



Health and the Environment: The Vulnerability of Female Populations

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From science to health

Inserm Ethics Committee

**«Gender
and Health
Research»
Group**

**Health and the
Environment:
The Vulnerability of
Female Populations**

November 2020

Health and the Environment: The Vulnerability of Female Populations

Memo by the Inserm Ethics Committee
Gender and Health Research group

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Contents

1. Introduction

Health and the environment: the case of women

2. The exposome in environmental health research programs

3. Exposome and vulnerability of female populations

3.1 Women and the *Early-life exposome*

3.1.1 The risks of the physical and chemical environment to pregnant women

3.1.2 Working environment and risk factors for pregnant women

3.2 Women and the *Working-life exposome*

3.2.1 Occupational risks and arduousness of work

3.2.2 Economic insecurity and health

3.2.3 Household and family workloads, domestic violence

3.2.4 The European measures for women's occupational health and safety

3.3 Women and COVID-19

3.3.1 Sex-based differences in COVID-19 mortality

3.3.2 COVID-19 and lockdown: the health and social fallout

3.3.3 Women and COVID-19: mobilization in France and abroad

4. Conclusion and perspectives

5. Bibliographic references

1. Introduction

Health and the environment: the case of women

The impact of the environment on human health has been the subject of major mobilization by research institutes and public authorities. According to the World Health Organization (WHO), 23% of deaths worldwide and around one quarter of chronic diseases can be attributed to environmental factors (see *The Lancet Commission on Pollution and Health*, Landrigan 2017).

In France, the Public Health Law of August 9, 2004 stipulates that a *Plan National Santé Environnement* [National Environmental Health Action Plan] (PNSE) be implemented every five years. The third such plan, PNSE3 (2014-2018) made an inventory of the health challenges posed by many illnesses related to the environment, such as cancer, as well as reproductive, metabolic, allergic, infectious, and neurodegenerative diseases.

In 2019, a group of experts from Inserm wrote a report entitled *Préfiguration du volet recherche du 4ème Plan National Santé Environnement* [Preliminaries on the Research Component of the 4th National Environmental Health Action Plan] (PNSE4). This report expands on the recent concept of the **exposome**, which is defined as every exposure (chemical, physical and biological) to which an individual is subjected from conception to adulthood, incorporating the psychosocial and economic factors linked to working and living conditions (Barouki 2018, Wild 2012).

With this in mind, consideration must be given to **sex-based aspects** in this field of research. Women and men are exposed to health risks differently through their living, social, cultural, and economic conditions. Environmental pollutants (physical, chemical, and microbiological), exposures related to occupational and domestic activities impact the health of women and men differently. These situations lead to social health inequalities and call for reflection from the ethical point of view.

Paradoxically, despite the importance of these issues in terms of public health, sex-based data remain rare in the majority of environmental health studies, as do studies that question the interactions between sex and gender. In particular, research into the environmental risks that more specifically affect the health of women (pregnancy, working and living conditions) remains insufficiently developed.

In order to address these issues, research on the exposome should be expanded by cross-referencing the themes of “health-environment”, “health-work” and “health-sex”.

We have identified three areas in which women’s health is under particular threat in the face of the environmental risks in their broad sense:

- The specific vulnerability of pregnant women to toxic environmental agents and the impacts on fetal and child development.
- Working conditions, economic insecurity, domestic and family workloads, violence, and their impacts on women’s health.
- The health situation of women in the face of the COVID-19 crisis.

This memo by the Inserm Ethics Committee Gender and Health Research Group builds on our 2019 statement of intent that was aimed at giving an overview of research into “Gender, Occupational Health and the Environment” conducted in France, North America, and Europe.

This 2020 memo has been enriched with new data and insights following interviews with experts specialized in fields of health in relation to the environment, work, and gender.

We would like to warmly thank the experts interviewed by the Ethics Committee in 2019-2020.

- Francelyne Marano: Honorary President of the French Society of Environmental Health (SFSE), member du French High Council for Public Health (HCSP) and Emeritus Professor of cellular biology and toxicology Paris Diderot University.

- Emilie Counil: Staff scientist at the French Institute for Demographic Studies (INED), RU5 “Mortality, Health and Epidemiology”. Research fellow at the Interdisciplinary Institute of Social Issues (IRIS, EHESS, PU13, Inserm).

- Bernard Jégou: Emeritus Director of the French Research Institute for Environmental and Occupational Health (IRSET, JRU 1085, Rennes) and research director at the French School of Public Health (EHESP).

- Florence Chappert: “Gender, Equality, Health and Working Conditions” project leader at the French National Agency for the Improvement of Working Conditions (ANACT).

2. The exposome in environmental health research programs

The 4th National Environmental Health Action Plan (PNSE4), entitled *Mon environnement, ma santé (2020-2024)* [My Environment, My Health (2020-2024)], is being co-led by the French Ministries of Ecological Transition and Health. It was made public in 2020 (<https://solidarites-sante.gouv.fr/sante-et-environnement/les-plans-nationaux-sante-environnement>).

This action plan is centered around four major pillars:

- Research to improve knowledge of the exposures and effects of the environment on health.

- Informing and training professionals and citizens for an environmental health prevention policy.

- Reducing the environmental exposures that affect health. Endocrine disruptors and air quality are priority themes.

- Increasing concrete measures implemented in the territories and mobilizing public policies in favor of environmental health.

The common denominator of the aforementioned pillars is the concept of the **exposome**, defined as the integration over the course of a lifetime of the totality of exposures that can influence human health. Proposed in 2005 by epidemiologist Christopher P. Wild, this concept has been incorporated in all US National Institute of Environmental Health Sciences (NIEHS) Strategic Plans since 2012 (www.niehs.nih.gov/strategicplan). In France, the concept was first introduced in 2015 in the 3rd National Environmental Health Action Plan. In 2016, it features as key health policy element in the Health System Modernization Law (2016-41 of January 26, 2016).

The objective associated with the exposome concept is to supplement knowledge on the human genome through the exploration of every exposure (chemical, physical, and biological) to which an individual is subjected from conception to adulthood, incorporating the psychosocial and economic factors related to working and living conditions (Barouki 2018, Wild 2005, 2012). Understanding the exposome requires the consideration of many parameters, such as chemical hazards (pollutants, fine particles, indoor and outdoor air, water, soil) and also many other factors: food and drink, everyday objects (toys, cosmetics, cashier's receipts), use of medication, standard of living, working conditions, stress, physical activity, microbial infections, noise and light pollution, climate change, effects of radiation, etc. The challenge resides in considering the multidimensional nature of the exposures, their interactions and effects over time, from conception to adulthood.

Evidently, studying the impact of the exposome on our bodies is an eminently ambitious project that requires the mobilization of considerable resources to collect and process the various physical, chemical, biological, epidemiological, sociological, economic, etc., data. This is the challenge that many research programs wish to take up.

Launched in February 2020 was the *European Human Exposome Network* (<https://www.humanexposome.eu/>) funded by the Horizon 2020 program. Out of the 9 proposed calls for projects, 5 include the active participation of French teams (Inserm, National Center for Scientific Research – CNRS, National Agency for Food, Environmental and Occupational Health and Safety – ANSES, university hubs, National Institute for Industrial Environment and Risks – INERIS, etc.).

Two flagship projects address the issues that relate to women's health:

- The ATHLETE **Early-life exposome** project is aimed at measuring environmental exposures during pregnancy, childhood and adolescence and their effects on health (<https://www.humanexposome.eu/portfolios/athlete/>)
- The EPHOR **Working-life exposome** project focuses on the cumulative effects of work-related exposures in the professional and domestic spheres (<https://www.ephor-project.eu/>)

These projects build on previous research programs whose results highlighted not just the vulnerability of certain female populations, but also the lack of solid documentation to attempt to remedy this.

These issues are expanded on in the following sections of this report.

3. Exposome and vulnerability of female populations

3.1 Women and the *Early-life exposome*

3.1.1 The risks of the physical and chemical environment to pregnant women

In 2005, the WHO had already drawn attention to air pollution and its effects on pregnancy and the fetus. Some studies suggested the implication of fine particles in premature births, low birth weight and infant mortality. But how can cause and effect be established

without considering the socioeconomic context? How can the long-term impacts of fetal exposure during pregnancy be demonstrated? These questions illustrate the complexity of the task and the importance of mobilizing numerous research programs to study the various exposome factors and monitor their health impacts over time.

The priority themes of the PNSE4 include research on **endocrine disruptors** which has been the subject of a national strategic plan (SNPE) since 2014 (<https://www.ecologique-solidaire.gouv.fr/strategie-nationale-sur-perturbateurs-endocriniens>).

In the second strategy for the 2019-2022 period, emphasis is on the protection of populations, particularly people of reproductive age, pregnant women, as well as children and adolescents.

Findings from several previously launched research programs on the exposome, endocrine disruptors, and environmental pollutants are gradually becoming available as the huge volumes of data collected are processed.

Here are some examples:

- The European project HELIX (2013-2017) in which many French teams are participating: Inserm, CNRS, Grenoble University, French Agency for Ecological Transition – ADEME, ANSES, etc. (<http://www.projecthelix.eu/index.php/fr/qui-sommes-nous>).

The objective of this project is to develop tools to estimate pre- and post-natal exposures to environmental factors (heavy metals, pesticides, air and water pollutants, noise, diet, etc.). All in all, exposures to **130 toxic agents** were studied in cohorts from six European countries (3600 mother-child pairs), in order to analyze their effects on child health, growth, and development.

The initial publications show that pre- and post-natal exposure to different chemical pollutants is associated with delayed fetal growth, decreased respiratory function in children, and the development of obesity.

- Other related research programs are ongoing that concern more specifically the effects of *air pollution*. The projects MOBILAIR and SEPAGE (funded by the European Union) are studying the impact of exposure to fine particles during pregnancy on child health and development (respiratory and cardiovascular diseases, brain function). The study is being conducted in the Grenoble region on a cohort of 700 couple-child trios enrolled in early pregnancy and followed over a period of several years. One of the merits of this project is that it brings together researchers from many disciplines: biologists, epidemiologists, economists specializing in transport and the environment, geographers, sociologists, etc. (<https://mobilair.univ-grenoble-alpes.fr/organisation-du-projet/wp1-des-sources-de-pollution-aux-impacts-sanitaires/wp1-des-sources-de-pollution-aux-impacts-sanitaires-743732.htm>).

These research programs (and many others) reflect the worrying context revealed by French biomonitoring survey ESTEBAN (2014-2016), whose initial findings were published in 2019 by Public Health France (<https://www.santepubliquefrance.fr/etudes-et-enquetes/esteban/les-resultats-de-l-etude-esteban>). The survey was conducted on a sample of 1104 children and 2503 adults, representative of the general population. It shows that everyday pollutants are present in the bodies of all of the adults and children, often with higher levels of impregnation in children. These pollutants particularly include bisphenols, phthalates, solvents, parabens, qualified for the most part as known or suspected endocrine disruptors or carcinogens. This survey establishes, for the first time, reference values of impregnation in the general population. These data are valuable for monitoring their evolution over time, for correlating them with the various sources of exposure (household cleaning products, cosmetics, food packaging, indoor air) and for estimating their health impacts. The results are in the process of being published.

It must be remembered that for the moment there is no official list of the endocrine disruptors found in everyday consumer products due to the lack of adoption at international level of a definition of the concept of endocrine disruptor in the regulatory texts (<https://www.anses.fr/fr/content/les-perturbateurs-endocriniens>).

It is one of the issues raised in the [report](#) requested by the European Parliament and produced by two French scientists: Barbara Demeneix (CNRS/French National Museum of Natural History – MNHN) and Rémy Slama (Inserm/University of Grenoble), ([https://www.europarl.europa.eu/RegData/etudes/STUD/2019/608866/IPOL_STU\(2019\)608866_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2019/608866/IPOL_STU(2019)608866_EN.pdf)).

The report, published in March 2019, presents the scientific evidence of the health effects of endocrine disruptors and highlights the gaps in the European regulations when it comes to identifying them in many sectors of everyday life. Following this report, the European Commission undertook to formulate proposals to bridge the regulatory gaps and support research into endocrine disruptors within the framework of the Horizon 2020 program (https://www.europarl.europa.eu/doceo/document/B-8-2019-0241_FR.html).

In this context, the French Agency for Food, Environmental and Occupational Health and Safety (ANSES) published, in March 2020, the conclusions of its expert report on the endocrine disruptive properties of Resorcinol. This substance (a bisphenol) is used in industry, cosmetics, food products and pharmacy. The report shows that Resorcinol impairs thyroid function, leading to harmful effects, particularly in pregnant women. Resorcinol is liable to trigger or worsen hypothyroidism which can interfere with the brain development process in unborn children. These scientific arguments make it possible to put forward Resorcinol as a known endocrine disruptor, which could, in time, lead to the banning of its use in the European Union, (<https://www.anses.fr/fr/system/files/REACH2018SA0110.pdf>).

Evidently, much remains to be done when it comes to evaluating and preventing the health risks of everyday environmental pollutants during the critical periods of pregnancy and pre- and post-natal development.

Added to that are the workplace-related health hazards that can constitute risk factors for pregnant women.

3.1.2 Working environment and risk factors for pregnant women

Nowadays, a large majority of women work during pregnancy. Nowadays, a large majority of women work during pregnancy. The percentage of women working during pregnancy has continued to increase, from 51% in 1972 to 67% in 2010 and 71% in 2016 (Inserm/DRESS National Perinatal Survey, <http://www.xn--epop-inserm-ebb.fr>).

The accumulation of the physical constraints of the job (noise, heat, working in a standing position, load-handling), organizational constraints (duration of work, night shifts), and psychosocial factors can lead to pregnancy complications (premature birth, low birth weight). Women often encounter difficulties reconciling pregnancy and work, particularly in jobs that involve risks, such as in the mass retail sector. In the absence of rearranged working conditions (nature of work, hours, breaks) or the possibility to be temporarily assigned to a role more compatible with pregnancy, pregnant women are often signed off work by their primary doctor as a precautionary measure. This early withdrawal from the workplace, which can result in loss of income, represents an injustice for women who wish to continue to work but whose employer is unable to eliminate the health risk factors at their source.

There is a specific legal framework (<https://www.anact.fr/>) devoted to the occupational situation of pregnant women as well as provisions for their protection. Where there is exposure to mutagenic or toxic chemical agents, the employer is obliged to inform female employees of the potentially harmful effects on fertility, early fetal development and for the child should the mother choose to breastfeed. Women must be made aware of the necessity to declare their pregnancy as soon as possible.

3.2 Women and the *Working-life exposome*

The term **Working-life exposome** concerns the study of the cumulative effects of the exposures related to work in the professional and domestic contexts (<https://www.eplor-project.eu/>).

3.2.1 Occupational risks and arduousness of work

Over the past ten years, various surveys (SUMER, RNV3P, SIP) conducted in France have revealed major differences between women and men in exposure to occupational risks. One primary cause lies in the segregation of occupations. Men, who account for the majority of industry and construction workers, have health risks related to asbestos, diluent solvents, carrying heavy loads, noise, etc. Women, who account for the majority of workers in the retail, service, and care industries, are exposed to the pollutants contained in cleaning products, cosmetics, cash register receipts (bisphenol A), etc. But the differences in risk exposure are not restricted to physical and chemical environmental factors. They also concern those related to working arrangements and constraints that affect women and men differently (see research by the French Research Institute for Environmental and Occupational Health-IRSET- , (<https://www.irset.org/>))

Occupational health under surveillance

- **RNV3P**: The French National Network for the Monitoring and Prevention of Occupational Diseases (RNV3P), created in 2001, is an offshoot of the Occupational Disease Clinics (CCPPs), structures integrated within the university hospitals (CHUs). Thirty-two such clinics across mainland France are participating in the network. The aim of RNV3P is to look for links between harmful occupational exposures and illnesses diagnosed in patients who consult the CCPPs.

- **SUMER** (2003-2010): French Survey on Medical Surveillance of Occupational Risk Exposures. This survey, co-led by the French Directorate for Research, Studies and Statistics (DARES) and the General Directorate for Labor (DGT), describes the organizational constraints, the physical, biological, and chemical occupational exposures to which employees are subject (dares.sumer2009@dares.travail.gouv.fr).

- **SIP**: French Health and Labor Market Histories Survey (2006-2010).

The survey designed by the French Directorate for Research, Studies, Assessment and Statistics (DREES) and DARES explores the links between health problems, professional background, and the physical and organizational conditions of work.

The risk factors and arduousness of work done by women are largely underestimated, in light of the surveys conducted by the French National Agency for the Improvement of Working Conditions (ANACT, <http://www.anact.fr>). Indeed, a hierarchy exists in the representations of risks associated with various occupations (Chappert, 2016, 2017). Greater attention is paid to the difficulties of male work associated with intense physical effort, carrying heavy loads, noise, etc. However, the mainly female occupations are generally considered easier and less dangerous: a view that contradicts the reality of difficulties linked to many female occupations (Messing 2014). This is the case of the overexposure of women to repetitive weight carrying, which particularly affects nurses, home care employees, checkout operators, manual workers, etc. These are all occupations in which loads often exceed the 25 kg French Labor Code limit for women.

Musculoskeletal disorders more common in women

The WHO defines musculoskeletal disorders (MSDs) as diseases for which the work and the environment in which it is performed contribute significantly, but not totally, to their multifactorial etiology.

Women are at greater risk of MSDs (54%) than men (46%), across all socio-professional categories. Roles within the sectors of cleaning, home care, and retail (checkout operator), in which women are overrepresented, are particularly conducive to repetitive movements of the limbs and back, as well as to uncomfortable and repetitive positions. The severity index of the MSDs affecting women is higher than that of men across all of the occupations. It is three times higher in the categories most confronted with economic insecurity, namely non-executive staff and manual workers (Chappert 2017, Roquelaure 2018).

In several European countries, MSDs are the most common occupational diseases. In France, lower back pain and MSDs of the limbs represented 87% of the occupational diseases recognized by the country's social security regime in 2017 according to an annual report (*Rapport annuel 2017. L'Assurance Maladie - Risques professionnels*).

However, these statistics do not fully reflect the reality due to the considerable under-reporting of MSDs, an observation that is not restricted to France. Among the reasons for under-reporting, one major factor is the refusal of the worker out of fear of losing his or her job (Rivière 2018). This attitude is more common in employees on short-term contracts than in those on permanent contracts, meaning that women are particularly concerned (Roquelaure 2018).

Occupational cancer under-evaluated in women

Surveys by GISCOP93 (a scientific interest group on occupational cancer in France's Seine-Saint-Denis region) have shown that epidemiological studies on exposure to carcinogens contained bias and prejudice relating to the occupational risks to which men and women are exposed.

One notable bias is the limited number of studies on the etiology of occupational cancer in women (Council 2014, Hohenadel 2015). A review of the literature on lung cancer between 2003 and 2014 showed that the carcinogenic risks remained largely understudied in women (2.9% of the studies) compared with men (55.6%), irrespective of industry (Betansedi, 2016, 2018).

Another example is the absence of epidemiological studies on carcinogens in the cleaning sector, in which women account for the majority of the workers. A toxicological analysis of the contents of a trolley used by female office cleaners revealed the presence of 14 carcinogens. Yet these products are used without any particular information or protection given to employees (Cavet 2013, Nicot 2014).

It can therefore be seen that in many occupational health epidemiology publications, the authors tend to generalize the results obtained from studies conducted only in men. It should be noted that the ongoing European survey *Exposome, Inheritance, Cancer and Health*, with which Inserm is associated, contains a women's health component (the E3N-E4N cohort). The objective is to improve understanding of the environmental and genetic risk

factors of common chronic diseases, such as cancer (<https://www.gustaveroussy.fr/fr/exposome-heredite>).

Psychosocial risks more common in women

Psychosocial risks are defined as work-related risks to physical and mental health. Their causes can be employment conditions, factors linked to work organization and workplace relationships. These risks are more common in predominantly female occupations: low-qualified roles, non-traditional working hours, piecemeal work, lack of autonomy, career breaks and discontinuities, etc. (Nicot 2014).

Added to this are factors of “emotional tension” in occupations in which human relationships are a major factor: retail, tourism, service-industry, receptionist, teaching, nursing, and caring roles. Such jobs, mostly done by women, expose them to tense situations with the general public, urgent demands, sexist remarks, etc. A poll conducted by IFOP in 2014 for France’s Defender of Rights (<https://www.ifop.com>) shows that workplace sexual harassment is no marginal phenomenon. It affects 20% of working women, i.e. one in five, during their working lives. Only 5% lodge a formal complaint.

In 2018, the Pierre Deniker Foundation published the results of a vast epidemiological study representative of the French working population (n=3200) on the links between work-related psychosocial risk factors and psychological distress veering towards mental illness (depression, addiction, etc.). The results showed that 22% of workers present risks of tipping from discontent and malaise into actual mental illness and among them 26% of women and 19% of men (<https://www.fondationpierredeniker.org>).

It must be stressed that mental health disorders are still not included in the registry of tables of occupational illnesses recognized by the French social security regime. The shortcomings of this system are for the most part responsible for the lack of visibility of some psychosocial risks to mental health of which women are the primary victims.

3.2.2 Economic insecurity and health

People in situations of economic insecurity cumulate social and economic difficulties that impact physical and psychological health and impede access to healthcare. Precarious living conditions have the corollary of increased health risks compared to the general population: substandard housing, poor diet, lack of physical activity, difficult and unstable nature of work. Substandard housing can cause or worsen many diseases: poisoning from lead paint, respiratory diseases linked to humidity, infectious diseases promoted by unsanitary living conditions, and so on. Added to that a deterioration in lifestyle linked to poor diet, alcohol and tobacco consumption, and lack of physical activity – all these factors promote obesity, diabetes, cardiovascular diseases, depression, etc. It thus follows that lack of financial resources is one of the primary reasons for forgoing healthcare (Cambois 2019, Lang 2010).

Women currently account for the majority of those living in precarious conditions (see the 2017 report by the French High Council for Equality (HCE) entitled, *Santé et accès aux soins : une urgence pour les femmes en situation de précarité [Health and Healthcare Access: An Emergency for Women Living in Precarious Conditions]*).

- Women account for 70% of all impoverished workers, hold 82% of all part-time jobs and represent 85% of all single-parent families – one in three of which is living below the poverty line. Obesity is much more common in women in experiencing economic insecurity (35%) than in men in the same situation (17.6%). Among women who have low incomes and receive supplementary health coverage (*Couverture Maladie Universelle Complémentaire – CMU-C*), 15% are overweight compared to 9% of the general population.

- Female manual workers present a cardiovascular mortality rate that is three times higher than for female executives, due to the increased risk related to lifestyle, less frequent screenings, and delayed treatment. The women most confronted with economic insecurity are by far the most affected by musculoskeletal disorders. The frequency rate of such disorders in female manual workers is 8.4 per million working hours versus 2.4 for male manual workers (Chappert 2017, Roquelaure 2018).

- Working nights is a known risk factor in the development of breast cancer, as was recently demonstrated in an international study conducted by a team from Inserm (Cordina-Duverger 2018). The risk is 26% higher in women having worked nights compared to those working days. Women in a situation of economic insecurity for whom working nights is more common are the most exposed: 14% of female manual workers usually or occasionally work nights versus 8% of executives (Menegaux 2013). More generally, women in economically insecure situations attend screenings for specific female cancers less often and survive them less often.

It must be noted that many environmental health studies and action programs do take into account the vulnerability of populations of low socioeconomic status. However, very rare are the reports that extend their analysis to include the situation of women who continue to remain the primary victims of economic insecurity.

3.2.3 Household and family workloads, domestic violence

The arduousness of women's working conditions and their psychosocial components are indissociable from the everyday context of domestic and family life. Reconciling it all is a mental burden that falls mainly to women (Cambois 2019, Lang 2010). Women for the most part have the burden of domestic tasks and parenting – including when they work. Following a separation, more women live in single-parent households, with lower incomes than men. As they get older, they are also more likely than men to care for relatives with reduced autonomy, with the consequent risk of burn-out (Bihan-Youinou 2006, Pinquart 2006, <http://www.lamaisondesaidants.com>).

The various events that punctuate the social and private lives of women can have negative consequences on their health, particularly with marked risks of developing anxiety and depression (Biotteau 2018, Cambois 2017). Domestic violence and sexual violence constitute a major risk to women's health: traumatic and gynecological injuries, psychiatric and psychosomatic disorders, sleep and eating disorders, anxiety, depression, post-traumatic stress disorder, addiction, suicidal ideation, etc. (Campbell 2002, Garcia-Moreno 2011, HCE 2020 report on domestic violence, (<https://www.haut-conseil-egalite.gouv.fr/IMG/pdf>)).

In 2019, according to the French National Observatory of Violence Against Women, 213,000 women were the victims of physical and/or sexual violence by their partner or an ex-partner: 25% consulted a doctor, 19% a psychiatrist/psychologist, 12% social services, 7% met with members of a victim support association and a similar number called a toll-free helpline. Nevertheless, over half of the victims (55%) did none of these things. In the same year, 146 women were killed by their partner or by an ex-partner (<https://stop-violences-femmes.gouv.fr/lettre-no14-violences-au-sein-du.html>).

Doctors, who are often the first points of contact of women who are victims of violence, before the police or social workers, are insufficiently trained in detecting signs of violence.

3.2.4 The European measures for women's occupational health and safety

European Agency for Safety and Health at Work (EU-OSHA)

In this agency, created in 1996, the subject of “Gender and Occupational Safety and Health (OSH)” is a highly documented research topic in itself. Under the auspices of EU-OSHA, the *European Risk Observatory* provides a statistical overview of trends in terms of employment and working conditions, exposure to risk, work accidents and health problems for women. It particularly explores combined exposures, occupational cancer, access to rehabilitation, women and informal employment, and female occupations in the home care and domestic work sectors. Several reports on “Gender and OSH” have been published (EU-OSHA, 2014, 2016 and 2019, <https://osha.europa.eu>). The principal conclusions and recommendations are as follows:

→ Occupational risks to the health and safety of women have been underestimated and neglected in relation to those of men, both in terms of research and prevention. This imbalance should be corrected in the realm of research, awareness-raising, and prevention.

→ Research and monitoring can be improved by taking systematic account of the gender aspect in data collection and by basing the evaluation of the exposure on actual research.

→ Epidemiological methods should be evaluated in order to detect any gender bias.

→ European directives in terms of health and safety do not cover domestic workers (many of whom women). Women working informally, for example the wives or partners of men managing a family farm, are also not always covered by the legislation. Gender-related incidences should be evaluated for current and future directives in terms of OSH, and mechanisms of defining standards and modes of compensation should be adapted.

→ Women are under-represented at all levels in decision-making structures relating to occupational health and safety. They should be more directly involved, and their opinions, experiences, knowledge, and skills should be taken into consideration when formulating and implementing OSH strategies.

→ Adopting a holistic approach in terms of OSH, taking into account the interactions between personal and professional life and the broader issues of work and employment arrangements, can improve the prevention of occupational risks, in the interests of both women and men. Such is the aim of the proposal of the new European Directive *Work-Life Balance for Parents and Carers* (Eur-Lex 2017, <https://eur-lex.europa.eu>).

The “Health and Environment-Wide Associations Based on Large Population Surveys/HEALS” European program

This project, launched in 2014, brings together a consortium of 15 European countries to study the health impact of environmental stress on the European scale (www.heals-eu.eu/). Its objective is to conduct a vast survey that includes the various exposome research activities: genome, epigenome, transcriptome, proteome, metabolome, sociocultural environment, and economic status. The ongoing survey is being conducted on a cohort of 300,000 people followed over a 5-year period.

One of the Work Packages (WP no. 10) is responsible for studying the health impact of the social, cultural, and economic environment, with special attention to vulnerable groups: underprivileged socioeconomic status, ethnic minorities, children, and the elderly.

It is worthy of note that issues related to working conditions and the situation of women are not explicitly mentioned in the objectives. We hope that they will be taken into consideration as the research of this WP (www.heals-eu.eu/index.php/portfolio/wp10) progresses.

3.3 Women and COVID-19

3.3.1 Sex-based differences in COVID-19 mortality

In the majority of the world's regions, men are statistically more likely to die of COVID-19 than women. In the USA, men accounted for 54% of SARS-CoV-2 deaths for the month of October 2020 (<https://covid.cdc.gov/covid-data-tracker/#demographics>). In France, they accounted for 59% of hospital deaths (Salje 2020).

Biological causes?

The question is to what extent women are “protected” by their biological characteristics, genes, hormones etc. (Vidal 2020). The hormonal protection hypothesis is regularly covered in the mainstream and social media. For example, *The New York Times* led its April 27 issue with: “*Can Estrogen and Other Sex Hormones Help Men Survive Covid-19?*”. The article mentioned two clinical trials ongoing in the USA that are testing the effects of administering estrogen and progesterone in male patients with moderate symptoms of the disease. Another clinical trial is studying the influence on the course of the disease of using drugs to reduce testosterone levels. Pending publication of the results, some scientists have expressed their skepticism as to the relevance of these clinical trials. The hormone hypothesis contradicts the fact that in the population of the most vulnerable elderly people, post-menopausal women – whose gonadal hormone levels are very low – are still more resistant

than men. Other studies are exploring the avenue of sex-related genetic factors implicated in the immune defenses and mechanisms of viral penetration in the cells (Wu 2008, Channappanavar 2017, Takahashi 2020). The results so far are still too preliminary to envisage sex-based therapeutic strategies.

Higher male mortality is not an absolute rule

New light has been shed on the sex-based differences in COVID-19 infection and mortality thanks to recently published epidemiological and demographic data collected since the crisis began. The *GenderSci Lab* research group led by Sarah Richardson, professor at Harvard University, has been collecting all of the COVID-19 cases that have occurred since mid-April in the 50 US states (<https://www.genderscilab.org/gender-and-sex-in-covid19>). The figures, updated each week, reveal that it is not an absolute rule that men are more vulnerable. The differences between the sexes in terms of prevalence and mortality vary greatly from one state to another. In the states of Dakota, Kentucky, Massachusetts, and Rhode Island, mortality is highest among women, ranging from 53 to 56%. However, in the states of New York, Oregon, California, and Nevada, mortality is highest among men, ranging from 56 to 58%.

It is important to note that the raw figures can be misleading. When the age factor is taken into account (by comparing the percentage of COVID-19 deaths to the population age pyramids of each state, Krieger 2020), excess male mortality is more common but with strong variations. In the states of New York, Texas, and New Jersey, twice as many men than women died from the infection compared with the usual mortality rates. However, in Kentucky, Maine, New Hampshire, Utah, and Vermont, equal numbers of men and women died from COVID-19.

Variability of the figures is found on a worldwide scale. Men account for over 70% of COVID-19 deaths in Thailand, Bangladesh, Haiti, and Costa Rica. On the other hand, their mortality rate is below 50% in Canada, Finland, Ireland, Estonia, and Slovenia.

Considering comorbidities

Evidently, the raw statistics on the differences in mortality between the sexes are meaningless in the absence of additional data on the prevalence context of the pandemic. One major element to take into account is comorbidity, namely the other diseases which, for a given age group, can affect men and women differently (Shattuck-Heidorn 2020). Heart and lung diseases, diabetes, asthma, kidney, and liver diseases are known risk factors. Their prevalence varies according to social, cultural, and economic environment, etc. In the USA, diabetes is more common in men whereas in South Africa, the opposite is true. Asthma affects more women in the USA and more men in Italy. In the African-American population, heart disease is more common in men than in women, and in a higher proportion than in the rest of the population.

Considering social and cultural context

Other risk factors, related to gender, must also be considered in the differences of vulnerability to the infection: alcohol consumption, smoking, occupation, social codes, living environment, access to healthcare, respect of preventive measures, etc. Irrespective of whether we are referring to COVID-19 or past epidemics, the social and cultural context is a key element to understanding the disparity between the sexes in vulnerability to infection (Danielsen 2020).

During the 1918 Spanish influenza pandemic, men were predominantly affected, particularly manual workers and those in the military. These groups were the most exposed to close contacts with others and more affected by tuberculosis, making them more vulnerable. Mortality in men from the wealthy classes was the same as that of women.

In coronavirus infections such as the SARS-CoV-1 (Severe Acute Respiratory Syndrome) epidemic in Asia and MERS (Middle East Respiratory Syndrome), men were more affected than women. However, social context played a decisive role in both cases. For SARS, the mortality of men was initially 10% higher than that of women. However, after

taking into account factors related to age, comorbidity, professional activity and lifestyle, the death rates were similar for both sexes. As for MERS, transmitted primarily by camels, the elderly men tending to them were the predominant victims.

Finally, before drawing any hasty conclusions on COVID-19 vulnerability based simply on biological sex, as the raw data might lead us to do, it is essential to conduct rigorous analyses that consider all of the risk factors (age, comorbidity, living conditions, etc.) related to susceptibility to and severity of infection. That is why the *GenderSci Lab* research group at Harvard has published recommendations on COVID-19 research and communication (<https://www.genderscilab.org/blog/covid-communication>). The purpose of this guide intended for scientists, doctors, public health officials, educators, and the media is to inform them of the statistical biases and need for the incorporation of factors linked to sex, gender, and social context (Vidal 2020).

3.3.2 COVID-19 and lockdown: the health and social fallout

Added to the concerns surrounding the principles and methodologies of research are the broader issues of the health and social fallout of the epidemic and the lockdown measures that affect men and women differently.

Economic insecurity

Since the start of the epidemic and lockdown in France, polls, surveys conducted in the field, and press articles have highlighted situations of inequality between the sexes. The COCONEL survey conducted by a consortium of researchers and the polling institute IFOP followed, throughout the month of March, the perceptions and behaviors of a representative sample of the French population in relation to COVID-19 and lockdown. The results show strong disparities between the sexes in terms of working and living conditions, with more marked worsening in the most impoverished social categories (<https://www.ehesp.fr/2020/04/08/etude-coconel>).

It is the economic situation of women that has deteriorated the most. Among those who were in work as at March 1, 2020, only 2 out of 3 were still in work two months later, versus 3 out of 4 men (Lambert 2020). A very large proportion of executives worked from home, whereas half of the manual and non-executive staff, many of whom women, were stopped. The personnel that continued to work was present on site with a high risk of exposure to the infection.

This situation has particularly affected women who are overrepresented in “care” work and the service industries (<https://drees.solidarites-sante.gouv.fr>): nurses and assistant nurses in hospitals (90% female), retirement homes (90%), care assistants (97%), mass retail checkout operators (90%), teachers (83% women at primary level), school staff, cleaning staff (76%).

The weight of lockdown

While some women were on the front line, others were dealing with lockdown. The “mental load” of women saw a marked increase with housework and supervising their children’s home-schooling, tasks which for the most part fell to them. With the closure of the schools, the single mothers who had to stop working were particularly penalized by the loss of income. The claustrophobic atmosphere of family lockdown exacerbated domestic violence towards women and children by 30%.

Another area of debate concerns the recognition of COVID-19 as an occupational disease. A draft decree refers to the “automatic recognition” for all healthcare workers and “facilitated recognition” for the other professionals having worked during lockdown. The latter are required to establish a direct link between the conditions of their exposure and their illness. Demonstrating this is very tricky for non-medical professionals who have had ongoing contact with the general public during the health crisis and who have played an essential role in keeping the country running (food, public transport, security, cleaning, etc.). Women have played a massive role in this.

Crisis and the media

The handling of the crisis in the governmental bodies and the media has revealed the invisibility of the female experts in biology and medicine, despite their high level of presence. But only a minority of management positions in hospitals, universities, and research institutions are held by women. The specialists in the various disciplines of medicine, epidemiology, sociology, and economics, called on by the public authorities and media could have been women, on an equal footing with men... During lockdown, women accounted for less than 20% of the experts present in the audiovisual media, a figure that is usually around 40% (report by Céline Calvez, Sept 2020, <https://www.culture.gouv.fr>).

3.3.3 Women and COVID-19: mobilization in France and abroad

In March 2020, the *Gender and COVID-19 Working Group*, federating doctors and researchers in the biomedical, human, and social sciences, published an opinion piece in *The Lancet* on the impact of the epidemic on women's health (Wenham et al 2020). The opinion piece also emphasizes the inadequate representation of women in national and global COVID-19 policy spaces, both at the WHO and in the US government administration. The aim of the group's research program is to prepare practical recommendations for health institutions and governments concerning the respect of women's rights in the management of the pandemic.

These concerns are shared by the UN Human Rights Council and its COVID-19 Working Group which has published a declaration on the risks of discrimination against women linked to the pandemic (<https://www.ohchr.org/en/issues/women/>). It calls on States to take a gender sensitive intersectional approach in their responses to COVID-19 and implement the following measures:

- Make testing universal and free and follow-up with containment strategies that do not put women and girls at greater risk of violence and abuse.

- Ensure access to treatment and provide paid sick leave without discrimination for women.

- Expand the systems of social protection, housing subsidies, increased support for child and elderly care.
- Ensure access to healthcare services, including sexual and reproductive health services.
- Provide protection against discrimination and abuse of domestic workers, many of whom are migrant workers.

In March 2020, the French National Research Agency (ANR) launched *Flash COVID-19*, a call for projects to meet the urgent new needs of research. Among the projects selected was *SAPRIS (Health, Perception, Practices, Relations and Social Inequalities in the General Population During the Covid-19 Crisis)*, driven by a multidisciplinary team of researchers from Inserm, INED, CNRS and universities, coordinated by Nathalie Bajos and Fabrice Carrat (<https://www.sapris.fr>). The objective is to conduct a vast survey of 200,000 subjects in order to link health data with the social conditions of the epidemic crisis. The issue of sex holds an important place. Particular attention will be paid to the medical characteristics of COVID-19, the use of or failure to seek treatment for other health conditions, the perception of risk, the effects of the lockdown measures on everyday life, work, and the education of children.

4. Conclusion and perspectives

Promoting living conditions that are conducive to good health requires taking into account the differences and inequalities between the sexes in exposure to environmental risk in all their dimensions. Particular attention must be paid to situations in which women's health is under more specific threat. The critical periods of pregnancy, working conditions, domestic load, economic insecurity, and violence expose women to health risks that should systematically be incorporated into research on the exposome.

Among the research programs currently ongoing, these issues are very unequally addressed and the concerns about them are not asserted clearly enough. One of the reasons for

this is the compartmentalization of the many disciplines concerned by exposome research (biology and medicine, physics, chemistry, epidemiology, sociology, public health, etc.). Difficulties in dialog between the “hard” sciences and the social sciences make it harder to raise the awareness of researchers concerning the integration of sex-based aspects in environmental health risks.

Yet at international and European level, many environmental health research programs call for consideration to be given to gender and the health situations of women. As such, the call for projects on *The Human Exposome* of the Horizon 2020 program stipulates that “effective preventive action will need to be designed, building on knowledge of various risk factors, including exposure to pollutants in daily life, individual behavior and the social context, taking into account gender issues” (Horizon 2020, *The Human Exposome Project, Funding and Tender Opportunities*).

We can only hope that these theoretical recommendations will find tangible expression, by supporting multidisciplinary exposome research projects that give greater visibility to the subject of the inequalities between women and men in their exposure to environmental risks. It is also desirable to support projects that federate teams from both industrialized and resource-limited countries. A major challenge resides in the effective construction of prevention and information policies targeted at vulnerable populations, and women in particular.

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