemias (Feinberg & Kelley, 1998). Occupational exposure to noise occurs across a variety of industries and is associated with spontaneous abortion, low birth weight, and pre-term birth (Burdorf et al., 2006) (Figà-Talamanca, 2006).

Ergonomic Factors

Performance of heavy physical work during pregnancy, including elements such as high energy expenditure, frequent heavy lifting and bending, and prolonged standing, is associated with increased risk of spontaneous abortion, decreased fetal growth, and pre-term birth (Burdorf et al., 2006; Figà-Talamanca, 2006; Mozurkewich, Luke, Avni, & Wolf, 2000).

Exposures in the Home

Exposure to many of these toxicants is not limited to the occupational setting, and may also be the result of engaging in hobbies or household activities. In contrast to exposures in the workplace, household or hobby-related exposures are less likely to be adequately controlled (Silbergeld & Patrick, 2005). The major household exposures of concern are cleaning agents, which may contain organic solvents, and pesticides. Hobbies of concern include painting, photography, furniture refinishing, silkscreening or printing (solvent exposure), pottery making, and stained glass work (metals) ((McDiarmid et al., 2008; Silbergeld & Patrick, 2005)). In an effort to prepare for the arrival of the new baby, families may undertake remodeling or repainting projects, which can also increase the risk

of the pregnant woman being exposed to reproductive and developmental toxicants (Silbergeld & Patrick, 2005).

Workplace Protection of Pregnant Workers

Occupational Exposure Limits

Many hazardous workplace exposures are subject to regulation by OSHA and have corresponding occupational exposure limits, dubbed "Permissible Exposure Limits" (PELs). PELs are established to protect "nearly all" workers and do not take into account vulnerable populations, including pregnant women (Grajewski et al., 2005). The vast majority of PELs are not based on data concerning reproductive and developmental outcomes (notable exceptions include lead, ethylene oxide, ionizing radiation, and the solvent dibromochloropropane (Gabbe & Turner, 1997)); accordingly, compliance with these exposure limits does not assure protection from reproductive and developmental toxicity (Lawson et al., 2003). The inadequacy of PELs in protecting against reproductive toxicity was illustrated by Jankovic and Drake (1996) in their attempt to generate "occupational reproductive guidelines" for substances known to cause reproductive toxicity in both humans and animals. About half (47% of the 180 chemicals for which dose-response analysis was completed) had no existing workplace exposure limits, and amongst the half that did, the exposure limit exceeded the authors' calculated occupational reproductive guideline in 75% of cases.

Communication of Risks to Workers

The OSHA Hazard Communication Standard requires employers to provide Material Safety Data Sheets (MSDSs) and safety training to workers using hazardous chemicals. The MSDS is a document produced by the chemical manufacturer detailing physical and chemical properties, physical and health hazards, routes of exposure, precautions for safe handling and use, emergency and first-aid procedures, and control measures. The MSDS often lacks information about reproductive and developmental toxicity (Fedoruk, 1996; Jankovic & Drake, 1996). While this frequently reflects data gaps, reproductive and developmental toxicity data may be missing from the MSDS even for well-established toxicants (Grason & Misra, 2009). For example, a study examining the MSDSs for the known reproductive toxicants lead and ethylene oxide found that reproductive toxicity data were missing in a third of the nearly 700 MSDSs surveyed (Paul and Kurtz, 1994, as cited by Grajewski et al., 2005). The MSDS is further limited by a loop-hole allowing manufactures not to disclose trade secrets or "inert" ingredients (creating the possibility that toxic ingredients are not disclosed), as well as highly variable quality (Grajewski et al., 2005).

Safeguarding Pregnant Workers

Legal protections for pregnant workers are insufficient in the U.S. and minimal in comparison with protections afforded by other developed countries (Frazier, Ho, & Molgaard, 2001). The U.S. is one of only three developed nations that does not provide paid maternity leave (Australia and New Zealand are the others) ((Mozurkewich et al., 2000)). The federal Family Medical Leave Act (FMLA) allows workers to take up to 12 weeks of unpaid leave for the birth or adoption of a child, to recover from a serious personal illness,

or to care for a family member, with job protection upon return (Feinberg & Kelley, 1998). The FMLA does not cover all workers, only those employed by companies with more than 50 workers; to qualify for unpaid leave, a worker must have worked at the company for 12 months and 1,250 cumulative hours (Von Busch, Frazier, Sigler, & Molgaard, 2002). Given these restrictions, the FMLA leaves out a large portion of the population, and it has been estimated that only 20% of new mothers are covered and eligible for the protections afforded by the law. Of the workers that do qualify, many cannot afford to take unpaid leave (Fass, 2009).

The Pregnancy Discrimination Act (PDA), an amendment to the federal Civil Rights Act, states that employers may not discriminate on the basis of pregnancy in actions related to hiring, granting leave, or providing employment benefits. It applies only to workplaces with 15 or more employees (Coyle, System, & Service, 1990). The PDA does not require employers to provide work accommodations to pregnant workers (Frazier et al., 2001).

Individual state laws may provide additional protections. The California Fair Employment and Housing Act extends unpaid medical leave provisions to workers at companies of five or more employees and provides pregnant employees with the right to job accommodation or transfer (Golden, 2006). A few states offer paid pregnancy leave (California, Washington, and New Jersey) or partial wage replacement through pregnancy disability insurance (California, Hawaii, New Jersey, New York, and Rhode Island). Unlike the FMLA, these temporary disability insurance programs typically do not offer job protection (Fass, 2009).

Considered in sum, existing regulatory and legal workplace policies do not go far enough to protect pregnant workers from exposure to reproductive and developmental toxicants. Occupational exposure limits for hazardous agents are too high to protect the developing fetus in many cases, and non-existent for many exposures of concern. Communication of occupational hazards to workers relies upon MSDSs, which are of variable quality and often lack data on reproductive and developmental toxicity. The option to avoid potential occupational risks during pregnancy by taking unpaid leave presents a substantial financial hardship, and the right of transfer to less hazardous job duties is not enshrined in federal law. Under current conditions, there is no guarantee of a workplace safe for healthy pregnancy and childbearing. An additional level of protection from reproductive and developmental hazards may occur through the early recognition of exposures in another environment pregnant women encounter: the doctor's office.

Screening for Occupational Exposures in the Obstetrics Clinic

In the years following the publication of ACOG's *Guidelines on Pregnancy and Work* (1977), there has been an increased push within the medical community to be aware of the potential for environmental and occupational exposures to adversely affect pregnancy and development. The Committee of Scientific Affairs at the *Journal of the American Medical Association* recommended that all physicians be familiar with the ACOG guidelines (1985) and the Institute of Medicine called on primary care physicians to acquire the skills needed to "identify possible occupationally or environmentally induced conditions and make the appropriate referrals for follow-up" (IOM 1988, as cited by Grason & Misra, 2009). A number of articles in the medical literature reaffirm this view and provide an overview of

hazardous exposures in the workforce and environment intended to familiarize physicians with the most common risks (see, for example, Feinberg & Kelley, 1998; Frazier & Jones, 2000; Genuis, 2006).

Public concern about environmental exposures and reproductive health is also on the rise. More than a quarter of calls received by Teratology Information Services hotlines nationwide from 2003 to 2004 were regarding occupational and environmental exposures (Grason & Misra, 2009). California's Proposition 65, a public health policy relating to environmental exposures and hazard communication, has undoubtedly increased the visibility of reproductive toxicants. This law, passed in 1986, requires labeling of products and environments with the potential to cause exposure to substances "known by the state of California to be carcinogenic or reproductive toxicants" (Silbergeld & Patrick, 2005).

Pregnant women, in particular, are concerned about the potential for environmental and occupational exposures to affect their health and that of their children, and want to be able to discuss these concerns with their healthcare providers (McDiarmid & Gehle, 2006); in some cases, they may be better informed than their clinicians (Grason & Misra, 2009; McDiarmid & Gehle, 2006).

The ACOG guidelines state that information on work activity, "including physical stress and chemical exposure," is an essential part of the obstetrical database, and should not only be gathered at the first prenatal visit, but also be reconfirmed at subsequent visits (ACOG, 1977). Despite this recommendation, and the increased attention paid to environmental exposures by the medical community, screening for occupational exposures is still not routinely performed (Genuis, 2006). The ACOG *Ante Partum Record*, a template

for the obstetrical database, already includes history questions about some environmental exposures, including cigarette smoke, alcohol, and medications, but it lacks questions on occupational exposures (McDiarmid et al., 2008). The absence of standardized screening questions for occupational exposures during pregnancy hinders medical providers' ability to incorporate the IOM and ACOG recommendations into practice.

Development of a New Screening Instrument

Theoretical Basis

In an effort to incorporate screening for occupational exposure to reproductive and developmental toxicants into routine prenatal care, a new instrument was developed. *The Pregnancy and Work Questionnaire* is designed to be self-administered by obstetric patients waiting to be seen by their providers for routine prenatal care. The use of self-administered questionnaires has been shown to be a feasible and sensitive screening tool in the context of clinical occupational health (Eskenazi & Pearson, 1988; Rosenstock, Logerfo, Heyer, & Carter, 1984). Eskenazi and Pearson (1988) demonstrated the usefulness of a brief self-administered questionnaire investigating occupational and household exposures to screen pregnant women seen in obstetrics clinic. These results were particularly encouraging in light of previous studies finding that screening instruments completed by the clinician were only inconsistently applied because of time constraints (Eskenazi & Pearson, 1988).

A comparison of a self-administered occupational questionnaire with a gold standard of job-specific personal interview by Blatter et al. (1997) found the questionnaire to be more than 93 to 100% sensitive in detecting exposure to drugs and anesthetics, domestic cleaning agents, and ionizing radiation, and 75 to 83% sensitive in detecting

pesticide exposures. Based on the finding that sensitivity values were higher than positive predictive values, the authors concluded that the self-administered questionnaire was more likely to result in exposure misclassification by over-reporting than by under-reporting. A highly sensitive instrument is desirable in the context of screening for occupational exposures to reproductive and developmental toxicants, in which a false negative, that is, not identifying hazardous exposures, could result in serious and irreversible harms to pregnancy and the health of the offspring, while a false positive could be ruled out with more in-depth screening and consultation with occupational health experts.

Design Process

The Pregnancy and Work Questionnaire was developed in partnership with the Hazard Evaluation System and Information Service (HESIS) of the Occupational Health Branch of the California Department of Public Health and the UCSF Program on Reproductive Health and the Environment (PRHE). The content of *The Pregnancy and Work Questionnaire* was guided by a prototype occupational and hobby questionnaire developed by HESIS for another project (HESIS, 2006). The HESIS prototype focused primarily on chemical exposures, including solvents, degreasing agents, toxic metals, pesticides, cleaners and disinfectants, glues, paints, anesthetic gases, x-rays and radioactive materials.

For this current project, *The Pregnancy and Work Questionnaire* was updated and expanded to include other exposures for which there was strong evidence of adverse reproductive and developmental outcomes. For example, on the suggestion of McDiarmid

(2006) and others, questions about physical conditions, such as prolonged standing and strenuous work, were added to the list of priority exposures.

A defining and novel feature of *The Pregnancy and Work Questionnaire* is its identification of potential exposures through means other than directly asking about specific agents by name. This approach is warranted because workers often have incomplete knowledge of occupational hazards present at their workplace and may not know the specific names of the chemicals they use (ACOG, 1977; Hemminki et al., 1995). This is particularly true of employees working for small employers (Dart, 2004), perhaps because these companies often lack a formalized industrial hygiene program (Sadhra, Petts, McAlpine, Pattison, & MacRae, 2002). It is common for workers to refer to chemicals they use on the job by trade name or composite material name, rather than citing a specific chemical name (Feinberg & Kelley, 1998; Teschke, Kennedy, & Olshan, 1994). Alternatively, workers may describe a chemical in terms of use (e.g., "solvent for cleaning tools") rather than using a specific name (Sadhra et al., 2002; Teschke et al., 1994). Even in cases where workers have access to a MSDS providing adequate ingredient information, workers may not read it, because their past experience has convinced them that MSDS are difficult to understand (Hambach et al., 2010; Sadhra et al., 2002). MSDSs are often written in language at the high school or college level, beyond the reading comprehension of many workers (Wallerstein, 1992).

The question of how to best assess a worker's exposure risk is difficult. Use of job title or industry as a proxy for exposure is a common method employed in epidemiologic studies, because it is an objective, standardized, and reliable measure, however, it does not account for variability in exposures within a given occupational group, which may be

substantial. More information may be gained by supplementing occupation-based questions with workers' own self-reports of exposure (Daniels et al., 2001), for example, in the case of the garden store clerk classified as unexposed by job title but who self-reported exposure to fungicides during fumigation activities. This example suggests that in addition to asking about occupation and self-reported exposure, it may also be useful to ask about specific tasks the worker performs. The use of task-related questions has been recommended by several authors (Blatter et al., 1997; Grajewski et al., 2005; Teschke et al., 1994).

Drawing from these perspectives on question design, *The Pregnancy and Work Questionnaire* used a three-pronged approach to assess the potential for occupational exposures, investigating job title and industry, work-related tasks, and self-report of exposure. Questions assessing potential exposure through hobbies were written with a similar intentional redundancy – hobby-related tasks and activities were asked in addition to self-report of exposure.

In order to identify the jobs, industries, and activities associated with each of the priority exposures, a literature search was conducted using PubMed and ToxNet to gather a body of primary and review papers in occupational epidemiology. Supplemental information was gleaned through examination of ATSDR Toxicological Profiles for specific agents from the priority list. Because data concerning relative rates of exposure by job/industry/task were not identified, determination of which exposure scenarios to include in the questionnaire relied on expert consultation. HESIS and PRHE staff scientists were interviewed and asked to prioritize a list of exposure scenarios according to their expert opinion on the likelihood of each scenario. Exposure scenarios that were assessed to

be substantially likely in a population of working pregnant women were included in the questionnaire.

The Pregnancy and Work Questionnaire uses a combination of open-ended and prompted questions. Open-ended questions can evoke a wider variety of responses than prompted questions but are less likely to be answered (Teschke et al., 1994), thus, a combination of approaches was used in an attempt to maximize both sensitivity and response rate.

An additional focus in developing *The Pregnancy and Work Questionnaire* was ease of use considering both time required to complete and literacy-level. The instrument was designed to be completed in the lobby of an outpatient prenatal clinic, while a patient is waiting to be seen by her provider, and so it is structured to allow completion in approximately 10 minutes. Attention was paid to question wording and layout to make the questionnaire more readable by readers with low literacy. Key design elements included simple language written for 6th grade-level reading comprehension, larger font, increased white space, minimal text, and use of images to illustrate question content.

Questionnaire Structure

Section I of *The Pregnancy and Work Questionnaire* is comprised of open-ended questions enquiring about industry of employment, job title, work-related tasks, and hours per week worked.

Section II consists of two types of prompted questions -- those concerning industry of employment, for which the participant provides a yes or no response to each of the offered options, and those concerning performance of certain job tasks, for which the

participant provides a frequency of performance (every day, some days, or never). Questions in section II are accompanied by illustrations, for example, the question asking about working in the printing industry features an image of a person standing next to a printing press.

Section III of the questionnaire assesses self-report of occupational exposure using open-ended and prompted question formats, with the prompted questions being structured similarly to the job task questions in Section II, that is, there was an illustrated list of chemicals and other agents and three answer choices corresponding to frequency of use (every day, some days, or never). Section III also includes two prompted short-form questions using alternate means of investigating potential chemical exposure, namely whether work involves any contact with chemicals, or whether chemicals are smelled at the workplace. Additional components in Section III relate to access to MSDSs, use of personal protective equipment, and experience of symptoms related to solvent exposure, such as headache (such symptoms have been correlated with increased risk of congenital malformations (Stillerman et al., 2008)).

Section IV of the questionnaire asks about household and hobby-related exposures using illustrated prompted questions asking about the frequency of performing certain tasks or using particular substances, with the option to select every day, some days, or never.

Pretesting in a Target Audience

Pre-testing of *The Pregnancy and Work Questionnaire* was undertaken in the outpatient prenatal care clinic at San Francisco General Hospital in a protocol approved by

IRB. Women were eligible to participate in pilot testing if they were in their first or second trimester of pregnancy, over age 18, able to read and write in English, and had worked at some point during their pregnancy. A small incentive was offered for participation. Six women consented to participate and were provided with the questionnaire to complete while they waited to be seen by their provider. After seeing their provider and filling out the questionnaire, participants met with study staff for a debriefing session, which included a brief history of work and hobbies during pregnancy, as well as retrospective cognitive interviewing in order to test hypotheses about suspected problems particular to each question. Additional feedback was elicited regarding ease of use, time required to complete the questionnaire, and relevance of illustrations used. The results of these pilot interviews were used to make minor modifications to question wording, but did not result in substantive change to the instrument.

Strengths and Weaknesses of the Instrument

In discussing the strengths and weaknesses of *The Pregnancy and Work Questionnaire*, it should be emphasized that the intention of this instrument is for screening rather than diagnostic purposes. Certainly, objective measurement of exposures such as environmental or biological monitoring would greatly increase the accuracy of exposure assessment, however such data points are not available for the typical pregnant patient presenting for routine prenatal visits. Even if they were, using them to make inferences about a given patient's risk of adverse reproductive and developmental outcomes would be overly time consuming and beyond the expertise of the typical clinician. *The Pregnancy and*

Work Questionnaire is an inexpensive and simple tool with which to identify potentially at-risk women, who should then receive further follow-up.

One major limitation of *The Pregnancy and Work Questionnaire* is that under normal clinical use, it will be administered too late to identify harmful exposures early in pregnancy. As discussed earlier, the fetus is most vulnerable to the effects of teratogens early in the first trimester, when a woman may not even realize she is pregnant. The first prenatal visit typically takes place after this vulnerable period (Grason & Misra, 2009). Although it would be too late to prevent exposures that have already occurred, using *The Pregnancy and Work Questionnaire* may still be useful for detecting later exposures with the potential to cause congenital anomalies, spontaneous abortion, pre-term birth, and other adverse outcomes; as such, it remains a valuable tool. Further, if the instrument is found to be feasible in an obstetric population, it may also be useful to screen women who are considering pregnancy in a primary care setting; such an application will be described in the discussion section.

The key strength of *The Pregnancy and Work Questionnaire* lies in its intentional redundancy, through the use of multiple means of assessing exposures, as well as both open-ended and prompted questions. These elements are anticipated to increase the sensitivity of the questionnaire in identifying women at risk for exposures to reproductive and developmental toxicants. The multiplicity of approaches also allows for the calculation of agreement between different question types, providing information on the relative merits of each approach. If agreement between short open-ended questions and long prompted questions is substantial, it may support the inclusion of the former question type in a standardized obstetrical history form, such as the ACOG *Ante Partum Record*.

Future Directions

Clinical Piloting of the Instrument

At the time of writing this thesis, a pilot feasibility study of the instrument in the target population had been recently initiated at the San Francisco General Hospital outpatient prenatal care clinic. This study will enroll 100 women in their first trimester of pregnancy who have worked during their pregnancy. In order to participate, women must be over 18 years old and able to read and write in English. Similar to the conditions of the pretesting, study participants will complete the questionnaire while they wait to be seen by their medical provider for a routine prenatal visit. Women whose responses identify them as being at risk for exposures of concern will receive follow-up care by the UCSF occupational medicine clinic. In order to enhance the capacity of the SFGH prenatal clinic to recognize and manage patients with exposures to developmental and reproductive toxicants, the study will also provide training sessions and educational materials to clinic staff and providers. Demographic data on participants' occupations, hobbies, and risk for exposures will be shared with the clinic with the goals of enhancing knowledge of the prenatal clinic population and improving patient care.

Reliability Testing and Validation of the Instrument

Pending successful piloting, reliability testing should be performed to measure the degree of consistency with which *The Pregnancy and Work Questionnaire* detects exposures of concern. Inter-rater reliability testing between self-reported results and those elicited through oral administration of the questionnaire would provide data necessary to calculate a kappa value. In addition to demonstrating that the instrument is reliable, a high kappa

would support the practice of interviewer administration in cases where this would be more feasible than self-administration, such as when a translator is required. Another aspect of reliability that should be considered is the internal consistency of the instrument. Calculation of Cronbach's alpha for the instrument as a whole, as well as for combinations of questions, would be useful in identifying a more economical question set, of the type that could be included on standardized medical record forms (e.g., the ACOG *Ante Partum Record*). Alternatively, factor analysis could be used to assess the instrument for domains using the eigenvalue calculations.

Validation of the instrument would depend on its comparison to a gold standard method of exposure assessment. Monitoring of the work environment (e.g., area sampling, personal monitoring, wipe samples) would be the most accurate means of determining worker exposures; however, this might not be a feasible approach in the clinic-based population for which *The Pregnancy and Work Questionnaire* was developed, given the large number of work sites to be monitored. Exposure assessment via examination of biological media ('biomonitoring') may be better suited to a clinical population and could potentially be completed during the same visit at which the questionnaire is completed. Unlike environmental monitoring, biomonitoring provides information about internal dose, the amount of a toxicant actually reaching the pregnant woman's body. (Note that fetal cord blood, amniotic fluid, or placental tissue sampling could provide further information about the amount of a toxicant reaching the fetus.)

Despite a strong rationale for using biomonitoring as a gold standard, certain limitations must be considered. The key restriction is that well-validated biomarkers do not exist for all exposures of interest, leaving parts of the questionnaire without an external

comparison measure. Biomonitoring is also very costly and involves invasive procedures to collect biological specimens. Further, biomonitoring does not provide information on the source of exposures, so it is possible that a woman exposed outside of work would be detected in the biomonitoring validation phase but not in the initial screening with the questionnaire. Additionally, toxicokinetic variability of the agents assessed by *The Pregnancy and Work Questionnaire* complicates timing of specimen collection and interpretation of biomonitoring results, as each substance is differentially cleared from the body. While maternal blood and urine specimens could be collected during critical early pregnancy periods, collection of cord blood or amniotic fluid would have to occur at birth and would not reflect earlier exposures to substances that are short-lived in the body.

Translation of the Questionnaire into Other Languages

Translation of the questionnaire into other languages would broaden the reach of the instrument to non-English speaking populations. Any effort to translate should include an iterative process of forward and back translation and additional pretesting of the translated instrument in the target population to ensure that the instrument retains validity.

Discussion and Policy Implications

The existence of a validated instrument for detecting exposure to reproductive and developmental toxicants would have several important ramifications. First, it would have the potential to improve medical care of pregnant women by improving the detection of exposure to reproductive and developmental toxicants. *The Pregnancy and Work*

Questionnaire also has applications beyond the obstetrics clinic -- a modified version could be employed in the primary care clinic as a tool for preconception screening. This would permit early detection of exposures, reducing the risk of exposures during organogenesis early in the first trimester, before a woman realizes she is pregnant or is able to be seen by her obstetrician. Screening in the primary care setting may also help to limit exposure to persistent chemicals, another potential source of fetal exposure.

Preconception care has been articulated as a priority by professional organizations such as ACOG and the American Academy of Pediatrics, as well as The Centers for Disease Control and Prevention (Atrash, Jack, & Johnson, 2008; Jack et al., 2008), yet it has not become part of routine clinical practice due to the limited availability of consensus-based guidelines and uniform tools for health assessment (Frazier & Jones, 2000). *The Pregnancy and Work Questionnaire* represents an early step in the movement towards greater clinical awareness of reproductive and developmental hazards in patients' work and home environments.

Beyond improving clinical practice, *The Pregnancy and Work Questionnaire* can serve an important role in data collection. As healthcare systems increasingly embrace electronic medical records, there is great potential for improvements in health outcomes research. Patient data gathered through validated risk assessment tools like *The Pregnancy and Work Questionnaire* can be linked to long-term outcomes such as development of chronic disease or healthcare services utilization, enhancing the understanding of predictors of population health and wellbeing.

Ultimately, however, improvements in clinical practice and research capacity fall short in achieving the goal of protecting the health of the next generation. Fully achieving this end will require meaningful improvements in public policy relating to chemicals production and worker safety. As use of *The Pregnancy and Work Questionnaire* and other similar instruments becomes widespread, clinicians, researchers, and public health practitioners will become increasingly familiar with issues surrounding preconception and prenatal environmental exposures, and will be in a position of strength with which to advocate for better public policy and social change.

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Appendix: Pregnancy and Work Questionnaire

1. **How many jobs have you had since you became pregnant?** _____

2. **What kind of businesses or industries have you worked at since you became pregnant?** For example, a restaurant, a grocery store, a nail salon, a house cleaning service. **Do you work there now?**

   Job #1: _____ ☐ I work there now

   Job #2: _____ ☐ I work there now

   Job #3: _____ ☐ I work there now

   Job #4: _____ ☐ I work there now

3. **What is name or title of your job or jobs?**

   Job #1:_____

   Job #2:_____

   Job #3:_____

   Job #4:_____

4. **What kind of work or activities do you do at the jobs you have had since you became pregnant?**

Job #1:_____

Job #2:_____

Job #3:_____

Job #4:_____

5. **How many hours per week do you work at these jobs?**

Job #1:_____

Job #2:_____

Job #3:_____

Job #4:_____

6. **Since you became pregnant, have you worked in any of these businesses or industries?**

Janitor or house cleaning ☐ No ☐ Yes 	Gas station ☐ No ☐ Yes 
Hair salon ☐ No ☐ Yes 	Construction ☐ No ☐ Yes 
Nail salon ☐ No ☐ Yes 	Healthcare or dentist ☐ No ☐ Yes 
Dry cleaning ☐ No ☐ Yes 	
Car or truck repair ☐ No ☐ Yes 	Science lab ☐ No ☐ Yes 

Farm or plant nursery

☐ No
☐ Yes

Electronics or semiconductor manufacturing

☐ No
☐ Yes

Yard work, landscaping or grounds keeping

☐ No
☐ Yes

Hazardous waste

☐ No
☐ Yes

Printing company

☐ No
☐ Yes

Plastic products or manufacturing

☐ No
☐ Yes

Chemical plant

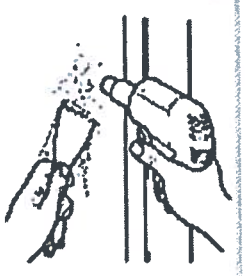
☐ No
☐ Yes

Other kind of factory

☐ No
☐ Yes

What kind of factory? _____

7. **Since you became pregnant, how often have you done these activities at your job?**

Clean floors, counters, sinks, or toilets ☐ Every day ☐ Some days ☐ Never 	Lift, push or pull heavy things ☐ Every day ☐ Some days ☐ Never 
Stand for a long time ☐ Every day ☐ Some days ☐ Never 	Use, make or handle pesticides ☐ Every day ☐ Some days ☐ Never 
Work with glues or adhesives ☐ Every day ☐ Some days ☐ Never 	Welding ☐ Every day ☐ Some days ☐ Never 
Degrease tools, machines or electronics ☐ Every day ☐ Some days ☐ Never 	X-ray, CT, radiotherapy, nuclear medicine ☐ Every day ☐ Some days ☐ Never 
Mix, thin or apply paints, varnish, finish, seals or lacquers ☐ Every day ☐ Some days ☐ Never 	Remove or strip paint ☐ Every day ☐ Some days ☐ Never 

8. **Since you became pregnant, have you come into contact with any chemicals at your job?**

   ☐ No
   ☐ Yes
   ☐ Don't know

9. **Since you became pregnant, have you smelled chemicals at your job?**

   ☐ No
   ☐ Yes
   ☐ Don't know

10. **Do you know where to find the Material Safety Data Sheets for chemicals that are used at your job?**

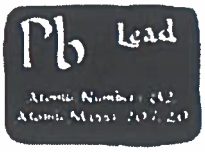
    (Material Safety Data Sheets give information about chemicals. They are also called MSDS for short.)

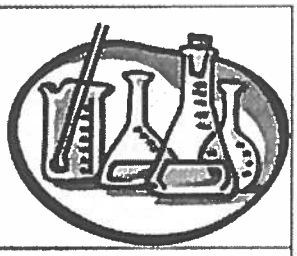
    ☐ No
    ☐ Yes
    ☐ Doesn't apply. Please explain why: _____

    _____

    _____

11. Since you became pregnant, how often have you used these chemicals at your job?

Janitorial chemicals or cleaners ☐ Every day ☐ Some days ☐ Never 	Solvents ☐ Every day ☐ Some days ☐ Never 
Dry cleaning chemicals ☐ Every day ☐ Some days ☐ Never 	Paint ☐ Every day ☐ Some days ☐ Never 
Nail polish remover ☐ Every day ☐ Some days ☐ Never 	Paint stripper, remover or thinner ☐ Every day ☐ Some days ☐ Never 
Pesticides ☐ Every day ☐ Some days ☐ Never 	Lead ☐ Every day ☐ Some days ☐ Never 
Glues or adhesives ☐ Every day ☐ Some days ☐ Never 	Mercury ☐ Every day ☐ Some days ☐ Never 

Degreasers ☐ Every day ☐ Some days ☐ Never 	**Laboratory chemicals** ☐ Every day ☐ Some days ☐ Never 
Ethylene oxide ☐ Every day ☐ Some days ☐ Never 	**X-rays** ☐ Every day ☐ Some days ☐ Never 
Nitrous oxide ☐ Every day ☐ Some days ☐ Never 	**Radioactive materials** ☐ Every day ☐ Some days ☐ Never 
Anesthesia gases ☐ Every day ☐ Some days ☐ Never 	**Other chemical or metal** Describe:_____ ☐ Every day ☐ Some days ☐ Never

12. **Since you became pregnant, have you had any of these symptoms at your job?**

Headache
- ☐ No
- ☐ Yes

Itchy or teary eyes
- ☐ No
- ☐ Yes

Sneezing or bloody nose
- ☐ No
- ☐ Yes

Coughing or sore throat
- ☐ No
- ☐ Yes

Hives, rash, or itchy skin
- ☐ No
- ☐ Yes

Dizziness
- ☐ No
- ☐ Yes

Nausea
- ☐ No
- ☐ Yes

Vomiting
- ☐ No
- ☐ Yes

Other symptom
- ☐ No
- ☐ Yes - Describe: _____

_____

13. **Do you think these symptoms are linked to your work environment?**
- ☐ No
- ☐ Yes
- ☐ I don't have symptoms

14. **Do these symptoms go away when you are home or away from your job?**
- ☐ No
- ☐ Yes
- ☐ I don't have symptoms

15. **Do the people you work with have any of these symptoms?**
- ☐ No
- ☐ Yes
- ☐ Don't know
- ☐ I don't have symptoms

16. Do you use any of these safety tools at your job?

Gloves
- ☐ No
- ☐ Yes

Protective clothing
- ☐ No
- ☐ Yes

Respirators or masks
- ☐ No
- ☐ Yes

Lab hood
- ☐ No
- ☐ Yes

Air vents or fans
- ☐ No
- ☐ Yes

Other tool
- ☐ No
- ☐ Yes – Describe: _____

_____

17. Do you have any concerns about your job and your health?

- ☐ No
- ☐ Yes

If yes, please tell us about your concerns:

_____

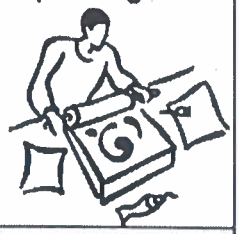
_____

_____

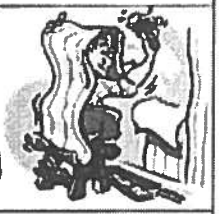
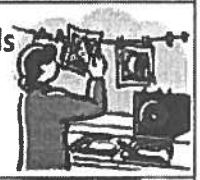
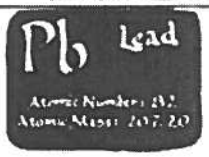
Hobbies and Activities:

The next 2 questions are about your hobbies and activities.

1. **Since you became pregnant, how often have you done these activities outside of your job?**

Paint or use paint thinners or strippers ☐ Every day ☐ Some days ☐ Never 	Soldering ☐ Every day ☐ Some days ☐ Never 
Repaint or refinish furniture ☐ Every day ☐ Some days ☐ Never 	Silkscreen or other art printing ☐ Every day ☐ Some days ☐ Never 
Ceramics or pottery ☐ Every day ☐ Some days ☐ Never 	Car or machine repair ☐ Every day ☐ Some days ☐ Never 
Welding ☐ Every day ☐ Some days ☐ Never 	Other hobby Describe: _____ ☐ Every day ☐ Some days ☐ Never

2. Since you became pregnant, how often have you used these chemicals outside of your job?

Nail polish or nail polish remover ☐ Every day ☐ Some days ☐ Never 	Paint stripper, remover or thinner  ☐ Every day ☐ Some days ☐ Never
Spray cleaner  ☐ Every day ☐ Some days ☐ Never	Glues or adhesives   ☐ Every day ☐ Some days ☐ Never
Other cleaner  ☐ Every day ☐ Some days ☐ Never	Photography chemicals  ☐ Every day ☐ Some days ☐ Never
Pesticides or weed killer  ☐ Every day ☐ Some days ☐ Never	Lead  ☐ Every day ☐ Some days ☐ Never
Solvents  ☐ Every day ☐ Some days ☐ Never	Cadmium  ☐ Every day ☐ Some days ☐ Never
Degreasers  ☐ Every day ☐ Some days ☐ Never	Paint  ☐ Every day ☐ Some days ☐ Never
Other chemical or metal Describe: _____	