The term “vulnerable populations” has a broad and flexible definition in the context of environmental health and includes sub-populations that are potentially more vulnerable to the adverse health effects of environmental exposure compared to the general population. Increased vulnerability may be the result of intrinsic biological factors or extrinsic exposure-related factors. Intrinsic vulnerability factors include age, life stage (such as pregnancy), gender, ethnicity, and genetic polymorphisms. Extrinsic vulnerability factors include socioeconomic status (SES), health status, nutrition status, geographic proximity to sources of exposure, and various lifestyle choices.

The developing fetus, for example, is uniquely vulnerable to the effects of environmental exposures due to intrinsic biological factors. Individuals or subgroups with genetic polymorphisms may be vulnerable to environmental exposures because of differences in the way the body accumulates, distributes, and eliminates environmental chemicals.

Low SES individuals are more vulnerable to the adverse health effects of environmental exposure due to extrinsic factors, for example, higher smoking rates (compared to the general public) and the increased likelihood of living near hazardous waste sites, industrial facilities, and major roads. Lack of information, resources, and choices can exacerbate the vulnerability of low SES individuals. Individuals who are compromised nutritionally (e.g., diets lacking antioxidants and anti-inflammatory nutrients) may be more vulnerable to hazardous chemicals throughout their life. Refugees may be more vulnerable due to the lack of access to safe water and poor sanitation.

There is growing evidence that vulnerable populations bear a disproportionate burden of disease that is associated with environmental exposures. This chapter describes the policies, data, and research in Israel on populations that may be particularly vulnerable to environmental pollutants.
Policy and Regulations

Environmental health policies in Israel generally aim to protect vulnerable populations. Ambient air standards and drinking water standards are developed to be protective of the most vulnerable individuals, primarily children and pregnant women. Pesticide labels often include specific warnings or instructions regarding children, pregnant women, and other sensitive populations, such as the elderly and those with allergies or asthma. Most of the mandatory consumer product standards in Israel target products intended for babies and children, including toys, baby bottles, cribs and infant mattresses, and playground equipment. Additional mandatory standards in the process of being approved pertain to children’s eating utensils and jewelry (see the “Chemicals in Consumer Products” chapter). However, despite specific standards for children’s products, there is no comprehensive and dedicated regulatory framework in Israel for children’s products. Such regulatory frameworks exist in other developed countries in the world.

The public advisories issued by the Ministry of Environmental Protection (MoEP) and the Ministry of Health (MoH) on exposure to air pollution primarily address vulnerable populations, including people with heart or lung disease, the elderly, pregnant women, and children. While the general population is advised to avoid intensive physical activity outdoors when air pollution is exceptionally high, vulnerable groups are advised to avoid spending extended periods of time outdoors (Table 1)[2,12]. The MoH, in collaboration with other government ministries, is currently working to raise awareness among educators (school principals and directors of kindergartens and institutions operating under the auspices of the Ministry of Labor, Social Affairs and Social Services) regarding severe air pollution events and their health effects, and to improve the flow of information to and within the educational system during severe air pollution events.

Ministry of Environmental Protection and Ministry of Health Recommendations: How to Act Following an Advisory on Severe Air Pollution

The Israeli Climate Change Information Center (ICCIC), which publishes recommendations regarding the health aspects of climate change, places particular emphasis on vulnerable populations, such as the elderly. The MoH regularly publishes information leaflets and recommendations for the elderly regarding heat waves and cold spells[14,15].

### Table 1

<table>
<thead>
<tr>
<th>Air Pollution Category</th>
<th>Recommendations for the General Population</th>
<th>Recommendations for People with Heart or Lung Disease, the Elderly, Pregnant Women and Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Moderate</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>High</td>
<td>Reduce intensive physical activity* outdoors</td>
<td>Avoid intensive physical activity* outdoors</td>
</tr>
<tr>
<td>Very High</td>
<td>Avoid intensive physical activity* outdoors</td>
<td>Avoid being outdoors for an extended period of time, including walking, sports, biking, shopping in open markets, and gardening</td>
</tr>
</tbody>
</table>

* Examples of intensive physical activity: intensive biking, long uphill walking, jogging, and ball games.
There are planning and construction processes that take into account the special vulnerability of various population groups that may be affected by certain aspects of the construction. For example, when Israel Railways proposed burying waste near Mesilat Zion, a community in the Jerusalem hills whose residents have a high incidence of asthma, the MoH demanded a Health Impact Assessment (HIA). The high background incidence of asthma and allergies in this community is apparently associated with genetic susceptibility among Jews with origins in Cochin, India. Similarly, in developing policy on Sde Barir, an area near Arad and Kseife where a new phosphate mine is planned, the MoH took into consideration the high background incidence of respiratory problems in the Arad population.

In recent years, the MoH has published advisories that focus on vulnerable populations:
• Dietary recommendations on arsenic consumption for infants and pregnant women;
• Recommendations on iodine consumption, with emphasis on pregnant women, breastfeeding women, women of reproductive age, and individuals with diets lacking in grains and milk products;
• Recommendations on the use of dental amalgam (containing mercury) to fill cavities in children, pregnant and breastfeeding women.

The Main Vulnerable Populations in Israel - Published Research and Data

The main populations in Israel with potential for increased sensitivity to environmental exposure are children and pregnant women; Arab populations, including Bedouins; people with chronic diseases and the elderly(24).

Children and Pregnant Women
The developing fetus is extremely vulnerable to environmental pollutants. The vital systems (e.g., the nervous and respiratory systems) and metabolic pathways in the fetus’ body are still developing. Environmental exposure at such an early stage of life prolongs the period in which chronic illness may develop as a result of exposure.

Children tend to spend more time outdoors than adults and have unique behaviors (e.g. mouthing behavior) that may increase exposure to environmental pollutants. It is important to note that the Israeli population is relatively young and children make up over 30% of the population. The fertility rate is relatively high in Israel (an average of 3.13 children for both Jewish and Arab women)(11).

Several studies on the adverse health effects of ambient air pollution have focused on children and pregnant women (see the “Ambient Air Quality” chapter). Additional research on pregnant women includes, for example, a study published in 2017 on iodine insufficiency in pregnant women in Israel(23) and a study on the impact of proximity to green spaces on birth outcomes(1).

A study conducted by researchers from the Hebrew University’s Center of Excellence in Agriculture and Environmental Health and the MoH showed that children have higher potential exposure than the general population to various types of pesticides, and that exposure of children to ten pesticides exceeded the Acceptable Daily Intake (ADI)(9).
**Arab Population**

The Arab population in Israel, which makes up 20.8% of the total population, is likely to be more exposed to tobacco smoke. Over 40% of Arab men in Israel smoke, and self-reported exposure to environmental tobacco smoke (ETS) is higher among Arabs than among Jews in Israel. According to data published by the MoH in 2014, over 50% of Arab infants are exposed to ETS, based on maternal report(10).

The Bedouins in southern Israel are considered a vulnerable population due to their low SES, high smoking rate, aspects of their traditional lifestyle, and the lack of infrastructure in unrecognized villages. In addition, Bedouin society is characterized by high fertility rates and this increases the relative proportion of vulnerable populations such as infants, children, and pregnant women. According to a 2014 publication on health and morbidity among the pediatric Bedouin population, 39% of Bedouins in southern Israel live in unrecognized villages, where residents live in prefabricated houses, shacks, or tents without regulated provision of water and electricity. Gas stoves or open fires are used for cooking and heating. Due to these living conditions, Bedouins in southern Israel are particularly exposed to indoor air pollution and the effects of extreme weather conditions, such as heat waves(25).

Researchers at the University of Haifa and the Baruch Padeh Medical Center, Poriya published a study in 2016 on the association between second-hand smoking and coronary heart disease (CHD) among Arab women in Israel. The researchers point out that exposure to domestic second-hand smoking is independently associated with CHD in Arab women, with a strong dose-response relationship(3).

According to a study published in 2011 by researchers from the MoH, the Hebrew University of Jerusalem, Bar-Ilan University and Ben-Gurion University (BGU), several polycyclic aromatic hydrocarbons (PAHs) were found in urine samples of Arabs and Druze at a statistically significant higher level than among Jews. Among non-smoking Arabs and Druze, several PAHs were found at higher levels among those consuming grilled food at least once a month. However, urinary bisphenol A (BPA) levels were lower among Arabs and Druze than among Jews(20).

A study published in 2017 by researchers from the Hebrew University of Jerusalem and Al-Quds University in East Jerusalem found different risk factors for B-cell non-Hodgkin lymphoma - those found among Palestinian Arabs are different from those found among Jews. The researchers concluded that effect modification by ethnicity raises the possibility of gene-environment interactions, but also may reflect differences in diet, cultural habits, SES, housing conditions, medical services, exposure to infections in early life, or other factors(17).

Researchers at BGU, the Sheba Medical Center, and the MoH examined pregnant Bedouin women in southern Israel and found higher urinary concentrations of aluminum in women residing within 10 km of a local industrial zone (Neot Hovav), or who reported cooking or heating on a wood-burning stove or an open fire(19).
Researchers at BGU studied exposure of pregnant Bedouin women to air pollution, high temperatures, and hazards in the home environment and effects on birth weight. The researchers found that exposure to ozone and high temperatures in the third trimester, and waste in the home environment, were associated with low birth weight among this population. It is worth noting that while exposure to high temperatures and ozone were associated with low birth weight, the contribution of poor household environment indicators to low birth weight was substantially higher\(^{(27)}\).

Researchers at BGU, the MoH, and Soroka Medical Center studied the association between exposure to nitrogen dioxide (NO\(_2\)) and congenital malformations in 1,024 pregnant Bedouin women in southern Israel. Maternal NO\(_2\) exposure during the first trimester (concentrations of more than 8.6 ppb) was significantly associated with minor congenital malformations (CMs). Major CMs were independently associated with using an open fire for heating\(^{(18)}\).

Researchers from BGU and the Soroka Medical Center found that maternal exposure to fine particulate matter (PM\(_{2.5}\)) presents a risk factor for lower respiratory tract infection among Bedouin infants during their first year of life\(^{(8)}\).

According to a 2013 report by Beterem - Safe Kids Israel organization on childhood pesticide poisoning in Israel in 2008-2013, most of the poisonings occurred among Arab children, particularly Bedouins. The data indicate that in most cases, the incidents occurred in or near the home\(^{(6)}\).

**Individuals with Chronic Disease and the Elderly**

Individuals with pre-existing diseases, such as asthma and diabetes, may be more vulnerable to the effects of environmental pollutants. The elderly may be more sensitive to environmental pollutants because of deterioration of their physiologic, biochemical and immunologic parameters. Increased oxidative stress weakens antioxidant defense. It should be noted that the elderly are particularly vulnerable to heat waves, extreme weather events, and other effects of climate change.

Studies conducted in Israel in recent years have examined the impact of environmental contaminants on populations with compromised health status. One study published in 2010 by researchers from the University of Haifa measured the effects of exposure to nitrogen oxides (NO\(_x\)) and sulfur dioxide (SO\(_2\)) on the development of pulmonary function in children in three groups (a) healthy children; (b) children with respiratory symptoms (wheezing and coughing); (c) children with asthma or spastic bronchitis. Exposure to both indoor and ambient air pollution had the strongest effect on children with respiratory symptoms\(^{(29)}\).

A study published in 2013 by researchers from Tel Aviv University (TAU) focused on the association between chronic exposure to PM\(_{2.5}\) and frailty. The researchers found an association between exposure to PM\(_{2.5}\) and incidence of frailty, an association that indicates a potential intermediary between air pollution and post-myocardial infarction outcomes\(^{(21)}\).
Research on Additional Vulnerability Factors

In addition to the vulnerable populations described above, there is evidence that individuals with genetic susceptibility factors, low SES groups, refugees, and communities living in proximity to sources of pollution may be more vulnerable than others to environmental threats.

Genetic Susceptibility

A study published in 2009 examined the impact of different environments on the prevalence of asthma and allergies in a genetically homogeneous population that immigrated to Israel from Cochin, India, fifty years ago. The study found that the overall prevalence of asthma in Cochin Jews was 23.7%; and of allergies, 29.5%. The rate of asthma and/or allergies among Cochins living in the Jerusalem hills was statistically significantly higher than in a control group of non-Cochin Jews living in the same region. The rates of asthma and allergies among Cochin Jews living in the Jerusalem hills were statistically significantly higher than these rates among Cochin Jews living in southern Israel(26).

A study published in 2015 showed that paraxonase (PON1) lactonase activity is significantly lower among Palestinians in comparison to Jews living in Jerusalem, while the PON1 functional genotype distribution is generally similar. The results suggest that the lower PON1 lactonase activity may explain part of the increased cardiovascular risk among Palestinians. It is unknown how these differences may affect susceptibility to environmental pollutants, including organophosphate (OP) pesticides(9).

Socioeconomic Status

Low SES (characterized by higher rates of unemployment, lower income, and lower educational level in comparison to the general population) is significantly associated with the current percentage of smokers among men, but not among women in Israel. Based on findings published in 2013 by researchers from the Hadassah Medical Center and the MoH, exposure to ETS was higher among those of lower educational level. On the other hand, exposure to BPA and OP pesticides was higher among individuals with higher SES and a higher educational level(4,5,19).

A study on birth outcomes and proximity to green spaces, conducted by researchers from the University of Haifa, TAU, Bar-Ilan University, and BGU, in collaboration with the Barcelona Institute for Global Health (ISGLOBAL), found stronger associations between proximity to green spaces and low birth weight among lower SES women(1).

Residence in Proximity to Agricultural Fields, Industrial Zones, and Haifa Bay

A study conducted in 2015 by researchers from BGU and TAU found a higher incidence of Parkinson’s disease (PD) among Jewish populations living in proximity to large cultivated agricultural fields in the Negev, based on data collected between the years 2000 and 2012. The researchers found that proximity to the field and its size contributed to the risk of PD. Since it is estimated that 33% of the population in Israel lives within 200 meters of agricultural fields or orchards, this is a sizable, potentially vulnerable group(29).
In 2015, researchers from the Hebrew University of Jerusalem, BGU, TAU, Clalit Health Services, and the Rabin Medical Center published a study in which they examined whether living near hazardous industrial parks is likely to increase the risk of pediatric hospitalization for respiratory diseases. Infants under the age of one who live within 10 km of the Neot Hovav Industrial Park were found to be at increased risk of hospitalization due to respiratory problems in comparison to children living more than 20 km from the industrial zone\(^{(22)}\).

Studies conducted in the Haifa Bay indicate an increased risk of lung cancer and non-Hodgkin's lymphoma, as well as cardiovascular and respiratory diseases, compared to other geographical areas in Israel\(^{(13)}\).

**Ongoing Research**

There are currently several longitudinal birth cohort studies underway in Israel that focus on the adverse effects of exposure to environmental pollutants on pregnant women and on the developing fetus (see the “Biomonitoring” chapter).

As part of the 2015-2016 National Health and Nutrition Survey (Rav-MABAT), urine samples were collected from 100 children ages 4-12 (49% male and 51% female). Jewish children comprise 59% of the sample, and Arab and Druze children 41%; children from both urban and rural areas were sampled in both groups. As part of the study, the urine samples are being tested for the presence of cotinine (a nicotine metabolite) and OP pesticides. Arab children were purposely oversampled in order to examine the hypothesis that Arab children are more exposed to ETS due to high smoking rates among Arab men in Israel.

**Progress and Challenges**

In 2016, the government decided to develop a National Plan for Health and the Environment. The plan places special emphasis on vulnerable populations, especially children, pregnant women, the elderly, and those with chronic diseases. One of the challenges in developing the national plan will be to identify additional vulnerable groups in Israel and tailor goals and specific targets to the various vulnerable groups.

Israel’s environmental health laws and policies apply within the state’s geographic borders. However, Israel is surrounded by countries and territories with less regulatory oversight of industrial pollution, pesticide use, and consumer products. A study published in 2014 showed that 42% of plastic toys sold in the Palestinian market contained concentrations of lead that exceed the maximum concentrations permitted in many countries in the world. The transfer of goods to Israel from bordering territories, including the West Bank and East Jerusalem, may place vulnerable populations in Israel at higher risk.
It is unknown which populations in Israel are most vulnerable to emerging environmental health risks. For example, it is unclear how different diets and other vulnerability factors affect the absorption and retention of magnesium and iodide from drinking water. There is evidence that genetic polymorphisms affect vulnerability to heavy metals, trihalomethanes, OP pesticides, and other environmental contaminants, but there is little data on the prevalence of such genetic polymorphisms in Israel’s population. Further research on genetic polymorphisms and other vulnerability predictors will help identify these vulnerable populations.

Although government ministries (including the MoH and the MoEP) publish recommendations specific to vulnerable populations, it is not clear to what extent such recommendations are accessible to the vulnerable populations themselves, in terms of language and media. Collaboration between government ministries and civil society organizations working on behalf of vulnerable populations may improve the flow of information regarding environmental hazards and their prevention, and may promote mechanisms for public participation.

References


