Environmental Health in Israel 2020
About the Environment and Health Fund

The Environment and Health Fund (EHF) is committed to expanding expertise in and knowledge about environmental health in Israel. EHF builds capacity and capabilities by supporting inter-disciplinary research, in-service professional training, and workshops and conferences. EHF helps connect Israeli scientists and policy makers to a network of international experts in environmental health research and policy. EHF works with scientists and professionals, government and the private sector to broaden stakeholder involvement in reducing exposure to environmental hazards and improving public health.

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Preface

Writing the preface to the third edition of *Environmental Health in Israel* is both an honor and a challenge. The report is the fruit of a continuing and extremely productive collaboration, more than a decade long, between the Environment and Health Fund and the Ministry of Health. The private/public partnership reflected in this collaboration demonstrates the partners’ respect and trust for one another. With each iteration, the report has seen improvements in form and content. We believe that these reports provide high quality, meticulously researched and reviewed data regarding environmental health research and policies. The current report is descriptive, providing a snapshot of the state of environmental health in Israel in 2020, and prescriptive, outlining current challenges and recommending future directions. Its fourteen chapters span a range of environmental factors that affect human health. It is indeed an honor to be involved in such an ambitious, comprehensive, and forward-looking project.

Yet one cannot write anything at this time without experiencing some degree of anxiety. The appearance of the novel coronavirus, COVID-19, and subsequent efforts to deal with the pandemic have introduced uncertainty into all aspects of our lives. The ways in which our government, our society, and particularly our healthcare system are all challenged at this time, along with the politicization of public health decision-making, have sidelined much of the most essential environmental health research and policy. The threats of environmental hazards to public health in Israel, however, will not disappear simply because they have escaped from the spotlight as all attention is focused on the pandemic.

In fact, one may argue that the opposite is the case. Exposure to environmental pollutants increases the severity of COVID-19. People in polluted areas are far more likely to die from the new coronavirus than are those living in cleaner areas. This knowledge should be leveraged to decide how to deploy resources to deal with the pandemic and how to ease back toward normalcy after lockdown.

How exposure to environmental pollutants influences individual susceptibility to coronavirus infection has yet to be determined. One theory is that exposure to environmental chemicals or other environmental pollutants weakens immune defenses and/or compromises the functioning of organs targeted by the coronavirus, including the
respiratory tract, the cardiovascular system, and the brain. Alternatively, environmental chemical exposures may indirectly exacerbate COVID-19 related disease by increasing individual risk to health issues associated with the heightened risk of death from COVID-19. For example, pre-existing asthma, diabetes, obesity, and cardiovascular disease worsen the prognosis of those with COVID-19, and each of these disease and health conditions has been linked to exposure to environmental chemicals and other pollutants in both animal models and human epidemiological studies.

The lessons we are learning during the current pandemic highlight the need to enforce and even strengthen existing environmental pollution regulations. We have also learned the importance of access to open green spaces, particularly in the built urban environment. The urgency of considering the health implications of planning processes has been highlighted by the pandemic. Implementing policies and lifestyle changes to reduce human exposure to chemicals and other environmental pollutants that compromise our health and resistance to pathogens will be a critical component in preparing for the next viral threat.

I would like to thank the many individuals who contributed to this volume. Professor Itamar Grotto, the outgoing Deputy Director General of the Ministry of Health, has been the single most significant figure in promoting issues of environmental health in the Israeli government for more than a decade now. Thanks to Dr. Tamar Berman, whose hard work and commitment to this project, among many, has been extraordinary. We also thank Dr. Zohar Barnett-Itzhaki for his contribution to the writing of the report and Dr. Udi Kaliner for reviewing the entire report. Maya Popper worked tirelessly as project manager and editor. Many, many contributors wrote, edited, and reviewed the chapters and deserve our gratitude. Professors Mark Nieuwenhuijsen and Mike Brauer greatly improved the report by participating in a kick-off workshop in January 2020 (MN) and offering comments on an earlier draft (MB). Dr. Linda Birnbaum, the recently retired Director of the National Institute of Environmental Health Sciences, once again read, reviewed, and commented on every chapter, every challenge, and every graph in this report, and again expressed her clear and concise wisdom in the Conclusions and Recommendations chapter. Finally, I thank my colleague, Dr. Sari Rosen. Although she is formally recognized as Editor-in-chief of this volume, that does not do justice to the time, effort, painstaking attention to detail, commitment to clarity, and uncompromising standards of excellence in everything she touches. Every aspect of this report was improved by Sari’s involvement.

Ruth Ostrin, PhD
Director
Environment and Health Fund
Introduction

The third edition of Environmental Health in Israel was written in 2020, the year when the COVID-19 pandemic dominated public health work globally and in Israel. The publication of this report at the end of 2020 is fitting: It demonstrates that even when public and political attention is directed elsewhere, pressing environmental health problems persist and need to be addressed. Accordingly, this report describes the most pressing environmental health problems in Israel and progress in addressing them in both research and policy.

Despite parliamentary paralysis throughout 2019 and amid the COVID-19 crisis in 2020, impressive progress was made in several aspects of environmental health in Israel, including reducing air pollution, expanding biomonitoring capabilities, and closing gaps in regulating chemicals in consumer products. Additional hard work is needed to ensure that the full public health benefits of these milestones are realized and that the findings of research and surveys continue to be translated into policy. In light of new findings on the presence of perfluorinated chemicals in groundwater in industrial hotspots in Israel, for example, there is an urgent need for policy to prevent environmental contamination and public exposure to this class of chemicals.

One of the results of the parliamentary paralysis and the COVID-19 crisis is that major environmental health policy reforms have been delayed. As Israel emerges from these crises, it must advance much needed environmental health policies, including restrictions on the sale and use of highly toxic pesticides and updating national air quality and drinking water standards.

Many challenges that were highlighted in the 2014 and 2017 reports persist and remain unresolved, such as enforcing the ban on smoking in public places and addressing the lack of magnesium in desalinated drinking water. We also need to address worrying national trends such as the gradual reduction in access to green open spaces and the increasing intensity and frequency of heat waves and extreme weather events. If these trends are not addressed, there will be major ramifications for public health in Israel.
Several newly proposed policy reforms may have major impacts on environmental health in Israel. Draft legislation for chemical management, spearheaded by the Ministry of Environmental Protection, is an important step because Israel lags behind the EU and the U.S. in registering and approving chemicals. The urgent importance of comprehensive chemical management in Israel is clear in view of new evidence on PFAS contamination in Israel and lack of regulatory restrictions on these compounds. Another proposed reform, championed by the Ministry of Economy and Industry, would reduce the testing of imported consumer products. Unless this reform is accompanied by far-reaching government inspection and oversight, it may result in increased exposure of the Israeli population to toxic chemicals in imported consumer products.

Despite growing economic and political pressure, environmental health regulatory requirements in Israel should not be loosened or reversed. Future budget cuts should not lead to reductions in government oversight and spending in the field of environmental health. Israel’s efforts to recover and rebuild public health resilience following the pandemic need to integrate efforts to build environmental health resilience, including steps to limit the public’s exposure to toxic agents in air, water, consumer products, and food, and to increase access to green open space. As the public health threats of climate change loom, Israel has no time to waste in preparing for the next crisis.

I wish to thank Drs. Ruth Ostrin and Sari Rosen from the Environment and Health Fund for their hard work on this report and their unfailing dedication to this challenging project. Dr. Linda Birnbaum has been a crucial part of this project from the beginning; here, as in the 2014 and 2017 reports, her insightful comments and recommendations are key to the success of the project. Gratitude is also owed to Drs. Tamar Berman and Zohar Barnett-Itzhaki, who led the preparation of the report.

Prof. Itamar Grotto, MD, MPH, PhD
Deputy Director General
Israel Ministry of Health
Ambient air pollution is the major environmental health risk factor in Israel. Ambient air quality in Israel is affected by various sources of pollution, some natural (such as desert dust) and others anthropogenic (such as emissions from industry, transportation, and biomass combustion). Exposure to ambient air pollutants is associated with adverse health effects such as respiratory diseases, cardiovascular morbidity, Type 2 diabetes, cancer, and adverse developmental outcomes including small for gestational age (SGA) and low birth weight. Ambient air pollutants include particulate matter (PM) of different diameters, ozone (O₃), nitrogen oxides (NOx), sulfur oxides (SOx), lead, carbon monoxide (CO) and volatile organic compounds (VOCs).

Ambient air quality is monitored by the Air Quality Division at the Ministry of Environmental Protection (MoEP) through a network of over 150 air quality monitoring stations, including widely deployed fixed and mobile units that continually monitor criteria pollutants (such as PM and ozone). MoEP also conducts biweekly sampling at nineteen permanent sampling sites for non-criteria pollutants such as VOCs, metals, and dioxins.

Ambient air quality in Israel is regulated under the Clean Air Law of 2008, which went into effect in January 2011. The statute set air quality values for numerous pollutants; MoEP updates them periodically in collaboration with the Ministry of Health (MoH) and other stakeholders, most recently in 2016. The two main values are: (a) target values—exceedance of which may harm human health or the quality of human life, property, or the environment, including soil, water, flora, and fauna; an effort should be made to meet these target values although they are not mandated by law; and (b) environmental values—exceedance of which constitutes severe or unreasonable air pollution. Although the environmental values are based on the target values, they are more lenient because they take into account the best available technologies and the feasibility of preventing exceedance of the target values. Notably, for many ambient air pollutants there is evidence of adverse health effects even at levels below the target values. Table 1 shows the environmental standards of selected pollutants listed in the Clean Air Law and compares them with EU and U.S. standards and World Health Organization (WHO) guidelines.
Ambient Air Quality Standards for Selected Criteria Pollutants in Israel Compared with Standards in the EU and U.S. and with WHO Guideline Values

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Israel (μg/m³)</th>
<th>EU (μg/m³)</th>
<th>U.S. (μg/m³)</th>
<th>WHO Guideline Values (μg/m³)</th>
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<tr>
<td>PM₁₀</td>
<td>24 h</td>
<td>130</td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>50</td>
<td>40</td>
<td>—</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>24 h</td>
<td>37.5</td>
<td>—</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>25</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>Ozone</td>
<td>8 h</td>
<td>140</td>
<td>120</td>
<td>138</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO₂)</td>
<td>1 h</td>
<td>200</td>
<td>200</td>
<td>188</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>40</td>
<td>40</td>
<td>98</td>
</tr>
<tr>
<td>Sulfur Dioxide (SO₂)</td>
<td>10 min</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1 h</td>
<td>350</td>
<td>350</td>
<td>197</td>
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<tr>
<td></td>
<td>24 h</td>
<td>50</td>
<td>125</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>20</td>
<td>—</td>
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Progress since 2017

The Environmental Health in Israel 2017 report defined challenges related to Ambient Air Quality. Progress achieved in this area during the past three years is outlined below.

**The challenge: Develop a strategy for regular sampling of contaminants that cannot be monitored continuously**

**In short:** Monitoring and biweekly sampling of dozens of air pollutants began in 2015. The nineteenth monitoring site was added in 2018.

**Challenge for the coming years:** Continue monitoring and extend it to additional sites.

Under the Clean Air Law, twenty-eight criteria ambient air pollutants (including O₃, SO₂, PM₂.₅, PM₁₀, NOₓ, NO₂, CO, benzene) and non-criteria pollutants (including VOCs, poly-aromatic-hydrocarbons [PAHs], aldehydes, metals, ammonia, and hydrogen sulfide) are monitored. Contaminants that reach concentrations of approximately one-tenth of their target or environmental values are sampled throughout the year on a biweekly basis. Monitoring began in 2015 at fourteen sites. In 2016, four additional monitoring sites were added; the nineteenth monitoring site was added in 2018. In total, some twenty air pollutants have been sampled in Israel since 2015 on a biweekly basis, including formaldehyde, PAHs, heavy metals, and ammonia.

**Legend:**
- Significant progress
- Some progress
- Little or no progress
In 2013, the National Plan for the Prevention and Mitigation of Air Pollution in Israel (Government Resolution 707) was approved and goals were set for 2015 and for 2020. The plan has been almost fully implemented. According to a report on the implementation of the plan, presented to the Government, the sections for which MoEP was responsible were implemented and other parts have yet to be applied:

- The 2008 plan to scrap old vehicles was renewed in 2018 for old diesel-powered vehicles only. According to MoEP estimates, diesel-powered vehicles are responsible for ~80% of traffic-related air pollution.
- The Ministry of Finance, in consultation with the Minister of Environmental Protection and the Minister of Transport, has not presented the Government with proposed tools and measures for reducing travel in leased vehicles.
- The Minister of Finance, in consultation with the Minister of Environmental Protection, has not set differential tax rates for different types of fuel.

MoEP is developing a follow-up plan for reducing air pollution in Israel.

Based on data reported to the MoEP managed Pollution Emissions Inventory, PM\textsubscript{10} emissions decreased by 57% between 2012 and 2018 following a downturn in the use of coal for energy production along with other regulatory requirements. The main sources of PM\textsubscript{10} emissions in Israel are industry (20%), transportation (33%), and waste incineration (20%).

Data from air monitoring stations in Israel indicate that annual average concentrations of PM\textsubscript{10} and PM\textsubscript{2.5} in different parts of the country exceed the target values (20 and 10 µg/m\textsuperscript{3}, respectively) but not the environmental values (50 and 25 µg/m\textsuperscript{3}, respectively). Although the number of exceedances in PM\textsubscript{2.5} concentrations at various monitoring stations, including those close to roads, has been decreasing, PM\textsubscript{2.5} concentrations remain relatively high, ranking Israel thirty-seventh among forty OECD countries. Ozone precursors including NOx have also been decreasing. Unlike other air pollutants that have seen declining concentrations over the years (such as SO\textsubscript{2} and NO\textsubscript{2}),
concentrations of PM$_{10}$ and ozone show no downward trend (Figure 1). Moreover, according to an assessment published in 2020 and based on 2016 exposure data, the entire population of Israel is exposed to PM$_{10}$ concentrations that exceed the target value while falling short of the environmental value.

According to the Global Burden of Disease database the mortality rate from PM exposure in Israel has remained constant in recent years and was 26.4 per 100,000 people in 2017. Based on OECD data, this rate stood at 28.41. The distribution of mortality attributed to PM exposure in 2017 was 35% from cardiovascular diseases, 22% from diabetes, 18% from non-malignant respiratory diseases, 12% from lung cancer, and 13% from other causes. Notably, a PM exposure mortality assessment tailored to Israel is needed because the composition of PM in Israel is different from that in Europe and the U.S. (i.e., high dust levels) and may be less toxic. The death rate from chronic obstructive pulmonary disease (COPD) attributed to ozone exposure in Israel has also remained constant in recent years (3.0 per 100,000 people in 2017).

Trends in Air Pollutant Concentrations (Annual Averages) at Selected Sights in Israel, 2001–2018
* No annual target and environmental values were defined for ozone.
In rural areas that have high concentrations of ozone, no decrease in concentrations was recorded. Moreover, the population-weighted mean exposure to ozone in Israel is significantly higher than the global average, the OECD average, and the European average (Figure 2). Therefore, it is essential to reduce emissions of ozone generating sources (hydrocarbons and NOx), including by promoting the use of renewable energy, encouraging green transportation, and implementing the updated National Plan for the Prevention and Mitigation of Air Pollution in Israel.

**Average Population-Weighted Ozone Exposure in Various Countries**
The target and environmental values of twenty-eight contaminants were last determined in 2011 and are supposed to be updated every five years. MoEP is expected to submit the next update by the beginning of March 2022. As part of this process, MoEP prioritized the chemicals that have target values in need of updating and reviewed new information published by regulatory organizations such as the WHO, the European Environment Agency (EEA) and the U.S. Environmental Protection Agency (U.S. EPA). The process also includes discussions on updating the target values of seven air pollutants: toluene, styrene, nickel, NOx, suspended particulate matter (SPM), sulfate, and settling dust. MoEP is conducting an assessment of the environmental values of nine air pollutants (toluene, styrene, nickel, \( \text{SO}_2 \), 1,2-dichloroethane, tetrachloroethylene, hydrogen sulfide, vanadium and arsenic). The assessment is expected to be completed in 2021. When the process of updating target and environmental values is completed, MoEP will present the Internal Affairs and Environment Committee of the Knesset with a proposal for its approval.

MoEP continues to establish new air quality monitoring stations and upgrade existing stations in order to monitor additional pollutants on the basis of two main criteria: areas with large or dense populations and proximity to emission sources. In recent years, monitoring stations were established in Ketura, Ashdod Port, Zikhron Yaakov, Atlit, Caesarea, and Tel Hai. (For a map of air monitoring stations in Israel, visit the MoEP website.) MoEP also set up air pollution monitoring stations east of the Leviathan natural gas rig for continual measurement of benzene. Another monitoring station is planned in the near future at Haifa Port. It is important to improve the spatial distribution of the air monitoring stations and to add stations in less populated places such as the Negev in order to include the populations of these areas in epidemiological studies and assist geo-climatic research that can validate and enhance the national models used in public health studies in Israel.

Notably, annual assessments of air pollutant concentrations and daily forecasts are based not only on information from these monitoring stations but also on computerized models of pollutant dispersion (CHIMERE), with which air pollutant levels in areas far from monitoring stations can be assessed.
MoEP, in collaboration with the Ministry of Transport, is leading several initiatives to improve and advance sustainable transport. Examples follow:

- support for low-emission zones - Several cities (Haifa and Jerusalem, for example) have imposed restrictions on diesel vehicles that fail to meet the Euro 4 air pollution standard or have not been fitted with a dedicated particulate filter for reducing air pollution. In Jerusalem, MoEP invested NIS 24 million to assist the municipality with this project, subsidizing the installation of filters for car owners and helping the Egged bus company to buy ten electric buses for use in the city;  
- promoting the use of electric buses - MoEP is offering public transport companies NIS 23 million in support for purchasing new electric buses (some eighty in all) for countrywide use;  
- promoting on-demand shuttle services such as Bubble;  
- promoting transition to electric or hybrid taxis - This project, in collaboration with the Jewish National Fund (KKL-JNF), provides a subvention of up to NIS 20,000 for taxis that switch to hybrid propulsion;  
- opening carpool lanes to reduce road congestion and traffic-related air pollution;  
- supporting the transition of heavy vehicles to natural gas propulsion;  
- implementing a NIS 260 million program for reducing emissions from old diesel trucks (by installing particulate filters and by scrapping);  
- promoting the installation of particulate filters in trains;  
- promoting installation of particulate filters in garbage trucks with NIS 10 million investment (in collaboration with KKL-JNF).

In recent years, MoEP has funded eight epidemiological studies related to exposure to air pollution in Israel. Most studies under way focus on the population in the Haifa Bay area and compare it with populations elsewhere in the country. The studies span a range of research fields: biomonitoring, pregnancy outcomes, infant respiratory morbidity, incidence of cancer and heart disease, and economic assessments of the costs of exposure to ambient air pollutants.
In addition, MoH has been examining asthma hospitalization rates in children and adults in Israel, by region, for more than twenty years (1996–2018). In collaboration with Clalit Health Services (which insures about 60% of Israel’s population), MoH is also assessing the incidence and prevalence of asthma in children (aged 2–18) and adults (25–54) by regions and districts in 1998–2015.

Since 2012, MoEP has been publishing assessments of the external costs of air pollution and greenhouse gas emissions in Israel, including the estimated cost of damage due to increased morbidity (Disability-Adjusted Life Years—DALYs) and mortality and to environmental impacts. At the present writing, MoEP is updating these assessments on the basis of the latest research and, in particular, the most recent WHO publications on the impact of air pollution on human health. The update includes an assessment of external costs based on recently defined values in EU countries; presentation of a range of values for air pollution from industry and transport; forecasts of the impact of climate change (in order to reflect the uncertainty that attends to such assessments); weighting by per capita GDP and population density; adjusting costs to the Consumer Price Index; distinguishing between smokestacks higher than 100 meters and shorter ones; and applying a conservative approach to assessing the external cost of greenhouse gases based on the cost of damage.

### The challenge: Collect data on the contribution of different sources to air pollution in Israel, using source apportionment techniques

| **In short:** MoEP significantly expanded the list of emission sources. | **Challenge for the coming years:** Collect information on the contribution of additional sources to air pollution in Israel; simulate chemical transport models. |

The list of emission sources that MoEP collects and publishes has been expanded to include many additional sources: trains, ships, waste incineration, animal husbandry, burning of biomass in agriculture, and use of fireplaces.

MoEP is also studying strategies for reducing air pollution from shipping vessels at Haifa and Ashdod ports. A feasibility study commissioned by MoEP indicated that vessels at these ports are responsible for significant emissions of air pollutants that can affect air quality in populated areas near the ports. Moreover, vessels at Israel’s seaports accounted for about 16% of total SOx emissions, 8% of NOx emissions, and about 7% of PM$_{2.5}$ emissions in 2018. In response, MoEP drafted recommendations on technological and regulatory measures that may mitigate emissions from these sources.
Research on Ambient Air Quality in Israel

Exposure to Ambient Air Pollutants

• Researchers from the Technion Center of Excellence in Exposure Science and Environmental Health (TCEEH) have developed a modeling framework for estimating exposure to air pollutants among a representative sample of working Israeli adults (N ~ 168,000) for whom both residential and workplace addresses were available. They found exposure misclassification that varies throughout the day, largely on account of intra-individual movement (between work, home, and other places). They also showed that short stays in areas with high concentrations of ambient air pollutants have a relatively small impact on overall exposure to pollutants.20

• Researchers from MoEP and MoH, employing a hybrid model to assess the exposure of Israel’s population to various air pollutants, found that the entire population is exposed to concentrations of PM_{2.5} and PM_{10} that exceed target values though not environmental values and that over 1.5 million residents are exposed to concentrations of NOx that exceed target values.7

• Researchers from Ben-Gurion University of the Negev and Soroka University Medical Center, studying the pattern of association between exposure to anthropogenic and non-anthropogenic PM and adverse health outcomes, found a linear correlation between exposure to PM_{10} and asthmatic exacerbations in asthma patients not related to a PM source.21

• Several MoEP funded studies on exposure to ambient air pollutants in the Haifa Bay area are underway: (a) biological monitoring of air pollutants in blood donors living in the Haifa Bay area22; (b) associations between air pollutants and heart disease—heart failure and acute coronary syndrome; and (c) an economic assessment of the health impacts of exposure to air pollutants in the Haifa Bay area.

• Researchers from TCEEH have launched a source apportionment study focusing on fine PM, in particular its varying spatiotemporal patterns and the atmospheric processes that govern these changes. The study aims to characterize and develop models of the chemical composition and of the distribution of the sources of PM emission in the Haifa Bay area. Its results may shed further light on the sources of fine particulate pollution and enhance the quality of the data used for exposure and risk assessment and for mitigation strategies.

Pregnancy and Childbirth

• Researchers from Ben-Gurion University of the Negev, in collaboration with colleagues from the Hebrew University of Jerusalem and Mount Sinai Hospital in New York, studied whether the exposure of pregnant women to ambient air pollutants and to extreme temperatures is associated with low birth weight and premature birth among the population of southern Israel. In the study, encompassing over 56,000 live births, it was found that exposure to below average temperatures during pregnancy may increase the risk of adverse birth outcomes such as low birth weight and premature birth, while exposure to above average temperatures may decrease the risk of premature birth.23
• Researchers from Maccabi Health Services and Tel Aviv University examined the head circumference of newborns in the Haifa Bay area using Maccabi Health Services’ database and did not find a higher prevalence of microcephaly (small head circumference in newborns) in Haifa Bay area in comparison with other areas in Israel.  

• University of Haifa researchers evaluated a model for spatial identification of environmental health hazards potentially associated with observed reduced birth weight and reduced head circumference patterns. The researchers identified a site in Haifa’s industrial zone as a significant source of risk.

• Researchers from the Hebrew University of Jerusalem, TCEEH, Ben-Gurion University of the Negev, and MoH, in collaboration with colleagues from Columbia University and Harvard University, studied whether the exposure of pregnant women to traffic-related air pollutants is associated with miscarriages. The research population included pregnant women from Boston and from Tel Aviv District. In both populations, an association between exposure to high concentrations of traffic-related air pollution and miscarriage, particularly between the tenth and twentieth weeks of pregnancy, was found.

• A Ben-Gurion University of the Negev researcher reviewed the contribution of green infrastructure (urban vegetation such as trees, hedges, and bushes, green walls, and green roofs) to mitigating the risk of adverse birth outcomes—with an emphasis on premature birth—as a result of exposure to high ambient temperatures and air pollutants. Exposure to PM and extreme temperatures during pregnancy (especially during the first and third trimesters) was found to be associated with increased rates of premature birth whereas green infrastructure lowers PM and prevents the formation of urban heat islands. Thus, green infrastructure mitigates the adverse effects of exposure to PM and high temperatures on birth outcomes.

• Researchers from the Hebrew University of Jerusalem, Ben-Gurion University of the Negev, the University of Haifa, Tel Aviv University, Rambam Health Care Campus and Maccabi Health Services are analyzing “big data” of pregnancies and births in the Haifa Bay area, with data from 1998–2017 (~750,000 births). The project examines environmental effects (including exposure to ambient and indoor air pollution) on fetal development in Haifa Bay area in comparison with other areas in Israel.

• Researchers from the Hebrew University of Jerusalem, TCEEH, and the Harvard School of Public Health studied the link between traffic-related air pollution and autism spectrum disorder (ASD). The researchers examined whether mothers’ exposure to NO₂ during pregnancy and newborns’ post-natal exposure to this pollutant were associated with a risk of ASD in children born in 2005–2009. It was found that exposure of newborns and toddlers to NO₂, but not that of pregnant women, was associated with increased risk of developing ASD.
In a follow-up study, researchers from the Hebrew University of Jerusalem, Columbia University, and Harvard University suggested two explanations for their findings on the inverse relationship between exposure to ambient air pollutants during pregnancy and ASD (relevant to live births). The first explanation attributes other ASD risk factors in addition to mother’s exposure to air pollutants; the second explanation relates to miscarriages of fetuses susceptible to ASD as a result of exposure to air pollutants.30

Three MoEP funded studies are under way on the following topics: (a) biological monitoring of organic pollutants and heavy metals in mothers and their children, and examination of the effects of exposure to ambient air pollutants during pregnancy on pregnancy outcomes; (b) examining the association between respiratory illness in infants and exposure to ambient air pollutants during pregnancy and infancy; (c) examining the association between environmental exposure to ambient air pollutants and fetal growth.

Biochemical and Physiological Outcomes

Researchers from Tel Aviv University, the Ministry of Agriculture and Rural Development, Ben-Gurion University of the Negev, and Sheba Medical Center at Tel Hashomer developed a method for exposing primary epithelial cells to PM under laboratory conditions in a way that simulates nasal respiration. They found that this exposure triggers a physiological response expressed in heightened excretion of cellular molecules such as IL-8.31

Researchers from the Weizmann Institute of Science and Peking University studied the biochemical mechanism in which the Nrf2 transcription factor operates. Nrf2 can protect lung cells from the toxic effects of PM2.5 exposure. Lung cells silenced for Nrf2 become hypersensitive to PM and exposure to PAHs increases mortality in silenced cells. The researchers showed that silencing the factor induced accelerated mitochondrial activity and that exposure to various pollutants led to lower mitochondrial membrane potential and a lower mitochondrial DNA copy number. They concluded that Nrf2 serves as a mediator for mitochondrial activity following PM2.5 exposure.32

Researchers from Tel Aviv University, Bar-Ilan University, and the University of Haifa studied the impact of exposure to noise, different temperatures, and CO concentrations on the heart rates of Jewish and Muslim women in different environments (a green space such as a park, a city center, and a residential area). They demonstrated the positive effect of visiting green spaces, where CO levels are negligible, on the women’s heart rates.33

Respiratory Morbidity

University of Haifa researchers reported on the prevalence of asthma among young men in urban areas in Israel (Tel Aviv, Haifa, Hadera) that have multiple sources of air pollution (industrial, traffic-related). They found that exposure to both industrial- and traffic-related air pollution have a negative effect on asthma risk in young males.34
University of Haifa researchers developed a model for reducing morbidity caused by exposure to ambient air pollutants. The model involves removing the sources of emission from densely populated areas and replacing them with a green environment. Applying the model to the Haifa Bay area, they showed that relocating sources of emission would reduce the asthma morbidity rate among children in the area by about 70%. 

Researchers from the University of Haifa and the Israel Defense Forces (IDF) studied associations between exposure to various air pollutants (NO\textsubscript{2} and SO\textsubscript{2}) and asthma morbidity. Examining data from over 137,000 candidates for military service (seventeen-year-old males) in 1999–2008 and using several models to assess the extent of exposure to these pollutants based on their place of residence, they found a strong direct correlation between exposure to NO\textsubscript{2} and asthma morbidity in this population and a weaker direct correlation between exposure to SO\textsubscript{2} and asthma morbidity.

Cancer and Cardiovascular Diseases

Researchers from Tel Aviv University, TCEEH, the Hebrew University of Jerusalem, and Hadassah, Beilinson and Hasharon medical centers studied the link between chronic exposure to traffic-related air pollutants and new cases of cancer in a population of 10,000 people suffering from coronary artery disease. They showed that a 10-ppb increase in mean exposure to NO\textsubscript{x} (indicating a traffic-related source) was associated with a higher risk of all types of cancer, particularly of the breast, lung, kidney, prostate, and bladder. In another study, the researchers found an association between a 10-ppb increase in mean exposure to NO\textsubscript{x} and increased risk of all-cause mortality among coronary-heart-disease patients (hazard ratio = 1.13). 

In a follow-up study, the same group of researchers used various models to examine the association between exposure to traffic-related air pollutants (NO\textsubscript{x}) and cancer. They found a statistically significant association between exposure to these pollutants and the incidence of cancers that had previously been linked to exposure to traffic-related pollutants (lung, breast and prostate cancer) but did not find an association between this exposure and other types of cancer.

An MoEP funded study, under way, is investigating the association between exposure of seventeen-year-olds to environmental air pollutants in the Haifa Bay area and cancer incidence in adulthood.

Future Challenges

Recent years have seen progress in monitoring and studying ambient air pollutants and in reducing the emissions of some. However, improving air quality in Israel continues to pose significant challenges, primarily related to changes in the country’s energy economy. In late 2019, natural gas began to flow from the Leviathan rig, located about ten kilometers west of Haifa, opposite the
Zikhron Yaakov shore. Preparing for the flow of gas, MoEP set up monitoring stations to measure benzene, toluene, and ethylbenzene. According to MoEP, the rig will have an inconsequential effect on ambient air pollution, contributing only 1% of the benzene environmental value. Nevertheless, it is important to continue to monitor emissions from the rig along with other air pollutants along Israel's coastline. The flow of natural gas to Israel offers additional opportunities in the field of energy, including the construction of gas-fired power stations (trigeneration plants) in new residential neighborhoods. Although trigeneration plants may reduce air pollutants in Israel overall, it is important to monitor pollutants emitted from these plants due to their proximity to population centers.

Most solid waste in Israel (76%) is sent to landfills. Incineration of waste in landfills is a major source of emissions of suspected or known carcinogens (about 60% of air emissions in 2018), and the expansion of this practice will likely lead to an increase in air emissions of carcinogens and population exposure to these contaminants. Given Israel's dwindling land reserves, MoEP has been working during the past decade to reduce use of landfills and to encourage environmental alternatives for waste treatment. One such alternative is controlled waste incineration, in which energy is produced. This would entail the construction of three waste incineration facilities in close proximity to the populated areas that generate the waste, in order to reduce the cost and environmental harm involved in transporting waste. Despite the energy potential of the plan, a health impact assessment is required before it can be implemented.

In addition to industrial, transport, and natural air pollution, livestock farms emit air pollutants including PM, ammonia, NOx, and VOCs. Concerns about air pollutants emitted by livestock farms have been raised by the EEA and U.S. EPA. Israel needs to monitor air quality near livestock farms and conduct studies on the impact of this potential source of emissions.
References


Indoor air quality (IAQ) refers to air quality inside closed environments such as buildings and their surroundings—private homes, offices, public buildings (for example, schools and hospitals), and mass transport systems. Poor IAQ may adversely affect the health of individuals who live or work in or around a building. Exposure to indoor air pollution creates a health risk because the majority of people in developed countries spend most of their time indoors and in enclosed spaces.

Indoor air pollutants include various types of chemicals: toxic gases such as carbon dioxide (CO₂) and radon, volatile organic compounds (VOCs) such as benzene and formaldehyde, respirable particles, combustion products, pesticides, tobacco smoke, and microbial biological pollutants, among which are hundreds of strains of bacteria and fungi that thrive indoors in sufficiently damp conditions.¹

Four factors affect IAQ: (a) indoor sources of pollutants including indoor biofuel for cooking and heating, materials used in construction and furniture, and products that emit VOCs; (b) the quality of ambient air entering the closed environment; (c) the rate of air exchange between the indoor environment and the outdoor environment; and (d) ventilation systems, which themselves often contain pollutants.
Spending time in a closed building with poor IAQ may result in adverse short-term health outcomes such as upper and lower respiratory tract infections, allergic reactions, irritation of the eyes, nose and throat, headaches, dizziness, and even cognitive impairment. In addition, most exposure to polluted ambient air occurs when ambient air penetrates the indoor space. This may result in adverse long-term health outcomes such as respiratory diseases (asthma, chronic obstructive pulmonary disease [COPD], bronchitis), heart disease, cancer, and diabetes. Certain population groups, like the elderly and nursing home residents, are considered particularly sensitive to indoor air pollution due to their age or underlying health conditions and the long hours they spend indoors.

Although there is no overarching legislation on IAQ in Israel, there are standards and regulations pertaining to indoor air (radon, ventilation requirements), some specified in building and planning codes and standards. Government ministries primarily address IAQ indirectly, by dealing with ambient air and establishing committees that regulate consumer products and furniture. Green building committees exist as well.

Israel’s warm climate poses challenges, especially related to home ventilation. Apartment air conditioners are widely used amid rising local living standards and global warming. Thus, Israelis are transitioning from natural ventilation (by opening windows) to more extensive use of air conditioners, most of which recirculate air. Despite the country’s warm climate, fireplaces and other means of open fire heating with biogenic fuel are also used in Israel.

**Progress since 2017**

The *Environmental Health in Israel 2017* report defined challenges related to Indoor Air Quality. Progress in tackling them in the past three years is outlined below.

**The challenge: Conduct a pilot study on indoor air pollution in schools**

**In short:** Researchers at the Technion are researching VOC exposure in daycare centers in the Haifa Bay area.

Researchers at the Technion Center of Excellence in Exposure Science and Environmental Health (TCEEH) are studying VOC exposure in daycare centers in the Haifa Bay area, including research on the relationship between ambient air quality and IAQ. According to interim results, indoor concentrations of more than twenty VOCs exceeded the simultaneously measured outdoor concentrations of the same VOCs. The surfeit of VOC concentrations indoors is related to emissions from indoor sources and the slower breakdown of organic matter in a protected indoor environment than in an outdoor environment, caused, among other factors, by less photochemical decomposition.
and oxidation due to the lack of direct sunlight. The study also found a strong effect of the rate of air exchange on VOC concentrations in the daycares; namely, VOC concentrations were lower in centers that extensively used natural ventilation (including those located near roads) than in others. Importantly, however, this study focused only on VOCs and not on other contaminants, such as particulate matter (PM).

**The challenge:** Study the health impacts of indoor air quality and the relationship between ambient air pollution and indoor air quality

**In short:** Several studies have been conducted.

In recent years, several studies have been conducted on the relationship between ambient air and indoor air and the health effects of IAQ. In one study, researchers from the Hebrew University of Jerusalem found that indoor and outdoor PM concentrations (with diameters less than 2.5 \( \mu \text{m} \) and ranging from 2.5 to 10 \( \mu \text{m} \)) were similar in the same area. Figure 1 displays the ratio of indoor to outdoor particles (IOR): the higher the ratio, the more particles enter the building. The ratios shown are in the city of Elad (three locations), Kibbutz Einat, and Kibbutz Givat Haim Ichud.\(^5\)

**Ratio of Indoor to Outdoor PM of Various Diameters, at Several Sites in Israel**

Other studies focus on the impact of smoking outside a pub on PM concentrations inside the pub, emission of VOCs from polyurethane mattresses under different sleeping conditions, and the effect of exposure to air pollution (indoor and outdoor) during pregnancy and early childhood on respiratory diseases.
The Ministry of Health (MoH) published a factsheet on indoor air pollutants, focusing on the types and sources of pollution. The document presents a series of recommendations for reducing exposure to these contaminants, such as refraining from smoking inside the home and from using wood-burning fireplaces, assuring ventilation, avoiding dampness, and spending less time in underground parking garages.  

In late 2019, the National Council for Planning and Construction formulated a recommendation for the Minister of Finance on standards to protect against dampness.

The challenge: Establish a central national authority to address indoor air quality

In short: No progress in meeting this challenge has been made.

To date, no central government authority has been established to address IAQ. Consequently, the topic receives neither priority nor funding. It is instructive to examine what other countries are doing: In the U.S., for example, a federal interagency committee on IAQ brings together representatives of various government agencies and departments, including the U.S. Environmental Protection Agency (U.S. EPA), the Department of Energy, the Occupational Safety and Health Administration (OSHA) and the Consumer Product Safety Commission (CPSC). In Germany, a national committee has been formed—the German Committee on Indoor Guide Values—to define values of indoor air pollutants. In South Korea, the government is instituting strict regulations on a wide range of indoor air contaminants.

The challenge: Conduct research on residential dust

In short: No progress in meeting this challenge has been made.
Research on Indoor Air Quality in Israel

- Researchers from TCEEH, the Hebrew University of Jerusalem, and Ben-Gurion University of the Negev are studying associations between respiratory diseases and exposure to air pollution (outdoor and indoor) during pregnancy and in early childhood.

- Researchers from TCEEH examined emissions of eighteen VOCs from eight types of polyurethane mattresses under varied environmental conditions (different temperatures, humidity levels, and CO₂ concentrations) and found that high temperature was the primary cause of increased VOC emissions from the mattresses.¹¹

- Researchers from TCEEH are studying VOC exposure in daycare centers in the Haifa Bay area and examining the relationship between ambient air quality and IAQ.

- Researchers from TCEEH examined whether smoking outside of a pub affects concentrations of PM inside the pub. By measuring particle number concentrations with special sensors installed at the entrance to a pub in Haifa, inside the pub, and in a designated smoking area outside the pub, they found an association between smoking outside the pub and an increase in particle number concentrations inside the pub.¹²

- Researchers from the Hebrew University of Jerusalem examined the association between indoor and outdoor PM concentrations in schools and residences. They found that indoor and outdoor PM concentrations (with diameters less than 2.5 µm and ranging from 2.5 to 10 µm) were similar in the same area.⁵

- Researchers from the Hebrew University of Jerusalem, Ben-Gurion University of the Negev, the University of Haifa, Tel Aviv University, Rambam Health Care Campus and Maccabi Health Services are analyzing “big data” of pregnancies and births in the Haifa Bay area from 1998–2017 (~750,000 births). The project examines environmental effects (including exposure to ambient and indoor air pollution) on fetal development in the Haifa Bay area in comparison with another area in Israel.¹³

Future Challenges

Although awareness of the harmful impact of indoor air pollution on public health has been growing in recent years, little progress has been made in tackling the challenges highlighted in the Environmental Health in Israel 2017 report. One reason for this is the lack of a central governmental authority or joint inter-ministerial task force to address the issue; another is lack of support for research in this field. Given the particular sensitivity of children to indoor and outdoor air pollution, it is essential to promote pilot studies on indoor air pollution in schools in Israel, expand the purview of such research, identify the sources of these contaminants in schools, and assess their impact on health. Such assessments may help shape relevant policy in Israel and formulation of guidelines for planning committees—for example, in choosing safe sites for schools in the context of main roads and other sources of pollution, such as agricultural fields and industrial plants.
Another challenge is to gain a better understanding of indoor air pollutants in Israel. For example: Are there sources of indoor air pollution that are unique to Israel? Which indoor micro-environments are more affected than others by air contaminants? How do the climatic conditions (wind, humidity, and temperature) in Israel affect the dispersion of contaminants inside high-rise buildings and the relationship between ambient air quality and IAQ?

Green building is gaining momentum in Israel and in the world, contributing to environmental quality and energy savings and thus contributing to public health as well. Israel’s current green building standards, however, do not include separate criteria for indoor air pollution. Furthermore, the principles of green building may sometimes have an adverse effect on IAQ. For example, the emphasis on sealing and energy conservation comes at the expense of ventilation of rooms. Therefore, it is important to address these aspects and to explicitly incorporate criteria on indoor air pollution into green building standards. The standard that relates to adequate ventilation in buildings with no central ventilation systems focuses on the size and location of openings (such as windows). In the current reality, however, with the widespread use of apartment air conditioners, this standard may not attain its objective and should be re-evaluated.
References


Exposure to environmental tobacco smoke (ETS), also referred to as secondhand smoke or passive smoking, increases the risk of lung cancer. In adults, exposure to ETS increases the risk of ischemic heart disease, asthma, and reduced lung function. In children and fetuses, it is causally associated with negative respiratory and developmental effects including low birth weight, Sudden Infant Death Syndrome (SIDS), lower respiratory tract infections, middle ear infections, upper airway sensitization, asthma, and lifelong cardiovascular effects.\(^1\) Childhood exposure to ETS is also associated with Type 2 diabetes and obesity.

There is evidence that exposure to ETS increases the risk of breast cancer, nasal sinus cavity cancer, and nasopharyngeal cancer in adults, and of leukemia, lymphoma, and brain tumors in children.\(^2\)

In Israel, smoking is banned in most closed public places including hospitals, schools and areas adjacent to them, trains and buses, restaurants, pubs, places of worship, and government buildings, as well as in some open public spaces such as playgrounds, zoos, swimming pools, railway station platforms, sports stadiums, and 75% of outdoor areas in pubs, restaurants, and wedding halls. Smoking is still permitted in designated areas in pubs, restaurants, and wedding halls, and there are special smoking rooms in the Knesset. The prohibitions on smoking in public places also apply to new tobacco products, such as electronic cigarettes and heat-not-burn tobacco products.

Despite extensive legislation to prevent exposure of the non-smoking population to ETS, surveys and studies show that over 50% of the Israeli population (including non-smokers and children) is exposed to ETS.\(^3\)
Progress since 2017

The Environmental Health in Israel 2017 report defined challenges related to Environmental Tobacco Smoke. Progress in meeting them during the past three years is outlined below.

**The challenge: Validate analytical techniques to measure cotinine levels in blood, urine and saliva samples**

<table>
<thead>
<tr>
<th>In short:</th>
<th>Challenge for the coming years:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Ministry of Health’s public health laboratory has validated and implemented a method for measuring cotinine levels in urine.</td>
<td>Continue to use the method.</td>
</tr>
</tbody>
</table>

In 2018–2019, staff at the Ministry of Health’s public health laboratory implemented an analytical method for measuring urinary cotinine levels. The method was validated in an international quality assessment program and is being used in biomonitoring studies in Israel.

**The challenge: Measure urinary cotinine levels in children**

<table>
<thead>
<tr>
<th>In short:</th>
<th>Challenge for the coming years:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant progress was achieved in measuring urinary cotinine levels in children.</td>
<td>Continue biomonitoring cotinine as part of the National Biomonitoring Program.</td>
</tr>
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</table>

In the National Health and Nutrition Survey (Rav-MABAT) in 2015–2016, urine samples were collected from 103 Jewish and Arab children aged 6–11, and urinary cotinine levels were measured to detect ETS exposure in the twenty-four hours prior to the sampling. Cotinine was detected in 59% of the children’s urine samples, indicating exposure to ETS. This contrasts with parents’ self-report, according to which fewer than 40% of the children were exposed to ETS. Among the children sampled, cotinine levels among those exposed to ETS at home exceeded cotinine levels of the others. Cotinine levels were higher in children of low socioeconomic status in both the Jewish and Arab populations.

In an international comparison of average cotinine levels, the findings among Israeli children exceeded those among children in Canada, Germany, England and Cyprus (Figure 1).

Recently published data from the Rav-MABAT survey (2015–2016) among over 1,500 children indicated that, according to parental reporting, 8.2% of children aged 2–11 were exposed to secondhand smoke to a large or very large extent (Jews: 3.9%, Arabs: 22.1%), while 22.3% were exposed to secondhand smoke to a small extent (Jews: 20.2%, Arabs: 29.4%) and 69.4% were not exposed at all (Jews: 76.0%, Arabs: 48.5%). It is possible the urinary measures of cotinine did not reflect differences in ETS exposure between Jewish and Arab children due to the small sample size of the study.

**Legend:**
- Significant progress
- Some progress
- Little or no progress
In the same survey, cotinine levels were measured in urine samples of 200 adults. Focusing on a sub-population of 133 non-smokers, urinary cotinine was detected in about 60% of the samples, indicating exposure to ETS. Both the scope and the level of exposure to ETS in non-smokers were unchanged relative to the findings of a similar study in Israel in 2011. Average cotinine levels in non-smoking adults were higher among the Arab population than among the Jewish population. Furthermore, the percentage of non-smoking Arabs who reported being exposed to ETS at home was higher than the percentage of non-smoking Jews who reported such exposure.

**Geometric Mean of Urinary Cotinine Levels in Children in Israel and in Selected Countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Urinary concentration (μg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada*</td>
<td>1.8</td>
</tr>
<tr>
<td>Sweden</td>
<td>1.6</td>
</tr>
<tr>
<td>Germany</td>
<td>1.4</td>
</tr>
<tr>
<td>Ireland</td>
<td>1.2</td>
</tr>
<tr>
<td>UK</td>
<td>1.0</td>
</tr>
<tr>
<td>Cyprus</td>
<td>0.8</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.6</td>
</tr>
<tr>
<td>Israel</td>
<td>0.4</td>
</tr>
<tr>
<td>Poland</td>
<td>0.2</td>
</tr>
<tr>
<td>Hungary</td>
<td>0.0</td>
</tr>
</tbody>
</table>

* Concentrations below the detection threshold were found in over 40% of the children; therefore, a geometric mean was not calculated.

**The challenge: Measure urinary cotinine levels in pregnant women**

**In short:** A study conducted at the Hadassah Medical Center measured cotinine levels in pregnant women and in newborns.

**Challenge for the coming years:** Continue biomonitoring cotinine levels in pregnant women and in newborns from different population groups in Israel.

In a study conducted at the Hebrew University-Hadassah Braun School of Public Health and Community Medicine in collaboration with Ministry of Health (MoH) researchers, cotinine levels were measured in urine samples collected from 265 pregnant non-smoking women and ninety-seven newborns. Cotinine was detected in the urine of about 40% of the women and 29% of the newborns. No association was found between the women’s cotinine levels and those of the newborns. (Notably, the urine samples were collected from the women during their pregnancy and from the newborns—soon after their birth.) Higher cotinine levels were found among women whose husbands smoked. The researchers found an inverse correlation between cotinine levels in newborns and their birth weight and head circumference. That is, newborns who had been exposed to ETS during their mother’s pregnancy were born with smaller head circumference and lower body weight than those of newborns not exposed to ETS.
A 2016 amendment to the Prevention of Smoking in Public Places and Exposure to Smoking Law completely banned smoking in schools, schoolyards, and anywhere within ten meters of a school entrance. In April 2018, the Director General of the Ministry of Education issued a circular regarding the implementation of the law and the enforcement policy concerning pupils and staff in the education system. The Ministry began to monitor enforcement in 360 elementary schools and anti-smoking curricular materials were updated and developed for different age groups—primary, junior-high, and senior-high.

An MoH study that examined asthma hospitalization rates in children (aged 0–14) between 1996–2015, analyzed by regions, found a significant downward trend in rates over the years. An MoH study that examined asthma hospitalization rates in children (aged 0–14) between 1996–2015, analyzed by regions, found a significant downward trend in rates over the years. An MoH study that examined asthma hospitalization rates in children (aged 0–14) between 1996–2015, analyzed by regions, found a significant downward trend in rates over the years. A joint study by MoH and Clalit Health Services is examining trends in asthma incidence and prevalence among children aged 2–18 between 1998–2015.

In 2018, new regulations expanded the ban on smoking in public places to open areas where over fifty people gather and to playgrounds, zoos, and parking garages. The injunction against smoking in public places was also extended to electronic cigarettes. Despite the expansion of anti-smoking regulations and various initiatives by local governments and the Israel Defense Forces (IDF), enforcement at the municipal level is insufficient and encounters a range of obstacles.

In 2018, municipal inspectors issued over 6,000 fines for violating the Prevention of Smoking in Public Places and Exposure to Smoking Law, mostly for smoking in restaurants and in hospitals (Figure 2). In many cities (Eilat, Haifa, Tur’an, Kefar Sava, Mevasseret Zion, Ma’ale Adumim, Nes Ziona, Acre, Afula, and Ramle), municipal inspectors were trained to enforce the law but few of those trained actually engage in enforcement.
As of 2019, seven municipalities (Herzliya, Kiryat Gat, Ashdod, Eilat, Ramle, Kefar Sava, and Ma’ale Adumim) joined the “Smoke-Free City” initiative, in which cities establish and enforce clear policies to ensure a smoke-free environment. Initiatives to bolster enforcement include Project Mahush (Promoting Innovation and Partnership), a collaborative effort involving municipal government, central government, and the public. The project aims to analyze patterns of ETS exposure, identify obstacles to enforcement and weaknesses in legislation, and jointly work to reduce ETS exposure.

In 2017, the IDF launched an intervention program aimed at reducing smoking and ETS exposure in the army. The program includes revisions of army policies and regulations, efforts to raise awareness of the harmful effects of smoking and to help soldiers quit smoking, and a gradual ban on selling smoking products on IDF bases. It was first applied on open bases and is gradually being expanded to other bases countrywide.

Research on Exposure to Environmental Tobacco Smoke in Israel

- Researchers from Tel Aviv University examined parents’ views regarding the exposure of their children to ETS. They found that the parents’ awareness of their children’s exposure to ETS was based on sensory perception in the context of the physical environment (whether smoke can be smelled or inhaled). The same group of researchers examined an intervention program aimed at reducing the exposure of children to ETS; the program includes measurement of nicotine in children's hair.
Tel Aviv University researchers asked what Israelis (smokers and non-smokers) know about cigarettes and found widespread ignorance of the harmful health effects of exposure to ETS. For example, 20% of the participants in the study did not know that ETS can cause lung cancer.\textsuperscript{14}

Researchers from MoH and the Israel Center for Disease Control analyzed cotinine levels in urine samples collected from 103 children and 200 adults (unmatched) who participated in the Rav-MABAT survey in 2015–2016. Cotinine was found in the urine samples of 59% of the children and about 60% of the non-smoking adults.\textsuperscript{4,7}

In a joint study by researchers from the Hebrew University-Hadassah Braun School of Public Health and Community Medicine and MoH, cotinine levels were analyzed in urine samples of 265 pregnant non-smoking women and ninety-seven newborns. Cotinine was detected in the urine of about 40% of the women and 29% of the newborns.\textsuperscript{8}

Researchers from the University of Haifa found a correlation between ETS exposure and an increased risk of breast cancer in Arab women.\textsuperscript{15}

Researchers from the Weizmann Institute of Science, in collaboration with colleagues in the U.S. and Japan, studied cellular defense mechanisms in mice exposed to cigarette smoke. They showed that certain molecules enable cells that were exposed to cigarette smoke to avoid cell death by triggering autophagy (orderly degradation of non-vital cellular components).\textsuperscript{16}

Researchers from Tel Aviv University and Mount Sinai Hospital in New York showed that ETS exposure affects atherosclerosis morbidity and is causally associated with coronary heart disease.\textsuperscript{17}

**Future Challenges**

Several countries have adopted new policies that further restrict smoking in order to reduce exposure of non-smokers to ETS:

- Smoking has been banned in cars when children are present (New Zealand in 2020, Puerto Rico and several U.S. states: Arkansas, Louisiana, California, Utah, Oregon, and Vermont).
- In the U.S., smoking was banned in multi-unit public housing in 2018 and, in various counties in California, in shared areas of multi-unit buildings (in 2006 and onwards).
- In Ireland, Scotland, England, and several states in the U.S. (New York, Michigan, and Minnesota), smoking was completely banned in restaurants and pubs (2004–2009).

Israel should consider adopting similar new restrictions and re-examining exceptions in existing restrictions on smoking in public places.
New MoH legislation from December 2018 limits the advertisement of tobacco products, requires uniform packs without advertisements, and expands the ban on smoking in public places. The legislation also subjects electronic cigarettes to all restrictions and requirements that apply to tobacco products and restricts nicotine content in electronic cigarette liquids. It is important to study the longitudinal impact of the new legislation on smoking, vaping, and ETS exposure among the non-smoking public. It is also important to update the 2011 National Tobacco Control Plan to include ETS from regular cigarettes, electronic cigarettes, and heat-not-burn tobacco products. As vaping becomes increasingly popular among youth in Israel (26% of whom smoked electronic cigarettes as of 2019), it is important to enforce the restriction on nicotine content in electronic cigarette liquids to prevent early nicotine addiction.

To strengthen enforcement of the smoking ban in public places, MoH should create a dedicated unit and develop innovative tools for reporting on smoking in public places. It is critically important to increase municipal involvement in controlling smoking in public places.

In addition to bolstering enforcement and raising the general population’s awareness of the hazards of smoking and ETS exposure, the focus should be on high-risk populations—including the Arab population, low socioeconomic status groups, pregnant women, and people with mental illness living in hostels in the community.

References


Exposure to chemical contaminants in drinking water is associated with adverse health effects in human populations. Exposure to the disinfection byproducts trihalomethanes (THMs), for example, has been linked to increased risk of bladder cancer and exposure to lead in drinking water is associated with impaired cognitive development.

Drinking water contains essential minerals that serve as trace elements (micronutrients) in human nutrition and in the food chain. Desalinated seawater is low in mineral content because minerals are removed during the desalination process. Consumption of drinking water with low concentrations of certain minerals—such as calcium, magnesium, iodine, and fluoride—may have adverse effects on health. There is evidence, for example, of a relation between low concentrations of magnesium in drinking water and increased risk of cardiovascular disease and between low calcium content in drinking water and a higher risk of bone fractures in children, certain neurological diseases, preterm birth and low birth weight, and some types of cancer. This issue is particularly relevant in Israel due to the growing use of low-mineral desalinated water in the drinking water systems of most areas of the country.
The chemical quality of drinking water in Israel is regulated by standards promulgated in 1974 and updated in 2013. The standards set maximum permitted levels of more than ninety chemical contaminants including metals, pesticides, radionuclides, and industrial organic pollutants. The standards require drinking water suppliers to conduct periodic testing for these contaminants in their sources (surface water, groundwater, and desalinated water) and to report the results to the Ministry of Health (MoH). While there is a requirement to add calcium to desalinated water, to date there is no requirement to add magnesium and iodine and the requirement to add fluoride is not implemented. Israel's drinking water standards include mandatory testing of supply systems for metals (iron, copper, and lead), water treatment chemicals (such as chlorine), and disinfection byproducts (total THMs, chlorite, and chlorate).

Even if the drinking water source is contaminant-free, the supply system can harm the quality of the consumer's tap water if, for example, pipes leach heavy metals. Therefore, all products that come into contact with drinking water (pipes, faucets, fixtures, and household drinking water systems) must meet the requirements of Israeli Standard 5452, which includes restrictions on lead content and leaching of heavy metals.

Progress since 2017

The Environmental Health in Israel 2017 report defined challenges relating to Chemical Parameters in Drinking Water. Progress achieved in this area during the past three years is outlined below.

The challenge: Conduct an updated survey to examine lead levels in tap water in residences and institutions, including schools

In short: In 2018, the MoH conducted a survey to quantify levels of heavy metals (including lead) in over 1,300 samples from drinking water taps in schools.

In 2018, MoH conducted a survey to quantify the levels of heavy metals in drinking water in schools (including kindergardens) throughout Israel, taking 1,379 drinking water samples in major cities and small towns in central Israel and in the periphery and analyzing them for lead, iron, and copper content. The concentrations of lead were below the standard in 99.6% of the samples, of iron in 99.7% of the samples, and of copper in 99.9% of the samples (Figure 1). In the few exceedances that were found, an investigation was conducted, flaws were repaired, and the water was resampled until the concentrations met the standard. There was no evidence of higher lead concentrations in samples containing both groundwater and desalinated water compared to those composed of groundwater only. The survey results indicate that lead concentrations in drinking water are lower in Israeli schools than in other countries. Although no surveys of lead in tap water are planned for the coming years, municipal authorities must routinely measure lead and other heavy metals in the supply system and make the findings available on an interactive online platform.
Following a joint effort by MoH and the Ministry of Economy and Industry (MoE), Israeli Standard 5452 for plastic and metal products in contact with drinking water was updated with the addition of a requirement, modeled after the U.S. Reduction of Lead in Drinking Water Act, 2011, to limit lead content to a maximum of 0.25% of product content. The mandate pertaining to plastic products went into effect in March 2018, and that pertaining to metal products went into effect in March 2020.

The challenge: Develop requirements to limit the lead content of products in contact with drinking water

In short: Israeli Standard 5452 was updated to include requirements to limit lead content to 0.25% in plastic and metal products that come into contact with drinking water.

Challenge for the coming years: Enforce Israeli Standard 5452; increase awareness among water suppliers, contractors, and the public, of the importance of purchasing and installing products that meet the standard.
Several studies in recent years examined the health effects of consuming desalinated drinking water with low-mineral content. Some of them investigated the association between morbidity and residence in a particular geographic area. Importantly, these studies were not based on individualized indices of mineral consumption by the study participants. Furthermore, residence in a particular geographic area yields limited information on consumption of desalinated water because the national water network provides a dynamic mix of desalinated water, water from the National Water Carrier, and groundwater, making it difficult to predict average mineral content in each geographic area.

Researchers from Bar-Ilan University and Sheba Medical Center at Tel Hashomer examined magnesium concentrations in tap water and in the blood of 380 patients who had been hospitalized for myocardial infarction in 2015–2017 and monitored the patients’ morbidity and mortality for a year. In areas where much of the water supply is based on desalinated water, lower concentrations of magnesium were measured in tap water and in patients’ blood whereas in areas where the water supply was based on groundwater or surface water higher magnesium concentrations were found (Figure 2). After a year of monitoring, the researchers found a non-significant increase in the risk of severe cardiac events and mortality in areas where much of the water supply was based on desalinated water.

Researchers from Bar-Ilan University, Sheba Medical Center, and Clalit Health Services explored whether increased consumption of desalinated water was followed by an increase in adverse health outcomes (heart disease, diabetes, and high cholesterol) in Clalit patients aged 25–76 in 2004–2013. They found that the risk of heart disease rose in those years, following the substantial increase in the supply of desalinated water in Israel, while the risk of diabetes and high cholesterol remained unchanged.

Researchers from the Hebrew University of Jerusalem studied the impact of desalinated water consumption on concentration of magnesium in blood, thyroid hormones, and use of cardiac medications among residents of Kefar Sava, Nes Ziona, and Rehovot. They found that switching to desalinated water consumption resulted in a decrease in magnesium in blood and thyroid hormone levels and an increase in use of cardiovascular medications.
As part of a study on the effects of iodine deficiency, researchers from Maccabi Health Services studied concentrations of hormones associated with thyroid function in 400,000 patients in 2010–2013 (before the upsurge in desalination) in comparison with 2014–2016 (after the upsurge). They found no changes in the prevalence of hypothyroidism in various populations before and after the upsurge in desalination. Likewise, they found no differences in hypothyroidism morbidity in patients from geographic areas that received larger quantities of desalinated water (since 2013) in comparison with patients from geographic areas that did not receive desalinated water.7

Researchers from the Hebrew University of Jerusalem and Barzilai University Medical Center conducted a cross-sectional study among 105 pregnant women living in an area primarily receiving desalinated drinking water and found that drinking water with low iodine content provided only about 9% of the recommended daily iodine intake. They also found that only a negligible percentage of women consumed iodized salt and only 52% took supplements containing iodine. Among those who did not take supplements, 92% had iodine deficiency. Low iodine intake was significantly associated with thyroid function.8
The 2013 drinking water standards include over ninety chemical contaminants including metals, pesticides, radionuclides, and industrial organic pollutants.9

The MoH’s public health laboratory and other laboratories (e.g., that of Mekorot, the national drinking water supplier) have been testing water with new analytical techniques in order to detect chemicals not included in the drinking water standards. MoH is using data collected by the labs to create a database of contaminants in drinking water. This includes data on volatile and semi-volatile organic micropollutants from different sources and all metals in the supply systems. The data serve as a decision support tool for regulatory activities.

The MoH database includes, for example, data collected by MoH’s public health laboratory in 2017–2018 that indicated the presence of the herbicide bromacil in 43% of drinking water wells, with an average concentration of 0.3 µg/L. In addition, MoH calls for monitoring the presence of the pharmaceutical carbamazepine (CBZ) and other organic micropollutants in wells at continual risk of contamination (in dense residential areas). The presence of these substances in wells may indicate the possibility of groundwater pollution from sewage. Between 2012 and 2020, only 160 of 711 collected water samples had quantifiable concentrations of CBZ (>10 ng/L); the concentration of CBZ in the other 551 samples was not quantifiable. MoH also monitors toxins released by cyanobacteria in Lake Kinneret (the Sea of Galilee). Cylindrospermopsin, a cyanotoxin, is unregulated in Israel but is carefully monitored in drinking water, especially during seasons in which concentrations are elevated.

There is currently no comprehensive data in Israel on concentrations of per- and polyfluoroalkyl substances (PFAS) in drinking water. The Water Authority conducted a survey in wells (not supplying drinking water) in vulnerable locations (such as fuel tank farms, landfills, and military airfields) and found high concentrations of perfluorooctanoic acid (PFOA)—as much as 25,000 ng/L—and perfluorooctanesulfonic acid (PFOS)—as much as 610,000 ng/L, along with evidence of contamination with other PFAS chemicals (PFBS, PFHxA, PFHxS, PFHpA, PFNA). In a second survey, which included drinking water wells, the Water Authority found lower PFAS concentrations: The maximum PFOA value was 47 ng/L and the maximum PFOS value was 330 ng/L, compared with the Canadian drinking water standard of 200 ng/L for PFOA and 600 ng/L for PFOS. The Water Authority and MoH are planning additional surveys.

The challenge: Establish a central database of emerging contaminants in drinking water

**In short:** Data was collected on concentrations of drinking water contaminants that are not included in the drinking water standards, e.g., bromacil (a herbicide) and carbamazepine (a pharmaceutical).

**Challenge for the coming years:** Collect data on the presence of per- and polyfluoroalkyl substances and disinfection byproducts (haloacetic acids) in drinking water in Israel.

In short: Data was collected on concentrations of drinking water contaminants that are not included in the drinking water standards, e.g., bromacil (a herbicide) and carbamazepine (a pharmaceutical).
Drinking water has not been fluorinated in Israel since 2014. According to HMO data from 2013, the year before fluoridation was discontinued, fewer than 5,000 children up to age five underwent dental procedures with anesthesia. In 2018, four years after the discontinuation of fluoridation, the number of pediatric dental sedations in this age group exceeded 10,000, an increase of over 100%.

In a 2019 survey of kindergartens in southern Israel (Beer Sheva, Mitzpe Ramon, Rahat, and Kuseife), MoH examined 283 children and found that 33% of them had no dental caries, compared to 38% of children in a 2014 national survey. The 2019 survey found an increase in caries in Jewish localities but not in Bedouin ones. Since desalinated water is low in minerals (including fluoride), the researchers concluded that the children in Bedouin localities, who drink groundwater that contains natural fluoride, were not adversely affected by the discontinuation of fluoridation.

According to nationwide data collected by the School Dental Service among twelve-year-olds, the percentage of children without dental caries declined from 26% in 2015 to 23% in 2017.\(^\text{10}\)

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**Research on Drinking Water Quality in Israel**

- Researchers from the Technion and Mekorot developed an algorithm for rapid detection of drinking water contamination (including nitrites and nitrates) using a UV spectrophotometer. When tested with both artificial and real life datasets, the algorithm demonstrated high detection and low false alarm rates.\(^\text{11}\)

- Several studies, mentioned above, examined the health effects of consuming desalinated drinking water with low mineral content on rates of heart disease, diabetes, and high cholesterol; hypothyroidism; iodine intake and thyroid function and magnesium in blood; thyroid hormones; and use of cardiovascular medications.\(^\text{6}\)

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**The challenge:** Assess the impact of discontinuing fluoridation on children’s dental health, especially among children of low socioeconomic status

**In short:** HMO data shows a 100% increase in the number of pediatric dental treatments with sedation and a rise in dental caries.

**Challenge for the coming years:** Reinstate compulsory fluoridation of desalinated drinking water in Israel.

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**The challenge:** Develop a model to estimate mineral content (iodine and magnesium) at central mixing junctions and points of consumption

**In short:** No progress was made due to lack of funding.
Researchers from Ben-Gurion University of the Negev, in collaboration with Dutch and British colleagues, developed a sensor for monitoring toxic compounds in water using genetically engineered (non-pathogenic) bacteria that respond to changes in water quality by emitting luminescence. The sensor was successfully tested in laboratory conditions and at the Meuse River in the Netherlands.\(^{12}\)

Researchers from Mekorot and the Geological Survey of Israel, in collaboration with French researchers, developed a technique for monitoring the “isotopic fingerprints” of water (concentrations of isotopes of various elements, such as boron). The technique makes it possible to monitor desalinated water and reclaimed wastewater (such as that treated at the Shafdan facility) and facilitates the analysis of the water cycle (i.e., which water reaches which areas). It may be helpful in planning Israel’s water economy.\(^{13}\)

**Future Challenges**

Theoretical work for a pilot study on the feasibility of adding magnesium to desalinated water was completed in 2020 and the on-site study is planned for 2021. A challenge for the coming years is to track the results of the pilot study and translate the findings into policy—compulsory addition of magnesium and an optimal level of this mineral in drinking water. In light of the rapid increase in consumption of low-mineral desalinated water, there is a need to examine the intake of micronutrients in Israel—including iodine, magnesium and fluoride—by using nutritional biomarkers. It is also important to study the effects of using low-mineral water in agriculture on the nutritional value of agricultural produce.

In 2018–2020, the EU issued recommendations on updating drinking water standards. The recommendation to lower the lead standard in drinking water to 5 µg/L will go into effect within fifteen years of its approval. One challenge for Israel in the coming years is to toughen its own standard on lead content in drinking water. Based on lead monitoring in the supply network, 99.6% of results comply with the standard. However, about 150 small localities do not routinely monitor lead in the supply network as required. It is imperative that all localities monitor lead in their supply networks in accordance with requirements in the drinking water standards. In addition, standards need to be set for new contaminants, such as haloacetic acid disinfectant byproducts and PFAS. To accomplish this, it will be necessary to collect data on the presence of haloacetic acid disinfectant byproducts and PFAS countrywide. Preliminary data from Water Authority surveys shows significant PFAS groundwater contamination in hotspots in Israel.

THMs are disinfection byproducts that are formed during chlorination of water with high levels of organic matter (such as surface water). Given the range of drinking water sources used in Israel (desalinated water, groundwater and surface water), each with its own level of organic
material, there are major geographical and temporal fluctuations in concentrations of THMs. In communities in northern Israel that receive surface water from the Sea of Galilee, over 5% of sampling results exceeded the standard of 100 µg/L in the summer of 2020. Due to the high bromate content of the Sea of Galilee, it is likely that much of the THMs are brominated, although bromoform is not routinely monitored in Israel. Mekorot has introduced several methods to reduce THM levels including evaporation stations, reduction of stagnation time, and a shift to chlorine dioxide disinfection. Notably, use of chlorine dioxide may result in the formation of two additional toxic disinfection products, chlorite and chlorate. Efforts to reduce THMs, chlorite and chlorate concentrations should be monitored. There is also a need for a reassessment of the Israeli standards for these disinfection byproducts.

Historically, the pesticides atrazine and simazine have been major contaminants of drinking water in Israel. Following the reduction in the use of atrazine and discontinuation of the use of simazine (2012–2014), atrazine concentrations in drinking water sources have decreased but simazine concentrations have not. It is important to continue monitoring concentrations of atrazine, simazine, and additional pesticides with potential for groundwater contamination.
References


(10) Israel Ministry of Health, Dental Health Department (May 2020).


Most raw wastewater (sewage) in Israel is treated in treatment plants. The treatment process includes biological, chemical, and physical methods to lower contaminant concentrations. In Israel, agricultural irrigation is the principal use (85%) of reclaimed wastewater (RWW). Roughly half of all water allocated for irrigation is RWW. Irrigation with RWW that meets the required Israeli quality standards is considered safe, however there is information on pathogens and organic contaminants, such as residues of pharmaceuticals or chemicals not routinely monitored, that may be absorbed by crops or may seep into groundwater. There is also concern that a temporary malfunction at a wastewater treatment plant could contaminate agricultural produce, streams, groundwater, and seawater.

Current RWW quality regulations in Israel address potential risks to public health that may result from transmitting pathogens and other contaminants from RWW to crops, groundwater, streams, and seawater, and ultimately to the public. The regulations also address the potential risks of metal concentrations in RWW to public health, environmental health, and agriculture. The Ministry of Health (MoH) and the Ministry of Environmental Protection (MoEP) jointly set quality standards for irrigation with RWW and discharge of effluents into streams. In addition, guidelines on irrigation with RWW require barriers between the water and the irrigated crops (for example, the use of drip irrigation or a specified minimal time interval between irrigation and harvest). Nevertheless, regulations have not been passed on monitoring and restricting a range of organic contaminants and micro-pollutants, such as pharmaceutical residues in RWW.
Progress since 2017

The Environmental Health in Israel 2017 report defined challenges related to Reclaimed Wastewater. Progress achieved in this area during the past three years is outlined below.

The challenge: Conduct additional studies on potential exposure to pharmaceuticals and other contaminants via produce irrigated with reclaimed wastewater

In short: A study conducted found higher urinary concentrations of carbamazepine in populations that consumed more vegetables; recent studies indicate the accumulation of carbamazepine in plants irrigated with RWW.

Challenge for the coming years: Study potential exposure to additional micro-pollutants in crops irrigated with RWW.

Researchers from the Hebrew University Center of Excellence in Agriculture and Environmental Health quantified urinary levels of carbamazepine (CBZ) and their metabolites in a reference group of healthy omnivorous adults and various sub-populations: children, pregnant women, the elderly, and vegetarians and vegans. High levels of CBZ were found among vegetarians, vegans, and other participants who consumed larger quantities of vegetables (Figure 1).\(^1\)

![Distribution of CBZ Urinary Concentrations in Sub-Populations in Israel](Schapira et al., 2020)

Researchers from the Hebrew University of Jerusalem studied the uptake, transport, and metabolism of CBZ in various agricultural crops, in different parts of the plant, and compared crops irrigated with freshwater and fertilized with biosolids with those irrigated with RWW. They showed that the crops irrigated with RWW tended to accumulate higher concentrations of CBZ.\(^2\)
MoH, MoEP and the Water Authority have created an integrated database that includes monitoring data on various contaminants in sewage, RWW, and sludge. The database, in advanced stages of development, allows direct data feed from accredited labs. The system includes a portal for online input of data from control procedures conducted by plant operators and allows for data analysis. At the present writing, the database contains tens of thousands of entries from some 400 wastewater treatment plants nationwide.

In addition to the information collected in the database, it may be useful to collect data on antibiotic resistant bacteria and antibiotic resistant genes in sewage, RWW, fields, and agricultural produce, and to cross reference them with data on antibiotic resistance from hospitals.

Research thus far has focused on CBZ. Studies on CBZ concentrations in plants irrigated with RWW have not shown that these concentrations pose a risk to public health. It is presumed, however, that RWW contains many other chemicals (micro-pollutants and pharmaceutical residues) that are not routinely monitored. Despite the widespread use of RWW to irrigate agricultural crops in Israel, no comprehensive risk assessment on the effects of these contaminants has been conducted. The regulations for RWW quality for agricultural irrigation in Israel comport with the World Health Organization's (WHO) 2006 risk assessment, which focused primarily on heavy metals and pathogens. Risk assessments dealing with chemical micro-pollutants in RWW are very few in number.

**Research on Reclaimed Wastewater in Israel**

- Researchers from the Hebrew University of Jerusalem exposed chicken eggs to low environmental concentrations of CBZ (0.02–0.2 pg/mg), resembling concentrations measured in RWW, and found that exposure to even low environmental concentrations induced increased embryonic mortality and teratogenic effects.³
• Researchers from the Hebrew University Center of Excellence in Agriculture and Environmental Health quantified urinary levels of CBZ and their metabolites in children, pregnant women, the elderly, vegetarians, and vegans. High levels of CBZ were found among vegetarians, vegans, and participants who consumed larger quantities of vegetables.¹

• Researchers from the Hebrew University of Jerusalem studied the uptake, transport, and metabolism of CBZ in various agricultural crops, in different parts of the plant, and compared crops irrigated with freshwater and fertilized with biosolids with those irrigated with RWW. They showed that the crops irrigated with RWW tended to accumulate higher concentrations of CBZ.²

• Researchers from the Hebrew University of Jerusalem, in collaboration with colleagues from the University of Leeds and Al-Quds University in eastern Jerusalem, conducted a holistic analysis that included an assessment and examination of the transfer pathways of pharmaceuticals found in RWW used in agricultural irrigation. Attempting to assess the impact of these pollutants on human health and on ecological systems, the researchers concluded that broad research is needed to understand these effects.⁴

• Researchers from Tel Aviv University analyzed regulation in various countries for monitoring and removing pharmaceuticals from various water sources—regulation that does not exist in Israel. Focusing on Switzerland, Austria, Singapore, and the U.S., where RWW is also used as a source of drinking water, the researchers offered several proposals for monitoring and treating these pollutants in Israel’s water systems, with emphasis on RWW, in order to reduce potential exposure of the public.⁵ Notably, no regulation exists anywhere in the world for monitoring and removing pharmaceuticals in RWW used for agricultural irrigation.

• Researchers from Tel Aviv University showed that the use of ethanol-activated granular aerogel was effective in adsorbing persistent organic pollutants (POPs) in hospital raw wastewater.⁶

• Researchers from the Hebrew University of Jerusalem, in collaboration with colleagues at the University of Chicago, studied the impact of RWW irrigation on a microbial community of soil and roots and on the growth of agricultural crops (tomato and lettuce). They found that in comparison with freshwater irrigation, RWW irrigation raised the level of soil acidity (pH) and increased the concentrations of various elements, such as potassium and sodium, in the soil. They also found that irrigation with RWW resulted in lower plant fruit and shoot weight and altered the plant’s soil and root microbiome.⁷

• Researchers from the Agricultural Research Organization's Volcani Center and the Hebrew University of Jerusalem found no correlation between the presence of certain antibiotic resistant genes (int11) in RWW and their presence in soil irrigated with this wastewater, with the exception of sandy soils. They also found no evidence that antibiotic resistant genes were transferred from the RWW to the soil or to the plant.⁸
Researchers from Ben-Gurion University in the Negev, in collaboration with colleagues from the Volcani Center, the Newe Ya’ar Research Center, and from the Environmental Protection and Research Institute – Gaza, studied the role of physical barriers (drip irrigation or plastic mulch) in preventing bacterial transmission from irrigation water (with an emphasis on treated wastewater) to agricultural crops. The researchers quantified the concentrations of fecal bacteria in cucumber and melon plants irrigated with treated wastewater or potable water, with and without these barriers. No association was found between the type of barrier or water source and the concentrations of fecal bacteria in the soil or the crops.

Future Challenges

Raw wastewater in Israel is treated regularly and, for the most part, efficiently. The existing wastewater treatment infrastructure, however, is insufficient for dealing with increasing loads, and with events involving exceptionally large quantities of raw wastewater, for example, during heavy rain. In such cases, excess untreated wastewater from the treatment plants is discharged to the environment, potentially exposing the population in Israel to a broad range of contaminants. In addition, the capacity of wastewater storage systems is inadequate (particularly during the winter, when there is no agricultural consumption of RWW). In these cases, wastewater is discharged into streams, posing a potential risk to public health. Consequently, it is necessary to improve the infrastructure for sewage treatment and RWW storage in Israel, and to adapt it to the steadily increasing volume of sewage and RWW.

In 2020, the Water Authority (via Mekorot, the national drinking water supplier, and in coordination with MoH and MoEP), launched a pilot facility for advanced treatment of RWW at the Shafdan plant—a preliminary step toward building an industrial facility for treating some RWW (5,000 m$^3$/h) without soil aquifer treatment (SAT). The facility will utilize advanced technologies such as membrane bioreactor (MBR), ozonation, biological activated carbon filtration, and UV to remove a large range of micro-pollutants known as “contaminants of emerging concern” (CECs), including pharmaceuticals, per- and polyfluoroalkyl substances (PFAS), and other industrial pollutants. The facility is expected to treat about a quarter of the secondary treated effluent at the Shafdan site and to remove more than 80% of these contaminants. MoH, MoEP and the Water Authority are working to enhance control of micro-pollutant concentrations in industrial sewage, especially in the pharmaceutical industry.

Risk assessments are needed, as are holistic analyses that integrate data collected in the new database, monitoring of data from the field (soil and agricultural produce), and monitoring of biological data (for example, CBZ in urine). It is important that the risk assessments address exposure to a large number of chemicals and pharmaceuticals in RWW (by using, for example, additive or synergistic models). In light of growing evidence that municipal wastewater is a source of PFAS$^{10}$ and POPs including flame retardants and organochlorine pesticides, it would also be worthwhile to consider monitoring other contaminants, such as PFAS, and POPs in RWW and sludge.
References


Pesticides

Pesticides are substances or mixtures of substances that are meant to prevent, destroy, repel, or mitigate pests. They include products for use in agricultural plant protection and in rural and urban environments to control weeds and protect humans from pests and vector-borne diseases.

Acute exposure to high doses of certain pesticides, whether occupational or by accidental poisoning, can cause severe adverse health effects including neurological impacts and even death. Even chronic low-dose exposure to pesticides has been associated with neurological, respiratory, reproductive, and endocrine effects as well as cancer. Toxicological and epidemiological studies indicate that fetuses, infants, and children are especially vulnerable to the adverse effects of pesticides.

New classes of biological pesticides (containing bacteria or fungi), as well as chemical pesticides such as pyrethroids and neonicotinoids, are increasingly replacing pesticides that are known to be toxic for humans—for example, carbamates and organophosphates (OPs). Evidence of the toxicity of these new classes of chemical pesticides, however, has been emerging.\textsuperscript{1, 2}

Four government authorities are responsible for registering pesticides in Israel:

- The Plant Protection and Inspection Services unit at the Ministry of Agriculture and Rural Development (MoAg) registers pesticides for plant protection.
- The Veterinary Services unit at MoAg registers pesticides and disinfectants for use in animals and animal husbandry.
- The Ministry of Environmental Protection (MoEP) registers pesticides used for sanitation purposes—that is, for controlling mosquitoes, rodents, and other pests harmful to humans and their property—in and around buildings and in open spaces.
- The Ministry of Health (MoH) registers pesticides that are applied on the human body, e.g., for lice treatment or mosquito repellent for topical use.
Most of the pesticides sold in Israel are for plant protection—more than six tons of active ingredients in 2016—along with 135,000 kilograms of active ingredients for sanitation and 33,780 kilograms of active ingredients for veterinary use.¹

The authorities responsible for registering pesticide formulations also share responsibility for monitoring their use. MoAg and MoH monitor pesticide residues in food—MoAg in local produce at the farm level, MoH in products on the market as well as food imports.⁴ MoEP oversees the use of pesticides for sanitation; MoAg oversees their veterinary and plant protection use. Since MoAg is the authority that registers herbicides, commonly known as weed killers, it also bears responsibility for overseeing herbicide use outside of agricultural areas, e.g., in cities.

MoEP and MoAg are jointly responsible for two standards that establish mandatory minimum distances from buildings that must be maintained when applying pesticides from the ground and air. MoEP is responsible for ensuring that these distances are maintained when pesticides are sprayed from the air or in proximity to water reservoirs and streams. The Ministry of Labor and Social Welfare is responsible for the safety of agricultural workers.

The environmental NGO Adam Teva V’din (the Israel Union for Environmental Defense) is advocating legislation that would require the government to prepare a national plan for reducing the use of pesticides. In the absence of regular Knesset committee hearings in 2019 (due to the political impasse), however, the initiative did not move forward. Even without a national plan, MoAg is promoting initiatives to reduce pesticide use—for example, a project targeting the Mediterranean fruit fly that includes non-chemical pest control.⁴

### Progress since 2017

The *Environmental Health in Israel 2017* report defined challenges related to Pesticides. Progress achieved in this area during the past three years is outlined below.

<table>
<thead>
<tr>
<th>The challenge: Conduct periodic re-evaluation of all active ingredients approved for plant protection</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In short:</strong> MoAg, in conjunction with the inter-ministerial advisory committee on pesticide formulations for plant protection, re-evaluated forty-six active substances used in 130 different pesticide formulations. These substances are registered in Israel but not in Europe.</td>
</tr>
<tr>
<td><strong>Challenge for the coming years:</strong> As part of the phaseout of active ingredients, the advisory committee should study pesticide substitutes; furthermore, pesticides registered in Israel for many years that have not been evaluated in the revisions should be re-evaluated.</td>
</tr>
</tbody>
</table>

In 2017–2019, MoAg and the inter-ministerial advisory committee on pesticide formulations for plant protection re-evaluated forty-six active ingredients that are registered in Israel but not in Europe.⁵

<table>
<thead>
<tr>
<th>Legend:</th>
<th>Significant progress</th>
<th>Some progress</th>
<th>Little or no progress</th>
</tr>
</thead>
</table>
The list of ingredients was not compiled on the basis of toxicity or potential public health risk; the sole criterion was that the ingredient is not registered in Europe. About one-third of these active ingredients are herbicides; another third are insecticides and acaricides. MoAg published decisions on thirty-two active ingredients. For five others, it asked pesticide manufacturers to submit additional documentation for further evaluation. Of the forty-six active ingredients registered in Israel and not in Europe, the committee recommended discontinuing the use of seventeen. Based on the committee’s recommendations, as of March 2020, MoAg was phasing out the use of eight active ingredients (Table 1). Decisions on the other active ingredients are slated to be published in the course of 2020.

### Plant Protection Pesticides Phased Out in Israel

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Main Reason for Phaseout</th>
<th>Last Date for Selling Formulations Containing the Active Ingredient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbendazim</td>
<td>Chronic toxicity (classified as a mutagen, harms fertility)</td>
<td>June 2020</td>
</tr>
<tr>
<td>Paraquat</td>
<td>Very high acute toxicity, chronic toxicity (Parkinson’s disease)</td>
<td>June 2020</td>
</tr>
<tr>
<td>Maneb</td>
<td>Harms the developing fetus</td>
<td>November 2018</td>
</tr>
<tr>
<td>Propargite</td>
<td>Carcinogenic</td>
<td>June 2019</td>
</tr>
<tr>
<td>Iprodione</td>
<td>Carcinogenic and harms fertility</td>
<td>December 2020</td>
</tr>
<tr>
<td>Guatazine</td>
<td>Not registered in Europe and in the U.S.; acute toxicity</td>
<td>December 2019</td>
</tr>
<tr>
<td>Tetradifon</td>
<td>Lack of agricultural need</td>
<td>November 2019</td>
</tr>
<tr>
<td>Alachlor</td>
<td>Carcinogenic</td>
<td>September 2020</td>
</tr>
</tbody>
</table>

The re-evaluation in 2017–2019 followed earlier rounds, including an evaluation of eleven active ingredients from the triazole family in 2016–2017. Following the latter evaluation, MoAg restricted the use of four active ingredients and banned the use of one – diniconazole-M.

Another re-evaluation addressed herbicides used in non-agricultural areas such as towns, roadsides, and the vicinity of water reservoirs. Following this re-evaluation MoAg published a list of herbicides approved for use in such areas and cited places where their use is permitted or prohibited. In a re-evaluation of urban use of glyphosate, MoAg allowed the continued use of this ingredient in Israel, including in non-agricultural areas.
In recent years, data have been published on the Israeli public’s exposure to OP pesticides. Researchers from the Hebrew University-Hadassah Braun School of Public Health and Community Medicine, collected urine samples from 273 pregnant women and from 107 newborns in 2012–2016, and measured OP metabolites. Researchers found a ~35% decrease in the concentration of total OP metabolites in the samples from both population groups during the period studied. No decrease was observed in the concentration of diethyl phosphate (DEP) metabolites. Similar findings were reported in an MoH study, part of the 2015–2016 National Health and Nutrition Survey (Rav-MABAT), that measured concentrations of urinary OP metabolites in 200 adults and 103 children. The researchers found a statistically significant decrease in urinary OP metabolites among adults compared with 2011 (Figure 1). As in the findings on OP pesticides among pregnant women and newborns, no decrease in the concentration of DEP metabolites was observed. The OP decrease was apparently the result of restrictions imposed on the agricultural use of certain OPs in 2012–2014. The quantity of OPs sold for agricultural use in Israel dropped from an average of 164 tons/year in 2008–2010 to 103 tons/year in 2012–2016. However, the fact that there was no decrease in concentrations of DEP metabolites raises concerns that the use of certain active ingredients such as chlorpyrifos and dimethoate did not decline.

Biomonitoring results in recent years in Israel indicate an association between fruit consumption and OP exposure. Among pregnant women who reported eating fruit in the twenty-four hours preceding urine collection, the concentration of a specific chlorpyrifos metabolite (TCPy) was twice as high as in women who did not report eating fruit before urine collection (3.0 µg/L versus 1.5 µg/L). Among children, concentrations of OP metabolites were higher in those who consumed large quantities of fruit than in those who consumed smaller quantities.

As part of the National Biomonitoring Program, an additional survey to monitor public exposure to OP and pyrethroid pesticides began in 2020.
Concentrations of Total Non-Specific Organophosphate Metabolites in Urine in Adults in Israel, 2015 vs. 2011

Based on dietary data from the 2015–2016 Rav-MABAT survey, MoH assessed the risks associated with children's exposure to pesticides and found that children's exposure to chlorpyrifos and dimethoate pesticides exceeded the health reference values (Acceptable Daily Intake—ADI) set by the European Food Safety Authority (EFSA). The results of the risk assessment were presented to MoAg and appeared in an MoH position paper on chlorpyrifos.

Importantly, the aforementioned exposure assessment was partly based on the results of pesticide residue monitoring of fresh farm produce marketed in Israel. In its monitoring of markets, MoH found exceedances in 12.7% of approximately 2,000 samples taken in 2017–2018 and detected no pesticide residues in 36.7% of the samples. A multi-year comparison (2013–2018) shows that in the years 2017–2018, there was a relative increase in the percentage of exceedances, along with a decrease in the percentage of samples in which no pesticide residues were found (Figure 2).

According to a MoAg report, exceedances were found in 11% of the samples tested for pesticide residues in 2017; half of them were not considered exceedances when compared with standards in EU countries.

The challenge: Conduct risk assessment on pesticides based on children’s diet

In short: MoH conducted a risk assessment on exposure to OP pesticides based on children’s diet.

Challenge for the coming years: Continue to conduct risk assessments of additional groups of pesticides, and in additional vulnerable groups such as women of childbearing age.
There is no systematic collection of data on all cases of pesticide poisoning in Israel. However, the Israel Poison Information Center at the Rambam Health Care Campus collects and publishes data on inquiries from the public and from physicians. Importantly, the Center’s data do not distinguish between cases of poisoning from agricultural pesticides and those from sanitation pesticides.

According to data on pesticide poisoning in 2018, there were over 1,200 inquiries concerning poisoning from insecticides, about eighty concerning poisoning from herbicides, and more than 100 concerning poisoning from rodenticides. Eleven of the seventy-seven inquiries related to OP poisoning were cases of severe toxicity. Also reported were 589 cases of poisoning from exposure to pyrethroid insecticides, thirty-three from glyphosate formulations, and fourteen from paraquat, two of them severe. Although the number of inquiries received by the Israel Poison Information Center has been increasing in recent years, the number of OP pesticide-related poisonings has been decreasing (Figure 3).\textsuperscript{13}
Pesticide Poisoning in Israel, by Type of Pesticide, 2007–2018

The challenge: Improve enforcement of sale and use of agricultural pesticides

In short: Legislation is needed to improve oversight in this area. No significant progress has been made in advancing legislation to limit the sale and use of toxic pesticides.

Under the proposed Safety Regulations at Work (Occupational Hygiene and Workers’ Health in Pesticides), 2018, only specially trained professionals may apply or purchase pesticides except those labeled for use by the public. In the absence of regular Knesset committee hearings in 2019, however, these measures were not approved. Legislation proposed by the Israel Union for Environmental Defense, titled “Public Health Protection Law: Reducing Pesticide Risk,” addresses the need to train workers who handle particularly dangerous pesticides. The bill, submitted to the Knesset in late 2017, was also stalled due to the Knesset’s paralysis.

The challenge: Monitor pesticides in the air near schools and residences

In short: There is no government plan in Israel for monitoring pesticides near schools and residences, and there are no academic studies in this field.

A study initiated by the Regional Councils Center at Emek Hefer measured air concentrations of pesticides near three localities in Emek Hefer: Kibbutz Ma’abarot, the Bat Hefer community settlement, and Elyakhin Local Council. The researchers, examining the adsorption of pesticides on filters, found higher air concentrations of two pesticides, pendimethalin and spirotetramat, for about eight hours after spraying than before spraying. Twenty-four hours after spraying, the concentrations of these substances in the air decreased but remained higher than the level detected during spraying.
In August 2017, MoEP issued professional guidelines for pest control in and around schools. The guidelines prohibit pesticide and herbicide use when children are present. Pesticide application in a school is permitted only after approval of the responsible official in the local government and in coordination with the principal of the school. However, there are no available data on the extent of implementation of the new guidelines by schools and local authorities.

The Israel Union for Environmental Defense is advocating a reform that would help to standardize registration requirements and working methods for all active ingredients and pesticide formulations and would require revision every few years based on clear criteria—for example, the level of risk posed by the pesticide.

The challenge: Advance uniform and comprehensive legislation on registration and use of all types of pesticides (including the establishment of an umbrella committee on pesticide registration and/or unification of registration committees)

In short: The inter-ministerial steering committee on pesticide registration has discussed the issue, without result.

Research on Exposure to Pesticides in Israel

- Researchers from Ben-Gurion University of the Negev examined the effects of prenatal exposure to chlorpyrifos in mice and found that exposure to this OP impairs social skills. The impairment is different in males compared with females. The researchers also found that prenatal exposure to chlorpyrifos causes behavioral disorders similar to autism.

- Researchers from Tel Aviv University and the Technion Center of Excellence in Exposure Science and Environmental Health (TCEEH), examining the environmental behavior of chlorpyrifos after it is sprayed on leaves, found that the environmental half-life of chlorpyrifos on leaves is 0.9–6.9 hours.

- Researchers from the Agricultural Research Organization’s Volcani Center and Kimron Veterinary Institute measured pesticide residues in cherry tomatoes as a function of irrigation water salinity, household rinsing, and storage. They found that washing the tomatoes for thirty seconds under running water was ineffective in removing pesticide residues from the peel.

- Researchers from the Hebrew University Center of Excellence in Agriculture and Environmental Health, MoAg, and Volcani Center studied the effects of the herbicide atrazine on sperm quality and the impact of early exposure to food additives on these effects in goats. They found that exposure to atrazine harms sperm quality and that early exposure to the food additive *pistacia lentiscus* mitigates the toxic effect of atrazine among goats to some extent. Researchers from the Hebrew University of Jerusalem, examining the effect of atrazine exposure on bovine sperm, found that sperm cells are particularly sensitive to atrazine.
Researchers from MoH measured concentrations of urinary OP metabolites in 200 adults and 103 children as part of the Rav-MABAT survey.\textsuperscript{9,10}

Researchers from the Hebrew University-Hadassah Braun School of Public Health and Community Medicine collected urine samples from 273 pregnant women and 107 newborns in 2012–2016, and measured specific and non-specific urinary OP metabolites.\textsuperscript{7}

Researchers from the Hebrew University of Jerusalem, Jewish General Hospital in Montreal, Al-Quds University in eastern Jerusalem, Al-Hussein Governmental Hospital in Beit Jala, and Augusta Victoria Hospital studied exposure to organochlorine pesticides in the Jewish and Palestinian Arab populations. The researchers found an association between non-Hodgkin’s lymphoma and exposure to dichlorodiphenyldichloroethylene (DDE) in the Palestinian Arab population only.\textsuperscript{22}

**Future Challenges**

In December 2019, the EU banned the use of the OP pesticide chlorpyrifos for plant protection. While Israel has narrowed the list of crops for which chlorpyrifos may be applied, it still permits use of this pesticide, mainly in orchards and vineyards, and residue exceedances are still found in agricultural produce. Given the toxicological characteristics of chlorpyrifos, the inter-ministerial advisory committee on pesticide formulations for plant protection recommended canceling the registration of chlorpyrifos formulations in Israel. MoAg should consider banning the use of this pesticide altogether.

The results of various analyses—monitoring pesticide residues in food, biomonitoring urinary OPs in children, and assessing OP exposure based on children’s diet—indicate the need to tighten oversight of pesticide use in Israel and to adopt enforcement measures. There is also a need to expand information outreach in order to reduce the use of pesticides and public exposure to them. To bring this about, all relevant entities, particularly MoH and MoAg, must cooperate.

Several active ingredients that are especially toxic and at the same time very effective, including paraquat and carbendazim, are slated for phaseout in the coming years. Therefore, economic and regulatory incentives are needed to develop substitutes. MoAg favors the accelerated registration of less toxic or substitute formulations that have already been registered in developed countries (primarily Europe and the U.S.). This would also entail adopting international regulation on maximum permissible residue levels. MoAg also supports the gradual phaseout of critical uses of formulations in order to avoid direct and immediate harm to certain agricultural sectors.

According to the Public Health Regulations (Food) (Pesticide Residues), 1991, food imported to Israel must meet the Israeli standard or the Codex Alimentarius (the international standard for pesticide residues). Thus, food may enter Israel even if it was treated with a pesticide that is banned for use pursuant to a risk assessment by the inter-ministerial committee (for example, certain OPs). A regulatory solution is needed to address this issue.
A regulatory framework is needed for prohibiting the sale of especially toxic pesticides to the public and restricting their use. Both the Ministry of Labor and Social Affairs and the Israel Union for Environmental Defense have proposed regulatory solutions that have not advanced due to the political impasse in 2019.

As part of its re-evaluation of the OP chlorpyrifos, MoH presented data from biomonitoring studies and a risk assessment based on children's diet. The challenge in the coming years is to expand the use of these tools to additional groups of pesticides, including pyrethroids and neonicotinoids, and to additional groups of vulnerable populations including women of childbearing age.

References


Chemical food contaminants are substances that are not intentionally added to food but may be present in various food products. They include inorganic and organic substances that enter the food chain from a range of sources, such as environmental pollution, agricultural methods, storage conditions, production and processing procedures, and packaging. Some of these contaminants are formed naturally in the soil, water or air; others are byproducts of the processing and production process itself.

Toxic substances such as dioxins, per- and polyfluoroalkyl substances (PFAS), polychlorinated biphenyls (PCBs), polybrominated biphenyls (PBBs), mycotoxins, alkaloids, heavy metals, and polycyclic aromatic hydrocarbons (PAHs) are present almost everywhere in the environment. They can be found in animal feed and, consequently, in food products of animal origin. In addition, veterinary pharmaceuticals and pesticides are used in animal husbandry and, thus, may be present in animal-based food products.

For many of these chemical food contaminants there is no safe threshold value. However, international organizations such as the Joint FAO/WHO Expert Committee on Food Additives (JECFA) and regional organizations such as the European Food Safety Authority (EFSA) have calculated acceptable exposure values for many of them. Exposure to these contaminants above a certain level may adversely affect human health depending on the type of contaminant, the level and duration of exposure, and the specific characteristics of the exposed individual.

In Israel, as in many places in the Western world, each food company is responsible for taking the necessary measures to reduce the levels of chemical food contaminants to a minimum. Responsibility for producing, importing, and selling safe food is set forth in the Public Health Protection (Food) Law, enacted in 2015. The Ministry of Health (MoH) has set maximum permitted levels for food contaminants such as heavy metals, dioxins, PCBs, PAHs, and mycotoxins.
Progress since 2017

The *Environmental Health in Israel 2017* report defined challenges related to Chemical Food Contaminants. Progress achieved in this area during the past three years is outlined below.

**The challenge: Conduct a survey of aluminum in baby food**

**In short:** The survey was conducted. Levels of aluminum above the limit of quantification were found in all samples of plant-based infant formulae and in about 60% of samples of milk-based formulae.

Human exposure to aluminum takes place primarily through food. Toxicological research on animals has shown that several aluminum compounds may cause neurotoxicity and affect the male reproductive system. In human studies conducted on dialysis patients, neurological effects were observed in prolonged exposure to high concentrations of aluminum compounds. Several studies revealed an association between exposure to aluminum and degenerative diseases but were not sufficiently robust.

Infants are a vulnerable population whose food consumption is not varied. To assess their exposure to aluminum, the National Food Service (NFS) at MoH conducted a survey to quantify aluminum in infant formulae. The formulae sampled were those commonly used in the Israeli market and in hospitals, including powder for preparation at home and ready-to-feed liquid. The survey included an exposure assessment that compared aluminum levels with the threshold value set by JECFA and EFSA. Levels of aluminum above the limit of quantification (LOQ) were found in all samples of plant-based infant formulae and were not found in about 40% of samples of milk-based formulae. The aluminum levels in plant-based infant formulae were higher on average than those found in milk-based formulae. Aluminum in infant formulae may originate in packaging, soybeans (which naturally accumulate aluminum), aluminum residue from other ingredients of soy-based formulae, and contamination in processing the formula.

**The challenge: Conduct a survey of phthalates in baby food**

**In short:** Packages of imported formula were tested and found to meet the Israeli standard, making the survey unnecessary.

Phthalates, a group of chemicals used to increase the strength and flexibility of plastic products, can contaminate food and beverages by migrating from food packaging.

Standard 5113, a mandatory Israeli standard for plastic packaging that comes into contact with food, applies to aluminum packaging with plastic coating, the kind typically used for infant formula. The standard has been updated several times since 2017 and now establishes maximum...
permitted levels for phthalates in food packaging that are consistent with European regulation. Packages of infant formula are imported to Israel and, in accordance with the Free Import Ordinance, are tested to determine whether they meet Standard 5113. In these tests, no excessive levels of phthalates were found relative to the standard. In light of the findings, and since most of infant formula in Israel is imported, NFS decided that it was unnecessary to conduct a survey to identify and quantify phthalates in infant formulae.

As part of the National Health and Nutrition Survey (Rav-MABAT), data on food consumption were collected from different sub-populations that together comprise a representative sample of the population in Israel. To use the collected data to assess the exposure of the general population and sub-populations to contaminants that originate in food, the foods reported by the survey participants must be broken down by their ingredients. In addition, the Rav-MABAT data are being used in preliminary assessments of pesticide exposure in children of various age groups.

A Total Diet Study project examines all food that an individual consumes and the way it is consumed. This includes sampling food consumed by the general population and sub-populations from the various markets, preparing the food in the conventional way of consuming it, and combining the types of food into several composite samples. These mixed samples are examined to identify and quantify contaminants originating in food, including pesticides, environmental contaminants, natural toxins, substances that migrate from food packaging, and more. The goal of this sort of project is to produce a quantitative assessment of chemicals to which the public is exposed from food, parsed by subgroups in the population. Such data are very helpful in assessing the potential health impact of exposure to contaminants in food. The TDS approach has an advantage of testing the food as it is consumed (for example, after rinsing, peeling or cooking), thus yielding a more accurate picture of exposure to chemicals in food. Accordingly, several countries have initiated national TDS projects.
To establish its own TDS project, Israel must develop a sampling plan that represents food consumption countrywide, prioritize the chemicals that are important to check, write clear protocols for food sampling and preparation, build an array that accounts for preparing food in the way it is consumed, develop the logistical capacity for transporting and storing food, and establish laboratory capacity for testing the requisite substances according to their prioritization. These phases, taken together, entail substantial personnel and budgetary resources. Due to budget constraints, the project has yet to be initiated.

Research on Chemical Food Contaminants in Israel

- Researchers from the Agricultural Research Organization’s Volcani Center examined the effects of phosphine fumigation on stored wheat grain and on the wheat grain microbiome, including mycotoxigenic fungi. The use of phosphine induced changes in the composition of the bacterial community: As the number of phosphine treatments increased, the diversity of the bacterial community in the stored wheat decreased. However, no similar effect on fungal diversity was detected. Mycotoxin analysis of the treated wheat revealed the presence of *Fusarium* toxins, primarily deoxynivalenol.¹

- Following the discovery of ergot disease in sorghum fields for the first time in Israel, a large amount of produce from the affected fields had to be destroyed. Researchers from the Volcani Center examined and identified the ergot alkaloid profile in the infected fields and, for the first time, detected dihydrolysergol as a significant ergot alkaloid component. In an assessment of the infected sorghum silages, taking the alkaloid profile into consideration, the silage was found to be safe for use as animal feed.²

- In a study conducted by researchers at the Volcani Center and the Kimron Veterinary Institute, a method was developed for detecting a range of mycotoxigenic fungi and mycotoxins in wheat.³

- Researchers from Volcani Center examined samples of bovine and goat milk sold in markets in Israel and detected pesticides and pharmaceutical residues. In about 50% of the milk samples tested, residues from several pesticides were found in the same sample.⁴

Future Challenges

Estimating exposure to contaminants originating in food is an important step in the process of assessing the risks that these contaminants present, and the use of food consumption data is important for tailoring exposure assessments to the population of Israel. Although extensive food consumption data is collected routinely in Israel in nutrition surveys (such as Rav-MABAT), these data are currently underutilized in assessing the risk of food contaminants. Conducting exposure assessments for contaminants such as heavy metals, on the basis of Rav-MABAT surveys and biomonitoring data, is an ongoing challenge.
NFS conducts periodic surveys on food contaminants (including mycotoxins in food, arsenic in rice and rice products, and aluminum in baby food). Some of these data are currently unpublished. As part of an effort to increase transparency, NFS intends to publish these data.

Climate change is affecting the proliferation of toxigenic fungi; rising mycotoxin levels have already been observed in edible crops in various places in the world. Israeli law sets maximum permitted levels of major mycotoxins in several food categories such as nuts, milk, grains, and legumes. Given the growing knowledge in this field and progress in the analytical capacity to identify and quantify mycotoxins, NFS is planning to update and significantly expand existing legislation by setting maximum levels for additional types of mycotoxins and adding more food categories.

NFS is also planning to regulate heavy metal content in food by converting the existing guidelines into regulations. To promote such regulations, more in-depth collaboration with the Veterinary Services unit at the Ministry of Agriculture (MoAg) is needed. A survey conducted by this unit to identify and quantify heavy metals in food of animal origin indicated that the consumption of animal-based food may be a source of exposure to heavy metals. In 2018, arsenic residues were found in about 65% of samples of pond-bred fish and mercury was found in 49% of the samples (at levels lower than the permitted maximum). In samples of seafish, numerous arsenic exceedances were found and residues of cadmium and mercury were detected in about 50% of the samples (at levels below the permitted maximum). Residues of cadmium (below the permitted maximum) were also found in 98% of turkey samples and over 40% of fattened poultry samples. To account for potential exposure to heavy metals in plant-based and animal-based foods, risk assessment based on data collected by different regulatory agencies (MoH and MoAg) is needed.

Dioxins are byproducts of uncontrolled combustion including those in industrial processes. Dioxins have been found everywhere including soil, air, water, precipitation, and food. Prolonged exposure to dioxins is associated with immunotoxic effects and adverse effects on nervous system development, the endocrine system, fertility, and the risk of cancer. The most recent published survey on dioxins in food in Israel was published in 2013. Based on findings of that survey, average adult exposure was calculated for dioxins, furans and dioxin-like PCBs. NFS is planning to conduct a new survey to identify and quantify dioxins in food in Israel and to perform an exposure assessment based on the results of the survey.

Another goal is to submit data from surveys on food contaminants in Israel to international databases such as that of the World Health Organization (WHO), which includes monitoring data on food contaminants. The database yields information—for governments, the Codex Alimentarius Commission and other relevant institutions, and the general public—on levels and trends of food contaminants, their contribution to total human exposure, and their implications for public health and international commerce. NFS has begun to align data on food contaminants sampled in Israel with the format of the WHO database and plans to submit data to this international database regularly.
PFAS are a group of man-made chemicals that have been used for many years in a wide range of industries worldwide. They are very persistent in the environment and are not metabolized in the human body; therefore they accumulate over time. Prolonged exposure to PFAS may lead to adverse health effects including high cholesterol, thyroid disease, immunotoxic effects, and certain types of cancer. The food we consume may contain PFAS that originates in polluted soil, animals’ drinking water, irrigation water, food packaging, or food processing equipment that contains these substances. While preliminary data is being collected on PFAS contamination in drinking water in Israel, no data on PFAS in food are available. A survey to measure the levels of PFAS in food in Israel is planned.

References


Chemicals in Consumer Products

Consumer products are potential sources of exposure to heavy metals, endocrine disrupting chemicals (EDCs), and volatile organic compounds (VOCs).¹

Heavy metals—including lead, mercury, and arsenic—may be present in toys, paint, jewelry, and personal care products. Cases of acute lead poisoning following exposure to toys and paint containing high levels of lead have been reported.²

There is increasing evidence that consumer products contribute significantly to cumulative exposure to EDCs such as phthalates, flame retardants, per- and polyfluoroalkyl substances (PFAS), and triclosan, and that chronic exposure may be associated with adverse health effects.³ For example, triphenyl phosphate (TPHP), an organophosphate flame retardant (OPFR) commonly used in consumer products, has been associated with altered thyroid function. PFAS used in consumer products—for example, in water repellant and stain resistant coatings for textiles—have been associated with cancer, thyroid disruption, immune system impairment, and reduced fertility.³
Paint, polyvinyl chloride (PVC), and wood products may emit VOCs including formaldehyde. Exposure to these consumer products has been associated with increased risk of allergic reactions and respiratory difficulties in children.4

**Progress since 2017**

The *Environmental Health in Israel 2017* report defined challenges related to Chemicals in Consumer Products. Progress achieved in this area during the past three years is outlined below.

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**The challenge: Improve regulatory enforcement for consumer products (enforcement in markets and not only at point of import)**

**In short:** Oversight and enforcement of consumer products’ standards in markets in Israel have improved thanks to stronger cooperation among regulators. Supervision and enforcement efforts were extended to product groups identified in market surveys as posing a potential danger to public health.

**Challenge for the coming years:** Establish an integrating authority (inter-ministerial committee) to improve and strengthen supervision and enforcement of regulation of consumer products sold in Israel.

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The Ministry of Economy and Industry (MoE) has ministerial responsibility for supervision and enforcement of compliance with relevant mandatory standards for consumer products sold in Israel. In recent years, professional collaboration between the Ministry of Health (MoH) and MoE has expanded. Researchers from the University of Haifa, the Standards Institute of Israel (SII), and MoH, in collaboration with the Environment and Health Fund (EHF), initiated several studies on the presence of chemicals in consumer products and shared the initial findings with MoE for further action and enforcement. Although MoE uses such findings to target and focus enforcement, there is no regulation or mechanism designed to ensure cooperation among the relevant ministries, i.e., MoE, MoH, and the Ministry of Environmental Protection (MoEP). The creation of a joint statutory inter-ministerial committee to formulate annual work plans and objectives would improve oversight and enforcement and would focus the limited resources on products that pose the greatest potential danger to public health.

MoE recently launched an online portal for safety of consumer products that conveys information on consumer products that entered the domestic market and were found to be non-compliant and removed from the shelves (recalled).5 Despite this improvement, there is still no data published on the scope and results of testing.

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**Legend:**

- **Significant progress**
- **Some progress**
- **Little or no progress**
MoH initiated a broad-based reassessment of the need for added flame retardants in a variety of consumer products and found that adverse health effects potentially associated with using flame retardant chemicals exceed the safety advantage these chemicals offer. Following this reassessment, the requirement to add flame retardants to the relevant products was no longer mandatory. Instead, in products to which adding flame retardant chemicals is allowed but not required, the presence or absence of these chemicals must be indicated on the product label so that consumers can make informed purchases in accordance with their personal preferences, as is customary in almost all developed countries. Thus, for example, it is now mandatory to indicate the presence or absence of flame retardant chemicals on the labels of adult mattresses, infant mattresses, and textile carpets.

The trend of reducing the use of flame retardant chemicals is expected to spread to other consumer goods such as furniture and home electronics. To date, there is no requirement to indicate the presence or absence of flame retardant chemicals in many consumer products for infants and children, including strollers, car seats, and nursing pillows. There is still no comprehensive requirement for uniform labeling of specific chemicals in all consumer products sold in Israel.

MoH has expanded its involvement in SII committee deliberations on consumer product standards. Furthermore, based on the findings of studies in which it participated, MoH has been promoting the adoption of new standards and the revision of existing standards—for example, setting a standard for heavy metals in children's jewelry and a comprehensive standard for lead in paint, and promoting revisions for a range of standards of consumer goods designed for infants, toddlers, and children including cribs, strollers, high chairs, changing tables, and playgrounds.
Israel still lacks a regulatory framework for the systematic evaluation and registration of chemicals, even though such a structure exists in all other OECD member countries except Turkey. In addition, as opposed to the U.S. and Europe, Israel has no comprehensive regulatory framework for chemicals in consumer products.

Currently, the Israeli regulatory framework for consumer products is based on non-binding standards and mandatory standards that apply to specific products only. Uniform and comprehensive framework legislation on chemicals in consumer products could help fill regulatory gaps that might not be addressed in the existing system of product-specific standards. In October 2020, MoEP published a bill that would create a chemicals registration system in Israel. The bill would leave regulatory authority for consumer goods with MoE but would give MoEP regulatory authority to promulgate standards in cases of regulatory gaps.

Given the special sensitivity of certain populations to chemicals, the National Council for the Child and EHF decided to focus their efforts on consumer products designed for infants, toddlers, and children. The two organizations formulated a proposal for dedicated legislative framework for chemicals in consumer products designed for these populations.

A joint research group of MoH, the University of Haifa, and SII, in collaboration with EHF, conducted several studies to test for the presence of chemicals in consumer products. One such study tested for the presence of heavy metals (primarily lead) in toys, children’s jewelry, and paint, including paint used for the painting and upkeep of playground equipment. A research conducted in 2019–2020 checked for the presence of chemicals in play mats for children, parquet flooring, and synthetic grass. The findings of these studies are helpful in identifying regulatory gaps and addressing them by adopting new standards, revising existing standards or promoting requests for non-binding standards to be made mandatory. By identifying disparities in regulatory requirements between Israel and other developed countries, these studies will create a basis for promoting mandatory regulation of specific consumer products.
Many months (and, in extreme cases, even years) may pass between the revision of a standard by SII and its publication, and between the declaration of a standard as mandatory and including it in the Free Trade Ordinance. The delay stems in part from the lack of a defined timeframe in which the ministers in charge must disclose their ministries’ assessment of the standard (consent or opposition). When several ministers’ assessments are needed, the process may take even longer. In recent years, several standards (for example, those on lead content in paint and heavy metals in children’s jewelry) have been declared in expedited proceedings. Still a limited and reasonable timeframe should be specified for completing each stage of the process so that updated standards may go into effect as soon as possible after the SII committees approve them.

Research on Chemicals in Consumer Products in Israel

- Researchers from Tel Aviv University and Shamir Medical Center (Assaf Harofeh) examined the effect of using aluminum-based deodorant on aluminum concentrations in breast milk. Fifty-eight women participated in the study. No significant association was found between the use of aluminum-based deodorant and concentrations of aluminum in breast milk.9

- Researchers from Tel Aviv University, Sheba Medical Center at Tel Hashomer, and MoH, in collaboration with researchers from Harvard University, Columbia University, and the U.S. Centers for Disease Control (CDC), measured concentrations of thirty-one chemicals (including phthalates and phenols) in urine samples from fifty pregnant women. Fourteen chemicals—including bisphenol A (BPA), various parabens, and benzophenone-3—were found in the urine of over 90% of the participants. Other chemicals—including bisphenol S (BPS) and DINCH (a phthalate substitute)—were found among 30%–63% of the participants.10 The same group of researchers is measuring concentrations of phthalates and DINCH in the urine of 136 women who underwent in vitro fertilization (IVF).

- A joint research team from MoH, the University of Haifa, and SII studied the presence of lead in spray paints and on painted surfaces in playgrounds and public areas in Israel. In 88% of the samples, levels of lead in paint exceeded the maximum set forth in U.S. regulation (90 ppm). As a result of these findings, Israeli Standard 1343 (Paints and Varnishes) was updated and lead was banned in paint, including industrial paint,8 effective January 2021.
An Israeli research group in collaboration with researchers from Canada and the U.S. examined the regulation of chemicals in children's products and studied how U.S. and European regulations would impact a small market like Israel. The study highlighted the lack of comprehensive framework legislation for all children's products and the difficulty in adopting American and European standards in view of their different approaches and requirements.\textsuperscript{11}

Researchers from the University of Haifa and MoH studied the impact of standards in Israel on promoting environmental policy, with standards for consumer products designed for infants, toddlers, and children as the case study. The conclusions of the study underline the inherent tensions that exist between safety and health issues, on the one hand, and economic and commercial interests, on the other. The researchers proposed solutions that would improve the decision-making process in a way that would place greater weight on health and environmental considerations.\textsuperscript{12}

Future Challenges

Direct online shopping poses a major challenge in regulating consumer products in Israel and abroad. Israel has the highest rate of per capita growth in e-commerce among OECD countries and has developed a significant gap between the volume of packages ordered for private consumption without oversight and regulated commercial imports. In 2018, over 50% of online orders were placed via the AliExpress website.\textsuperscript{11}

Official commercial importation of consumer goods gives regulators a certain level of control over product safety and standards; personal importation of products purchased online presents regulators with a significant challenge in this context. In practice, the Personal Import Ordinance, effective 2019, exempts all consumer goods (with several specific exceptions) from having to meet the official and mandatory standards that apply in Israel. The ordinance provides a sweeping, structured exemption from supervision of consumer products purchased online or brought to Israel via personal importation—up to thirty units of the same type if the total value of the shipment does not exceed $1,000, and up to five units of the same type if the total value exceeds that sum.\textsuperscript{14} Public service campaigns should be initiated to reduce the potential risk of online shopping to consumer safety and health. Publication of regulatory guidelines and recommendations for the public would enable consumers to make informed online purchases.

Like the Personal Import Ordinance, the cosmetics reform in Israel was designed to lower the cost of living and alleviate the regulatory burden. The reform shifts the responsibility for the safety, quality, and effectiveness of cosmetics to manufacturers and importers, leaving MoH with enforcement and oversight duties as opposed to registration of cosmetics.\textsuperscript{15} The potential impact
of the reform on the public’s exposure to chemicals in cosmetics, however, needs to be studied. Mitigating the risks of nanotechnology and nanomaterials in cosmetics and consumer products in general is also a regulatory challenge.

In 2020, MoE published a proposed amendment to the Free Import Ordinance that would relax testing requirements for certain imported consumer products. According to MoE, the reform will be accompanied by an increase in inspection and enforcement. After the reform goes into effect, it will be important to monitor changes in the quality of imported products, with emphasis on the presence of toxic chemicals.

There is currently no data in Israel on concentrations of PFAS in consumer products. These water-resistant substances are used in many consumer products, including textiles, food packaging, and cookware. Evidence of adverse health effects from exposure to these substances has been mounting in recent years. The challenge going forward is to continue to study potential exposure to these substances via consumer products in Israel and to evaluate potential regulatory measures.
References


Human biomonitoring (HBM) is a tool for assessing exposure to environmental chemicals by measuring concentrations of substances, their metabolites, and biological markers at the cellular or molecular level, in biological fluids and in tissues such as urine, blood, breast milk, and hair. HBM has emerged as a powerful tool for assessing cumulative exposure to mixtures of chemicals; it can be used to assess environmental exposures of individuals and of population groups. HBM data can also be combined with environmental data to identify exposure pathways and with clinical data to find evidence of associations between exposure to chemicals and health outcomes.

HBM data have many uses in environmental and health research and in policymaking. They can be used to identify populations that are more exposed than others to environmental contaminants, support the formulation of policies designed to reduce exposure to contaminants, and assess policy effectiveness. Thus, many countries—including the U.S., Canada, Germany, France, Belgium, Spain, Italy, the Czech Republic, and South Korea—have developed national biomonitoring programs. In addition, twenty-eight countries, including Israel, are collaborating in the HBM4EU consortium, a project that promotes the use of HBM and the application of its results in policymaking in Europe.
Progress since 2017

The *Environmental Health in Israel 2017* report defined challenges related to Human Biomonitoring. Progress achieved in this area during the past three years is outlined below.

**The challenge:** Join a regional or international human biomonitoring project

**In short:** Israel joined the HBM4EU consortium, a European HBM project. Within this framework, Israel shares information on biomonitoring research and biomonitoring data with the International Platform for Chemical Monitoring.

**Challenge for the coming years:** Promote Israel’s continued involvement in regional and international HBM initiatives.

Israel’s involvement in the HBM4EU consortium includes sharing information on research and data from biomonitoring studies conducted in Israel. For example, Israel shared data on the exposure of women to bisphenol A (BPA) for a meta-analysis of sources of exposure to bisphenols among women in Europe. In addition, information on six HBM studies in Israel, including surveys by the Ministry of Health (MoH) and birth cohort studies, was uploaded to the International Platform for Chemical Monitoring (IPCHEM). Israel is also participating in discussions on promoting the sustainability of HBM in Europe, including the use of biomonitoring data in risk assessment and advancement of environmental health policy.

HBM4EU’s activity was planned and funded for five years (2017–2021). As the end of the project approaches, the participants are weighing whether to create follow-up programs or join parallel programs. Either way, it is important that Israel continues to participate in such international projects.

**The challenge:** Develop laboratory capacity for human biomonitoring

**In short:** The staff of the National Biomonitoring Laboratory at MoH validated protocols for measuring cotinine, organophosphate pesticides, pyrethroids, and heavy metals in urine and whole blood.

**Challenge for the coming years:** Utilize tools developed for monitoring and research; continue validating measurement techniques for other contaminants.

The staff at MoH’s National Biomonitoring Laboratory validated protocols for measuring various environmental contaminants in human biological samples (Table 1). There is also a plan to validate analytical techniques for measuring per- and polyfluoroalkyl substances (PFAS) and flame retardants.

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**Legend:**
- **Green** Significant progress
- **Yellow** Some progress
- **Red** Little or no progress
In 2019 and 2020, the laboratory passed quality assurance tests conducted by an international quality assessment program for analyses in biological materials. During 2019, it conducted measurements of environmental contaminants in more than 400 biological samples.

The National Biomonitoring Program, established with the support of the Environment and Health Fund (EHF), outlines a framework for the next decade including three rounds of collecting biological samples and measuring environmental contaminants. Contaminants of interest were chosen following preliminary prioritization, in which relevant experts ranked thirty-five chemicals and chemical groups under five criteria (such as indication of population exposure in Israel and potential regulatory use of data). The target populations and contaminants are displayed in Table 2. As part of the program, children (ages 4–11) and adults (ages 18–65) will be recruited from the general Jewish and Arab population in a nationwide convenience sample. The main objectives of the program are to provide data on trends of exposure to environmental contaminants, sources of exposure, and subpopulations at risk of high exposure. The program will also yield exposure data for use in quantitative risk assessment and environmental health policy analysis.

### Table 1

<table>
<thead>
<tr>
<th>Contaminant Category</th>
<th>Analyte (biological media)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pesticides</strong></td>
<td>Organophosphate (OP) metabolites — Dialkylphosphates (urine)</td>
</tr>
<tr>
<td></td>
<td>Chlorpyrifos metabolite — TCPy (urine)</td>
</tr>
<tr>
<td></td>
<td>Pyrethroid metabolites (urine)</td>
</tr>
<tr>
<td><strong>Heavy metals</strong></td>
<td>Arsenic, cadmium, lead, mercury, chromium, nickel, selenium, and thallium (urine)</td>
</tr>
<tr>
<td></td>
<td>Lead, mercury, cadmium, and nickel (whole blood)</td>
</tr>
<tr>
<td><strong>Environmental tobacco smoke</strong></td>
<td>Cotinine (urine)</td>
</tr>
<tr>
<td><strong>Other (nutritional biomarkers)</strong></td>
<td>Iodine (urine)</td>
</tr>
</tbody>
</table>

* As of December 2020

The challenge: Establish and fund a government framework for human biomonitoring

**In short:** The National Biomonitoring Program began in 2020 and there is a commitment to fund it through 2030.

**Challenge for the coming years:**

A. Fully implement the National Program.
B. Use the program as a platform for monitoring nutritional biomarkers.
C. Incorporate the analysis of blood samples into the program.
Outline of the National Biomonitoring Program in Israel, 2020–2030

<table>
<thead>
<tr>
<th>Contaminants</th>
<th>Year</th>
<th>2020–2021</th>
<th>2024–2025</th>
<th>2029–2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target population</td>
<td>200 children</td>
<td>200 adults</td>
<td>(pregnant women?)</td>
</tr>
<tr>
<td>Cotinine</td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>OP pesticides</td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Pyrethroid pesticides</td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Heavy metals</td>
<td></td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Benzophenones, flame retardants, and emerging chemicals of interest such as PFAS</td>
<td></td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

The challenge: Develop a framework for using human biomonitoring data in quantitative risk assessment

In short: Data on the concentration of urinary organophosphate metabolites in children was used in a quantitative risk assessment.

Challenge for the coming years: Expand the use of HBM data in risk assessment for exposure to metals and additional groups of pesticides, for example pyrethroid pesticides.

Using data on the concentration of urinary OP metabolites in 103 children, MoH researchers calculated the children's estimated daily intakes (EDI) of OP pesticides. The urine samples were collected as part of the 2015–2016 National Health and Nutrition Survey (Rav-MABAT). The researchers compared the EDI with the acceptable daily intake (ADI)—a value expressing the level of exposure below which no adverse health effect is expected—as defined by the European Food Safety Authority (EFSA). According to this calculation, about 15% of the children were exposed to the pesticide chlorpyrifos at a level exceeding the ADI (Table 3).²


<table>
<thead>
<tr>
<th>Pesticide</th>
<th>Acceptable Daily Intake as Defined by EFSA (μg/kg of body weight per day)</th>
<th>% of Children with Daily Intake Above the Tolerated Dosage</th>
<th>Estimated Daily Intake (μg/kg of body weight per day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diazinon</td>
<td>0.2</td>
<td>79.4%</td>
<td>0.02–10.73</td>
</tr>
<tr>
<td>Chlorpyrifos</td>
<td>1</td>
<td>14.7%</td>
<td>0.01–9.06</td>
</tr>
<tr>
<td>Phosmet</td>
<td>10</td>
<td>2.9%</td>
<td>0.09–50.08</td>
</tr>
<tr>
<td>Malathion</td>
<td>30</td>
<td>4.9%</td>
<td>0.32–173.79</td>
</tr>
<tr>
<td>Dimethoate</td>
<td>1</td>
<td>22.5%</td>
<td>0.05–28.14</td>
</tr>
<tr>
<td>Phorate</td>
<td>0.7</td>
<td>17.6%</td>
<td>0.01–7.87</td>
</tr>
</tbody>
</table>
The National Biomonitoring Program includes a plan to present the selection and prioritization of chemicals for HBM to representatives from academia, government, and the public, in order to improve the transparency of the process in Israel. It is essential to conduct a periodic reassessment of the prioritization and to consider including additional contaminants, such as OP flame retardants and PFAS.

Human Biomonitoring Research in Israel

- In a pilot study, researchers from Ben-Gurion University of the Negev quantified environmental contaminants in pooled urine samples of pregnant women from the Negev. They found heavy metals in all urine samples and metabolites of OP pesticides and OP flame retardants in some. No significant differences between Bedouin women and Jewish women were found.¹

- Researchers from Shamir Medical Center (Assaf Harofeh), Tel Aviv University, Dana-Dwek Children's Hospital, Kimron Veterinary Institute, and Columbia University studied the association between intrauterine exposure to polychlorinated biphenyls (PCBs) and 1) thyroid hormone levels (TSH) in pregnant women and newborns and 2) anogenital distance (AGD) in newborns. The mean maternal serum concentrations were 2.95 ng/g, 4.62 ng/g, 7.67 ng/g and 5.10 ng/g for congeners 118, 138, 153 and 180, respectively. The researchers found no association between PCB exposure and TSH levels in pregnant women in the study. Among women with a low weight-to-height ratio, however, a significant association between PCB exposure and TSH was reported.⁴ Higher maternal concentrations of PCBs were found to be associated with reduced AGD in male infants.⁵

- The Ministry of Environmental Protection is funding several studies on epidemiological aspects of exposure to air pollution in the Haifa Bay population, including research with an emphasis on HBM (including biomonitoring of heavy metals and organic contaminants in pregnant women, and heavy metals in blood donors⁶).

Exposure to Chemicals in Consumer Products

- Researchers from Tel Aviv University, Sheba Medical Center at Tel Hashomer, and MoH, in collaboration with colleagues from Columbia University, Harvard University, and the U.S. Centers for Disease Control and Prevention (CDC), measured concentrations of thirty-one chemicals including phthalates and phenols in the urine of fifty pregnant women. Fourteen chemicals,
including BPA, various parabens, and benzophenone-3 were found in the urine of over 90% of the participants. Other chemicals, including bisphenol S (BPS) and DINCH (a phthalate substitute), were detected in the urine of 30%–63% of the participants. Concentrations of benzophenone-3, a component in sunscreen, were low in comparison with populations in other countries, even though most of the adult population in Israel reports using sunscreen.7

- Researchers from Sheba Medical Center, in collaboration with colleagues from Harvard University, Columbia University, and the University of Milan, measured concentrations of phenols and phthalates in the urine of 130 women who underwent in vitro fertilization (IVF) and analyzed miRNA molecules found in follicular fluid. They found an association between concentrations of eight miRNA molecules that play a role in the development of ovarian follicles and oocytes, and concentrations of phenols and phthalates. They concluded that exposure to chemicals from consumer products may change the concentrations of cellular regulatory molecules that play a role in female fertility.8

- Researchers from Sheba Medical Center, in collaboration with colleagues from Harvard University, Columbia University, and the CDC, measured urinary concentrations of phthalates and DINCH in the same cohort of women who underwent IVF. They found several phthalates of which concentrations were inversely associated with several IVF outcomes: total number of retrieved oocytes, number of mature oocytes, number of fertilized oocytes, and number of top quality embryos. Conversely, no association between concentrations of DINCH and IVF outcomes was found.9

**Exposure to Pesticides**

- Researchers from MoH, measuring urinary OP levels in children during 2015–2016, found higher concentrations of several metabolites in children's urine in Israel than in other Western countries. They also found associations between fruit consumption and concentrations of several OP metabolites (DMP, DMTP and DETP) and between cucumber consumption and concentrations of DEP and DETP.10

- MoH researchers, measuring urinary OP levels in adults in Israel in 2015–2016, found a statistically significant decrease in concentrations of most urinary OP metabolites relative to the findings of a survey conducted in 2011. The average concentrations, however, were still high relative to populations in the U.S., Denmark, and Canada.10, 11

- Researchers from the Hebrew University-Hadassah Braun School of Public Health and Community Medicine measured concentrations of urinary OP metabolites in 273 pregnant women and 109 newborns. The urine samples were collected during a four-year period (2012–2016) in which stricter regulations were imposed on the use of OPs in Israel. The researchers found that average concentrations of dialkyl phosphates (DAPs) in the women decreased by about 40% during those years (from 248 nM/L to 148 nM/L). A similar trend was observed among the newborns.12
Exposure to Environmental Tobacco Smoke

- MoH researchers, measuring urinary cotinine concentrations in children in 2015–2016, found cotinine in the urine of over 60% of the children even though only 40% of parents reported that their children were exposed to environmental tobacco smoke (ETS). These concentrations are much higher than corresponding concentrations among children in several Western countries.¹³

- Researchers from the Hebrew University-Hadassah Braun School of Public Health and Community Medicine and MoH measured urinary cotinine levels in 265 non-smoking pregnant women and ninety-seven newborns. Most of the participants were of high socioeconomic status. The researchers found cotinine in the urine of 37.7% of the women and 29% of the newborns. No association was found between the maternal and infant cotinine levels. The researchers found an inverse association between cotinine levels in the newborns and their birth weight.¹⁴

- MoH researchers, measuring urinary cotinine concentrations in urine samples collected from adults in 2015–2016, found cotinine in the urine of over 60% of non-smoking participants. Urinary cotinine levels were higher among Arab participants than among Jewish participants and higher among non-smoking participants who reported exposure to ETS at home than among non-smoking participants who reported no exposure to ETS at home.¹⁵

- Researchers from Sheba Medical Center, the Hebrew University of Jerusalem, and MoH examined the association between self-reported smoking among 125 fertility patients and cotinine levels in their urine. The research population comprised eighty-three women who self-reported as non-smokers and forty-two who self-reported as smokers. Importantly, the sample does not represent the percentage of smokers among women who underwent IVF at Sheba (18%, according to polling). High urinary cotinine values (>150 µg/L) were found in 4.8% of the eighty-three women who defined themselves as non-smokers.

Future Challenges

The establishment of the National Biomonitoring Laboratory and the development of the National Biomonitoring Program are significant milestones in advancing the field of HBM in Israel. Full implementation of the program—including regular collection of biological samples, analysis of the samples in the national laboratory, and publication of the data and their application in shaping policy in Israel—are the main challenges for the coming years. Within the framework of the program, it is also important to improve collaboration between researchers in academia and the government personnel who collect HBM data and to utilize the data appropriately in planning, management, and budgeting.
While the National Biomonitoring Program focuses on exposure to harmful environmental chemicals, it is also important to note the centrality of HBM in assessing beneficial dietary metabolic exposures (for example, folates, vitamins, iodine, and magnesium). There is currently no national system for regular monitoring of the nutritional status of the population in Israel, and no coordination between the system that monitors chemical exposures and that which monitors nutritional exposures. Nutritional HBM should be conducted in coordination with the National Biomonitoring Program.

Public interest in HBM results has grown in recent years. An MoH conference in 2019 on exposure to ETS focused on HBM data and analytical techniques for measuring exposure to ETS. Increasing public interest in the HBM findings and publishing data in a way that is accessible to the public is key. For this purpose, a strategy for reporting National Biomonitoring Program data to the public and to decision-makers should be developed. In addition, it is vital to develop a strategy for providing access to HBM data and using HBM data to advance environmental health policy.

Beyond their use by decision-makers, HBM data may influence ordinary individuals’ behavior, as in the context of reducing children’s exposure to ETS. It is important to examine the clinical use of HBM (for example, in asthma or well-baby clinics) as a tool for identifying infants or children who are exposed to ETS.

Potential public exposure to PFAS—in water, consumer products, and food—raises the need to incorporate tests for these contaminants into the National Biomonitoring Program. A combination of environmental analyses and HBM analyses can facilitate research on the primary sources of exposure to these contaminants.

References


(4) Berlin, M., Barchel, D., Brik, A., Kohn, E., Keidar, R., Livne, A., ... Berkovitch, M. (2019). Intrauterine exposure to polychlorinated biphenyls (PCBs) and thyroid hormones in Israeli women: Data from EHF-Assaf Harofeh-Ichilov birth cohort. Poster presented at Environment and Health Fund annual conference, Environment and Health: Complex Interactions, Tel Aviv, Israel.


Non-ionizing radiation (NIR) refers to electromagnetic fields (EMF) that range from low frequencies (LF) to ultraviolet (UV) frequencies. This radiation is not powerful enough to change the structure of atoms or molecules through ionization.

NIR may have a biological effect via other mechanisms. Tissue heating is a proven and well-known effect of NIR, primarily within the range of radio frequencies (RF). In most personal devices that emit NIR, however, the heating effect does not pose a risk of significant damage due to their low output power (as in wireless telephones, Wi-Fi, and Bluetooth) or sufficient protection from the source of radiation (as in microwave ovens). Public discussion of the topic focuses mainly on the non-thermal effects of NIR, which involve a different mechanism through which a magnetic or electric field operates, or which involve another characteristic of radiation that affects the living body.

Studies examining the effects of NIR exposure on human health, particularly its carcinogenicity, have yet to determine whether exposure to NIR causes non-thermal adverse health effects. In 2001, the World Health Organization (WHO) determined that NIR at extremely low frequencies (ELF) is possibly carcinogenic,¹ and in 2011 added RF to this classification.² Most countries, including Israel, have adopted the precautionary principle, which calls for measures in cases of potential risk even if the causal association between exposure and a harmful effect has not been proven. Exposure thresholds in Israel are ten times stricter than those established by the WHO.
Researchers have examined the possible association between NIR exposure in a range of frequencies and health outcomes. In the RF range, for example, effects on fertility (sperm quality), cognitive function, the cardiovascular system, hearing loss, and saliva composition have been investigated. In the LF range, research on the effects on birth outcomes (miscarriages and low birth weight), cognitive functions, heart diseases, and neurodegenerative diseases has been conducted. The results of these studies are equivocal.

Progress since 2017

The Environmental Health in Israel 2017 report defined challenges related to Non-Ionizing Radiation. Progress achieved in this area during the past three years is outlined below.

The Non-Ionizing Radiation Law of 2006 authorizes the Ministry of Environmental Protection (MoEP) to issue licenses and supervise and enforce restrictions on devices that emit NIR, including transmission sites operated by cellular companies. In this capacity, MoEP regularly monitors the level of radiation produced by cellular transmission sites. Its surveillance system monitors the activity of about 60,000 antennas and checks them for compliance with the transmission power levels stipulated in their licenses. Currently, the system that examines 3G antennas has been expanded to monitor 4G transmission sites (Long Term Evolution [LTE] technology).

MoEP, with support from the Ministry of Communication, initiated a regulatory policy of sharing cellular sites that caused the number of active transmission sites in Israel to decline steadily by 20% from 2014 to 2020. Cellular coverage also improved as the sites enlarged their capacity for serving a large number of users simultaneously (Figure 1). In addition, the levels of exposure to radiation around these sites rose by only about 50% from 2013 to 2019, while the amount of data transferred via the cellular networks increased by a factor of 14.5 (Figure 2).

Legend:  
- **Green**: Significant progress  
- **Yellow**: Some progress  
- **Red**: Little or no progress
Cellular Transmission Sites in Israel, 2012–2020

Data Consumption over Cellular Networks in Israel, 2013–2019
The possible association between NIR exposure and adverse health outcomes has been studied for many years; the scientific evidence, however, indicates that this association has yet to be established.

In March 2020, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) updated its guidelines on limiting exposure to EMF in the RF range of 100 kHz–300 GHz. The threshold values for cellular frequencies and Wi-Fi were not revised. Importantly, the recommendations on exposure limits pertain only to thermal effects (i.e., proven effects). According to the ICNIRP, thresholds cannot be set in the absence of proven scientific evidence; therefore, long-term non-thermal effects are not taken into account.

In October 2019, the Institute of Electrical and Electronics Engineers (IEEE) issued a new international safety standard for human exposure to NIR in the 0 Hz–300 GHz frequency range. The standard updated the levels of exposure in accordance with new physical models that provide a more accurate assessment of the effect of environmental exposure to EMF on the human body. The update did not revise existing standards for exposure to power frequency fields (50Hz), current generation cellular frequencies, and Wi-Fi frequencies.

Notably, with regard to the public’s exposure, MoEP adopted the ICNIRP’s restrictions on exposure to NIR but added strictures of its own. The threshold for exposure to radiation from broadcasting sites, for example, should not exceed 10% of the exposure level determined in the ICNIRP recommendations for areas where people spend prolonged periods of time, such as residential areas and offices, and no more than 30% of the exposure level determined in the ICNIRP recommendations for areas where people spend short periods of time, such as sidewalks and roads.

The challenge: Increase public awareness of the potential adverse health outcomes of non-ionizing radiation, the need to reduce exposure, and the potential risks from exposure

In short: The Israeli National Information Center for Non-Ionizing Radiation (TNUDA) published updated recommendations for educated use of cell phones, including by toddlers and children.

Challenge for the coming years: Continue working to raise public awareness of the potential adverse health outcomes, and guide the public on educated use of technology involving NIR.

In 2019, TNUDA updated and expanded its recommendations for the educated use of cell phones, including by toddlers and children, in view of the time that had elapsed since the Ministry of
Non-Ionizing Radiation

Heath (MoH) published its recommendations (2008), the increase in the public’s use of devices that emit RF radiation, and changes in technology and use patterns. For this purpose, TNUDA conducted an extensive survey of the latest recommendations for educated use of cell phones in various countries. The updated recommendations include revisions of existing guidelines and new guidelines. For example, it is preferable to send a text message instead of making a phone call and the phone should be kept at a distance from the body during a prolonged transmission. Recommendations on reducing exposure to radiation are organized under three guiding principles: distance from the body, duration of exposure, and power of transmission. The objective is to convey the recommendations to the public in the simplest way so that they will be widely understood and assimilated. The recommendations also relate to distraction while driving and sleep hygiene (healthy sleeping habits and patterns conducive to falling asleep, staying asleep, sleep quality and quantity, and sleep environment, especially among children).

The challenge: Establish mandatory regulations regarding permissible levels of non-ionizing radiation

| In short: The stakeholders have yet to reach an agreement and no standards have been legislated. |
| Challenge for the coming years: Reach agreement among all stakeholders on maximum permitted levels and establish them in law. |

The 2006 Non-Ionizing Radiation Law is designed to protect the public from effects of exposure to NIR and includes directives relating to the installation and operation of radiation-emitting sources. In 2011, MoEP and MoH formulated joint recommendations that set maximum levels of 2,000 mG for momentary exposure and 4 mG for continuous and prolonged exposure. The recommendations, however, were never translated into legally binding regulations. In 2015, an NGO, the Public Council for the Prevention of Noise and Air Pollution in Israel (Malraz), petitioned the Supreme Court to instruct MoEP to correct this. As of August 2020, the case is still pending in court.

Research on Exposure to Non-Ionizing Radiation in Israel

- Within the framework of the international INTEROCC study, researchers in seven countries, including Israel, examined occupational exposure to EMF and subsequent health outcomes, including the development of brain tumors. The results did not show an increased risk of developing malignant or benign brain tumors due to occupational exposure to EMF. However, an indication of increased risk of developing glioma (and less so meningioma) was observed at the highest exposure level (upper percentile) of RF when the exposure occurred in the four years preceding the disease. Notably, even in this large study (3,978 patients with brain tumors and 5,601 healthy people who served as a control group), few were exposed to EMF at the workplace: about 10% exposed to EMF in the RF range at their workplaces and around 1% exposed to intermediate frequency (IF) fields. Therefore, the strength of the study is limited.
The international MOBI-Kids study, launched in 2009 and involving sixteen research centers including an Israeli research team, examined the association between cell phone use and the risk of developing brain tumors in children and adolescents. At the present writing, the researchers have processed the data and are writing a summary report and scientific articles. Within the framework of the study, the Israeli research team was also asked to investigate a possible association between mothers’ exposure to NIR during pregnancy and childbirth (including exposure to ELF radiation during pregnancy—for example, from using an electric blanket) and newborns’ risk of developing brain tumors in childhood and adolescence.

Researchers from the Gertner Institute for Epidemiology and Health Policy Research are examining the possible effects of fetal exposure to MRI on neurodevelopmental, behavioral, and hearing outcomes in childhood. This innovative study compares the results of tests that examine developmental and behavioral disorders such as ADHD among children who were exposed prenatally to MRI, with those of an individually matched unexposed group. The research results will contribute to the limited knowledge on the safety of MRI tests and will help to establish guidelines for the safe use of MRI as a diagnostic tool.

Another study underway at the Gertner Institute on the long-term health effects of MRI investigates the possibility of a carcinogenic effect of exposing children and adolescents to MRI. This study, based on data from Clalit Health Services, examines a possible association between the exposure of children up to age seventeen to MRI and the development of cancer—particularly malignancies of the brain, the circulatory system, and the lymphatic system. In this case-control study, cancer incidence rates among a group of individuals who underwent MRI examination in childhood were compared with those of a control group of unexposed children who were matched for sex and age.

Researchers from the Soreq Nuclear Research Center conducted a study in which detailed measurements of power frequency magnetic fields were taken at 222 computer workstations in twelve computer classrooms in three schools. The background levels before the computers were turned on were very low in nine of the classrooms (median and mean smaller than 0.25 mG) and slightly higher in the other three (0.7–1.2 mG). Connecting the computers to the network and operating them had a negligible impact in ten classrooms (<0.1 mG), raised the median level by 0.2 mG in one classroom, and by 0.7 mG in another. In the overwhelming majority of measurements, field strength was homogeneous in all parts of the body (legs, chest, hands, and head).

Another study by researchers from Soreq Center measured adolescents’ levels of exposure to power frequency magnetic fields. In this study, eighty-four students in grades 6–10 had a meter attached to their body that measured the magnetic field every 1.5 seconds for twenty-four hours. The students also kept a journal documenting their whereabouts. The study yielded copious statistical data on the participants’ exposure: 0.59 mG geometric mean of average daily exposure, 0.73 mG arithmetic mean, and 1–15 minutes spent at levels above 4 mG. The average daily exposure of three participants (3.6%) was measured at more than 2 mG. The lowest exposures were measured while the students were at home (0.3 mG geometric mean). The findings are comparable to those in other countries.\[5\]
Researchers from the Technion Faculty of Education in Science and Technology examined the public's understanding and perceptions of NIR-related risks, focusing on parents' perceptions of Wi-Fi radiation in schools. The study, comprised of an analysis of media discourse, social media discussions, and in-depth interviews with sixty-seven parents of children in primary schools, found that 70% of published articles and news items on this subject expressed the view that NIR is dangerous, 52% of comments on social media expressed the same view, and 27% of social media comments expressed an opposing view. The parents who were interviewed agreed to introduce Wi-Fi into the school for various reasons. Although some expressed concern about radiation risks, they considered it pointless to object to Wi-Fi exposure because their children were already exposed to radiation elsewhere.\(^7\)

**Future Challenges**

Many countries, including Israel, have designated the next generation of cellular communications—the fifth generation (5G)—as a target for technological advancement and implementation. The volume of data consumed via cellular communication is rising steadily every year, thus increasing the level of exposure to radiation. MoEP expects this volume to increase by some 50% per year. There are two main ways to mitigate or prevent the increase in exposure to radiation: 1) build more transmission sites; 2) use new technologies that allow data to be transferred faster and more efficiently. In MoEP's assessment, the introduction and full deployment of these new technologies will result in greater uniformity of NIR exposure from cellular sites. By increasing the number of sites and expanding their deployment within buildings, exposure to radiation from personal cellular devices can be reduced because the devices will require less effort to communicate with the transmission source (and expend less transmission power). However, the increase in use of mobile devices may increase transmission power. Furthermore, the greater efficiency of the technology will allow data to be transferred at a higher rate with better use of transmission power, thus shortening the duration and strength of NIR exposure. The 5G technology uses massive MIMO antennas that enable transmission in a narrow and precise beam that focuses on end devices. Antennas that use earlier technology transmit a broad beam that exposes wider areas to radiation—unnecessarily. The high energy efficiency of the MIMO antennas reduces the exposure to radiation significantly.

It is difficult to assess the health effects of exposure to 5G radiation, for several reasons:
- Scientific knowledge on the health implications of exposure to radiation in this RF range is equivocal and the existence of potential adverse non-thermal health effects is disputed.
- The 5G technology will operate near the frequencies of current generations as well as frequencies that are higher by a factor of ten or more (in the range of millimeter waves). This technology is not yet in use; therefore, the public has not been exposed to radiation in this range of frequencies and few studies have looked into the implications of exposure to millimeter waves on human health. Further studies in the field (under laboratory conditions and among populations) are required.
There is a need to collect data and track the accumulated knowledge on exposure from multiple radiation sources. Furthermore, the publication of health research should be monitored in order to update existing standards as this technology is implemented.

The use of LED lighting in Israel and in the world is expanding because of the advantages it offers, including energy savings and a reduction in air pollution. In recent years, however, some concern has arisen that the use of LED lighting, especially in exposure to its blue light component, may have adverse effects such as disrupting metabolism and circadian rhythms and causing damage to the skin and eyes. Expanding scientific knowledge on these potential adverse effects would give policymakers a basis for decision-making.

In addition to concern about exposure to NIR, parents, educators, health experts, and researchers in Israel and abroad are increasingly worried about the possible adverse health effects of the use of digital media by children and adolescents, such as poor nutritional habits and obesity, headaches and backaches, impaired vision and eye diseases, sleep disturbances, depression, and anxiety. The scientific literature on the health implications of prolonged screen time indicates that the scientific knowledge is not yet sufficiently established. To address this concern, some countries (including Israel) and health organizations have recommended limiting screen time exposure for small children, while others have refrained from defining hour limits due to the scientific uncertainty that surrounds the matter. Given the increasing use of screens and growing health concerns related to them, additional research is needed in order to establish a scientific basis for recommendations.

References


Climate change poses a great challenge to humanity and significantly affects public health. The World Health Organization (WHO) has called it “the greatest threat to global health in the 21st century.” Climate change may have direct and indirect effects on public health. Direct effects of exposure to extreme temperatures include physiological harm such as sunstroke and dehydration, impaired heart function, neurological and renal damage, an increase in rate of preterm births, cognitive changes, and aggravation of chronic conditions such as cardiovascular and respiratory disease. Extreme climate events such as drought, floods, heat waves, sandstorms, and wildfires can cause physical injury and even death.\(^1\)\(^,\)\(^2\)

In addition to their direct effects on human health, environmental changes induced by climate change have indirect impacts including the proliferation of disease transmitting vectors such as the Asian tiger mosquito, which can transmit the Dengue and Chikungunya viruses, and changes in water availability, quantities of food and its nutritional composition, and air quality.\(^1\)\(^,\)\(^2\) Changes in the precipitation regime or extreme heat or cold weather events can severely diminish agricultural output (livestock and crops) and increase the risk of food spoilage due to the proliferation of bacteria and mold. Premature flowering of plants and a longer flowering season due to high temperatures may exacerbate the condition of people who suffer from allergies.\(^3\) Finally, changes in weather patterns can impact pollutant formation and transport and increase human exposure to them.

Climate change affects members of the public differentially. Some populations—including children, the elderly, people of low socioeconomic status (SES) and outdoor workers—are more exposed to its dangers than are others. According to the WHO, the effects of climate change are expected to cause an additional 250,000 deaths annually in the years 2030 to 2050.\(^4\) The 2019 issue of The Lancet Countdown emphasized the vulnerability of children to climate change: Unless greenhouse gases are substantially reduced, a child born today will live in a world that is at least 4 degrees Celsius hotter than in the pre-Industrial Revolution period, to the detriment of his or her health from infancy through old age.\(^2\)
The effects of climate change and their severity depend on a population’s geographic location, demographic composition, SES, and preparedness for various climatic phenomena. Populations in areas heavily affected by climate change may have to migrate to other areas (“climate migration”). Rising temperatures in sub-Saharan Africa in conjunction with inferior health and environmental conditions may lead to refugee migration to Israel. If this occurs, Israel’s healthcare system will need to provide refugees with medical care.\(^5\,^6\)

In September 2015, the member states of the United Nations, including Israel, adopted the 2030 Agenda for Sustainable Development and its seventeen sustainable development goals (SDGs). In 2019, Israel reiterated its commitment to this agenda in Government Resolution 4631, incorporating the UN development goals and undertaking to improve governance and governmental strategic planning processes.\(^7\) One of the key SDGs is no. 13: “Take urgent action to combat climate change and its impacts.” This goal includes developing national strategies for coping with climate change, raising awareness regarding these changes and promoting mechanisms for dealing with them. In 2019, the Israeli government issued a report on its progress in implementing these goals.\(^8\) The same year the OECD published its own report on this issue and found that Israel falls very short of meeting the UN development goals (Figure 1) and is farther from the SDG targets than the average in OECD countries.\(^9\)

### Distance from Selected UN Development Goals, Israel in Comparison with the Average in OECD Countries

![Figure 1](OECD, 2019\(^9\))

The distance from attaining the goal is measured in standardized units: 0 indicates that the target level for 2030 has been attained; 3 is the distance that most OECD countries have traveled so far. The columns show Israel’s performance relative to a particular SDG (that is, the distance traveled toward the goal), distinguishing between people-related goals (in blue) and planet-related goals (in green). The diamond indicates the average performance in OECD countries.

The Israeli government’s response to climate change focuses on two topics: reducing greenhouse gas emissions (mitigation) and preparing for climate change (adaptation).
Reducing Greenhouse Gas Emissions

In the Paris Agreement, signed at the UN Climate Conference in 2015, the Government of Israel declared a national goal of reducing greenhouse gas emissions to 8.8 tons per capita in 2025 and 7.7 tons per capita in 2030. In late 2018, the Minister of Energy presented a plan with goals for the energy sector for 2030, focusing on discontinuing the use of coal for energy generation and transitioning to transportation powered by electricity and natural gas. In response to the Ministry of Energy’s claim that these steps would significantly reduce greenhouse gas emissions and enable Israel to meet its emissions goals, the scientific community in Israel called for a re-evaluation of the expanded use of natural gas and advocated a transition to renewable energy sources. Notably, according to an OECD report published in 2020, emissions have been rising in Israel in recent years and will rise by another 23.6% by 2030 if the current trajectory continues. Some of the measures for reducing emissions provide the co-benefits of mitigating climate change and benefiting public health. They include transitioning to renewable energy and clean transportation and reducing meat consumption. (See the “Planning” chapter for more information on planning issues related to transportation and energy.)

Preparing for Climate Change

In Government Resolution 4079—Preparedness for Adapting to Climate Change: Implementing Government Recommendations on a National Strategy and Action Plan—approved in 2018, the Israeli government acknowledged the need to prepare for climate change by implementing action plans and policy measures that would mitigate the health, environmental, and economic risks of climate change. The strategy includes three tiers: a) strengthening research and reducing knowledge gaps; b) incorporating climate change considerations into everyday economic activities; (c) pursuing a “no regret” policy.

Pursuant to the government resolution, an Interministerial Administration for Climate Change Adaptation was formed, headed by the Ministry of Environmental Protection (MoEP). The new administrative body is responsible for inter-ministerial coordination, monitoring execution of the national strategy for adaptation, implementing adaptation plans, and updating them from time to time. The thirty-five members of the administration, including representatives of government ministries and other entities, are divided into seven committees that address the key recommendations for a national action plan and strategy for climate change (Figure 2).

Committees at the Interministerial Administration for Climate Change Adaptation

- Energy, Technology and Infrastructure
- Natural Resources, Agriculture and Water
- Emergency and Health
- Science and Closing Knowledge Gaps
- Strategic Integration Committee
- Information and Education
- Local Government
The Strategic Integration Committee ranked the effects of climate change on various economic sectors based on the gravity of the effects in order to create a basis for prioritizing projects and choosing primary courses of action. Thirty experts in various fields participated in the ranking process, which identified the most critical effects of climate change in Israel: increased frequency of extreme heat waves and droughts, a greater number of hot days in the year, desiccation of riverbeds and moist habitats, desertification, and decreased replenishment of natural water sources. With respect to the effects on human health and safety, increased frequency of wildfires, harm to vulnerable populations and urban heat islands were ranked as most critical.

According to an Israel Meteorological Service (IMS) report from 2020, which included possible scenarios for climate change in Israel, in the severe scenario the average temperature in Israel will rise by 4 degrees Celsius by the end of the current century. According to the moderate scenario, from 2040 to the middle of the century the average temperature will rise by 1.5 degrees Celsius and will then level off.\(^\text{14}\)

### Progress since 2017

The *Environmental Health in Israel 2017* report defined challenges related to Climate Change. Progress achieved in this area during the past three years is outlined below.

**The challenge: Implement the National Plan to Combat Cutaneous Leishmaniasis**

**In short:** The National Plan to Combat Cutaneous Leishmaniasis began in 2012. At the end of 2018, MoEP allocated an additional NIS 30 million to support the plan.

**Challenge for the coming years:** Raise public awareness.

Leishmaniasis is caused by the Leishmania parasite, which is transmitted to humans by the female sand fly, which can get infected after stinging an infected animal. This vector’s activity may be affected by climate warming because ambient temperatures impact spatiotemporal sand fly activity patterns.\(^\text{15}\) Two main parasites are implicated: *Leishmania tropica*, whose host animal in Israel is the hyrax, and *Leishmania major*, hosted by various rodents including several types of gerbils.\(^\text{16}\) The Ministry of Health (MoH) data indicate a decrease in incidence rates of leishmaniasis since 2014 (Figure 3), with 432 cases reported to MoH from 2018 through July 2019. Notably, however, there is substantial underreporting and the real scope of morbidity is unknown.\(^\text{17}\)
The National Plan to Combat Cutaneous Leishmaniasis was launched in 2012. At the end of 2018, MoEP allocated NIS 30 million in support of the plan (in addition to an earlier allocation of the same sum). The plan offers professional assistance for local governments and funding for research, including a spatiotemporal epidemiological study of the Leishmania parasite during the past decade in southern Israel, and development of rapid and accessible molecular diagnosis for various species. The 2020 report of the Israel State Comptroller revealed that MoEP transferred funds to local governments for clearing stones that hyraxes use as habitats. For reasons of medical confidentiality, however, MoEP does not receive precise reports on patients’ location (receiving only the names of their localities), making it impossible to precisely target the habitats to destroy. Subsequently, MoH is developing specific procedures for reporting to MoEP.
As noted, the government has approved a national action and adaptation program for coping with climate change (Government Resolution 4079, July 2018) and established an Interministerial Administration for Climate Change Adaptation, headed by MoEP. The program aims to mitigate the adverse effects of climate change, including water shortages, droughts and an increase in extreme climatic events. The program includes assessing risks, developing methodological models for prioritizing challenges and actions relevant to Israel, monitoring morbidity and mortality (with an emphasis on vulnerable populations), incorporating climate change adaptation in decision-making processes, and promoting relevant collaborative initiatives.

Importantly, although the government has approved the National Program, it has yet to fund it. Consequently, the various ministries have limited personnel and funding for advancing the strategic program. The Administration for Climate Change Adaptation plays an integrative role but lacks authority vis-à-vis the participating government ministries.

As part of the adaptation to climate change, MoH was tasked with developing an operative action plan to prepare the healthcare system for potential scenarios stemming from the evolving climate situation. MoH’s mandate also includes formulating a strategy for real-time data collection, developing morbidity forecasts in various extreme weather scenarios, and defining work procedures for coping with them. MoH’s readiness for climate change focuses on responding to the immediate health impact of extreme climate events such as heat waves, cold waves, and floods. In this context, it has elaborated a program to improve the adaptation of hospitals and medical services as part of emergency preparedness. MoH has also published information on climate change, including recommendations for coping with heat waves and extreme cold, with emphasis on recommendations for the general public and for vulnerable populations such as the elderly and the chronically ill.

The Emergency and Health Committee, established under the Interministerial Administration for Climate Change Adaptation, has begun its work and is expected to recommend steps to prepare the healthcare system for climate change in both the short and the long terms. As part of this effort, MoH is conducting a comprehensive review of the health consequences of climate change and actions being taken internationally to address them. The review indicates that the greatest threats to human health from climate change include morbidity due to heat stress, aggravation of chronic diseases, diminished food security, and the spread of vector-borne infectious disease.
MoH is in the initial stages of defining health-related climate change indicators, including:
- emergency room hospitalizations due to respiratory problems and stroke during heat waves;
- outbreaks of food- and water-borne diseases;
- outbreaks of vector-borne diseases;
- physical harm caused by extreme climatic conditions.

According to data published by the Information Center for the Study of Natural Disasters in Israel, the country experienced three extreme climate events in 2018 (Figure 4).  

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**The challenge: Develop specific climate change indicators**

**In short:** An initial list of specific climate change indicators has been compiled.

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**The challenge: Strengthen collaboration between the Israel Meteorological Service and the Ministry of Health in order to prepare for extreme climate events**

**In short:** In 2019, MoH and IMS held several meetings but did not achieve significant progress in tackling this challenge.

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**The challenge: Create a national database that includes exposure metrics and health indicators related to climate change**

**In short:** No progress was made in meeting this challenge.

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* Extreme heat stress refers to temperatures above 30 degrees Celsius with relatively high humidity.
Research on Climate Change in Israel

- Researchers from the Shamir Research Institute and the University of Haifa, examining how temperature changes affect the activity of *Leishmania tropica* vectors (*Phlebotomus sergenti* and *Phlebotomus arabicus* sand flies), found a positive correlation between air temperature at the beginning of the night and the number of active adult sand flies. As temperature at those hours increased, there were more active adult sand flies, thus increasing the risk of human infection.\(^{15}\)

- Researchers from Tel Aviv University, the University of Haifa, and MoH, studying morbidity caused by the Campylobacter bacterium (a food-borne bacterium that causes gastrointestinal diseases) in 1999–2010, found that higher temperatures during the year (above 27 degrees Celsius) increase the risk of morbidity in the general population and particularly among young children.\(^{24}\)

- Researchers from Tel Aviv University, Ben-Gurion University of the Negev, the University of Haifa, and MoH, studying patterns of morbidity caused by the Campylobacter bacterium in Israel, found that the risk of developing Campylobacter-infection is higher in the spring than in the winter. They also found, however, that the risk of illness is affected by several variables including population density and temperature. The researchers concluded that there is a spatiotemporal ambient temperature effect on Campylobacter morbidity.\(^{25}\)

- Researchers from MoH, the Ministry of Agriculture and Rural Development, Clalit Health Services, Ben-Gurion University of the Negev, the Hebrew University of Jerusalem, the Israel Institute for Biological Research, the Israel Nature and Parks Authority, the Israel Defense Forces (IDF), and Mekorot, the national drinking water supplier, analyzed the outbreak of leptospirosis that occurred in August 2018 in the streams of northeastern Israel. The disease is caused by exposure to *Leptospira* bacteria in the urine of infected animals. The researchers reported that the drop in stream levels and reduction in water quality following the drought in 2018 and previous years contributed to the outbreak.\(^{26, 27}\)

- Researchers from MoH and Lev Academic Center analyzed patterns of shigellosis morbidity in Israel in 2002–2015. Shigellosis is transmitted through contact with *Shigella* bacteria in food or water or through human contact. The researchers showed that shigellosis morbidity in Israel has significantly declined, especially since 2010. They also found that most incidence of shigellosis occurred during the warm months of the year, implying that climate change and rising temperatures in Israel may spur an increase in shigellosis morbidity.\(^{28}\)

- Researchers from MoH, Tel Aviv University, and several medical centers—Assaf Harofeh, Barzilai, Meir, Kaplan, HaEmek, Rambam, Laniado, and Sheba—found an association between the outbreak of West Nile fever in 2015 and extreme heat waves that year.\(^{29}\)
• Researchers from the University of Haifa, Rambam Health Care Campus, and the Israel Center for Disease Control analyzed data from the National Stroke Registry to examine the association between high environmental temperatures in the summer and the risk of stroke. They found that while hot summer days may increase the risk of stroke in subsequent days, the risk of stroke decreases as the disparity between daytime and nighttime temperatures widens.30

• Researchers from the Hebrew University of Jerusalem, Ben-Gurion University of the Negev and Soroka University Medical Center studied the association between extreme temperatures and preterm birth among pregnant women in southern Israel. They found that exposure to high temperatures in weeks 32–39 of pregnancy is associated with a higher risk of preterm birth, especially among female fetuses.31

• A group of researchers from Soroka University Medical Center, Ben-Gurion University of the Negev, and Harvard University found that high mean temperatures during the first or third trimester of pregnancy increase the risk of developing preeclampsia. Preeclampsia can occur in high temperatures due to perturbations in maternal heat homeostasis, resulting in reallocation of energy resources and their availability to the fetus.32

• Researchers from the University of Haifa, Meuhedet Health Services, the University of Tulsa and the University of Córdoba compared concentrations of dust particles during a hamsin (days of high temperature and low humidity), on hot days (high temperature and high humidity), and on cold days (low temperature) and found the highest concentrations of dust particles in the air during a hamsin. Allergy sufferers experience stronger symptoms during a hamsin than on other days, and these symptoms may worsen as climate change brings on an increase in the number of hamsin days in Israel and the Middle East.33

• Researchers from the University of Haifa and the Hebrew University-Hadassah Braun School of Public Health and Community Medicine are examining urban resilience to extreme climate events in Haifa. The initial findings indicate that while Haifa and its healthcare system are prepared for emergencies such as war or earthquake, they have made no specific preparations for extreme weather.

• Joint research by Soroka University Medical Center and Harvard University found an association between high temperatures with low humidity and the number of snakebite incidents in Israel in 2008–2015. The researchers also found that heat waves led to a higher frequency of snakebites in both the cold and warm seasons.34

• A study conducted by researchers from Soroka University Medical Center and Harvard University among 2,338 residents of Beer Sheva found an association between a 5 degrees Celsius spike in temperature and suicide attempts during the two subsequent days. The researchers concluded that a steep rise in temperature has a substantial impact on the likelihood of suicidal behavior, especially among patients with a psychiatric diagnosis or with previous attempts at suicide.35
Future Challenges

In recent years, Israel has made some progress in preparing to adapt to climate change. The Interministerial Administration for Climate Change Adaptation and its committees were established; the Administration worked to rank the criticality of climate change effects as a basis for prioritizing projects and making decisions on primary courses of action. It appears that the main emphasis on health at the Administration for Climate Change Adaptation is on short-term effects such as heat waves, cold waves, and floods.

It is also important to prepare for the long-term effects of climate change on public health—for example, the expected increase in the spread of food pests, mosquitoes, and other vectors. Effective response is needed in case of spread of vector-borne infectious diseases such as leishmaniasis, Zika fever, dengue, West Nile fever, and rabies. Also needed are preparations for unknown viral, bacterial, and parasitic threats potentially related to climate change. In bracing for additional long-term effects of climate change, it is important to ensure that the nutritional value of food is preserved and that the impact of climate change on mental health is addressed.

While climate change may significantly affect public health in Israel, epidemiological research in Israel in this field is still in its very early stages. In particular, there is a lack of interdisciplinary research on the health effects of climate change with emphasis on morbidity and mortality among various populations—for example, examining the association between environmental temperature and hospitalization of chronically ill adults. Also needed is research in the fields of economics, the social sciences, and healthcare system management in the context of climate change. It would be useful, for example, to examine the health effects of climate change using co-benefit models, both in the contexts of mitigation and adaptation. To promote research in this field, relevant data must be systematically collected, and this requires the creation of a digital system capable of gathering the data in real time.

From a broader perspective, legislative action is needed in order to better cope with climate change and its impact on health. MoEP is drafting a “Climate Bill”—a statute that would make Israel’s emission targets binding for the first time. Also, measurements and assessments of climate change should be incorporated into decision-making processes such as those related to planning. Additional partners should be enlisted in the effort to address the health implications of climate change. This includes HMOs and medical centers, which can collect data and raise medical teams’ awareness of the health effects of climate change as well as methods for treatment and prevention; and government ministries, which can advance adaptation plans for heat waves.

Local governments have a central role to play in preparing for climate change. As part of the EU’s Clima-Med program, representatives of forty Israeli local authorities participated in 2019 in a workshop on preparing and coping with the steady increase in consumption of energy resources. The local government committee of the Interministerial Administration for Climate Change Adaptation prepared an adaptation action plan at the local level that would, among other things, identify risks according to climatic regions. One of the challenges in the coming years is to raise involvement of local authorities in mitigation and preparedness for climate change.
References


Urban and transportation planning are closely linked to human health. Planning plays an important role in preventing health hazards and sanitation problems in the urban space, and contributes to ensuring drinking water quality, sewage and waste treatment, and open green spaces in cities. In 1946, the World Health Organization (WHO) defined the term “health” as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” Urban planning has a critical impact on public health because a healthy environment means not only an environment free of air pollution, noise, water pollution, and other hazards that directly endanger public health but also an environment that encourages physical, community, and social activity.1

Studies have shown that the urban environment—including transportation infrastructure, neighborhoods, buildings, parks and open public spaces—affects an individual’s health. The extent to which an individual is exposed to air pollution, noise, temperature, and green areas encourages or inhibits daily physical activity.2 There is evidence that living near industrial areas and main roads increases exposure to air pollution and noise and raises the risk of morbidity and early mortality, whereas living in proximity to green spaces contributes to mental health and healthy birth outcomes and reduces rates of cardiovascular morbidity and early mortality. Several factors have been identified that encourage people to go out into the urban space, take walks, and ride bicycles—including low building density, mixed-use planning that enables use of resources throughout most of the day, and the accessibility and availability of frequent and reliable public transportation. These variables, where present, create an infrastructure that facilitates walkability, bikeability, and a neighborhood that encourages a healthy and active urban lifestyle.

Israel is one of the world’s most densely populated countries and has the highest rate of population growth among developed countries. At its current rate of growth, its population is expected to double by the middle of this century. (Figure 1).3 This rapid population increase, however, is not evenly distributed across the population and is accompanied by an alarming reduction in open space. When looking at the past twenty years, the rate of reallocation of open space to developed land peaked in 2014–20174 and is expected to lead to an overall reduction in access to quality open space countrywide.
The *Environmental Health in Israel 2017* report defined challenges related to Planning in Israel. Progress achieved in this area during the past three years is outlined below.

**The challenge: Promote shading in open public spaces**

**In short:** The Planning and Construction Regulations (Playground Shading) went into effect in 2019; the amended Planning and Construction Regulations (Calculating Land-to-Building Ratio in Plans and Permits) went into effect in 2020.

**Challenge for the coming years:** Raising awareness of the importance of shading and continuing to install shading in the public sphere in order to create climatic comfort in public spaces.

The Planning and Construction Regulations (Playground Shading), effective September 2019, mandate the shading of 70% of playground facility areas. An amendment to the Planning and Construction Regulations (Calculating Land-to-Building Ratio in Plans and Permits) (1992), effective 2020, encourages the installation of shading in open public spaces such as public gardens, paths, beaches, promenades, city squares, sports and recreation facilities, parks, trails,

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**Legend:**
- **Significant progress**
- **Some progress**
- **Little or no progress**
city boulevards, and open public areas, as well as open private property for which plans include a public right of way. Notably, the amended regulations exclude means of shading from the calculation of land-to-building ratios.

A cost-benefit analysis of shading in Israel, jointly prepared by the Ministry of Health (MoH), Tel Hai Academic College, and the Ministry of Construction and Housing, found that shading helps to lower pollution levels, mitigate the risk of skin cancer, and increase physical activity—all yielding health and economic benefits (Table 1). 5

### Table 1

<table>
<thead>
<tr>
<th>Age Group</th>
<th>16–44</th>
<th>45–64</th>
<th>65+</th>
<th>Weighted Average</th>
</tr>
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<tbody>
<tr>
<td>Adjusted life years added</td>
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<td>1,221</td>
<td>2,971</td>
<td>721</td>
</tr>
<tr>
<td>Savings for the healthcare system</td>
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<td>172</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>Productivity gain</td>
<td>260</td>
<td>290</td>
<td>290</td>
<td>290</td>
</tr>
<tr>
<td>Total annual benefit</td>
<td>600</td>
<td>1,684</td>
<td>3,433</td>
<td>1,178</td>
</tr>
</tbody>
</table>

* The benefit of physical activity is estimated at NIS 600–NIS 3,433 per year. The maximum benefit is gained by someone who moves from “inactive” status to regularly “active” status (about 150 minutes per week).

### The challenge: Promote plans for paving bicycle paths

**In short**: Paths for bicycles and other alternative means of transport are being planned and built in accordance with the planning guidelines of the Ministry of Transport.

**Challenge for the coming years**: Improve connectivity between bicycle paths and urban intersections; enforce riding on dedicated paths or on roads only.

Sound urban planning includes a dense network of streets, sidewalks, and shading that facilitates walking and cycling and improves the quality of urban life.

In April 2020, the Israel Planning Authority (IPA) at the Ministry of Finance (MoF) published a policy document examining the degree to which urban planning is oriented toward the use of public transport. 6 The document was intended to help planners and planning offices learn how to realize the potential urban use of public transport.

The Central District (Machoz Merkaz) Planning and Construction Committee is promoting a plan to build paths for bicycles and other alternative means of transport (electric bicycles, electric scooters, and Segways), separating them from motor vehicles and pedestrians in order to prevent conflicts among road users. The plan is to link all communities in the district in
order to give bicycle riders efficient access to central train stations, employment zones, and education institutions. The plan is part of a comprehensive effort by the District Planning Office and the Ministry of Transport (MoT) to encourage the use of public transportation, including creating public transport lanes, building park-and-ride facilities, and strengthening connectivity between train stations and employment zones. The plan envisions three networks for bicycle riders—metropolitan, secondary, and local—that would stretch across 1,351 kilometers in this district.

In addition, a new national master plan for land transport infrastructure, TAMA 42, includes areas with detailed plans for bike paths. In March 2020, the National Council for Planning and Construction decided to submit the plan to the government for its approval.

The Planning and Building Law requires an Environmental Impact Assessment (EIA) as part of the planning and construction process in plans that could significantly affect the environment. An EIA, however, does not address expected health effects and implications, leaving the health impact of various plans unclear. MoH sees great importance in including health considerations in the planning processes by incorporating an Health Impact Assessment (HIA) into the planning of future projects. For several years, MoH has been advocating for mandatory HIAs, unsuccessfully so far.

The purpose of an HIA is to prevent or minimize harm to public health that might result from implementing the proposed plan. An HIA offers many advantages, including a broad perspective of health (physical, mental, and social well-being), a comprehensive and in-depth review of the direct and indirect health effects of construction and development projects, public involvement in decisions that affect citizens’ lives and health, and an examination of several alternatives. It also conveys recommendations on maximizing positive health benefits, minimizing negative effects, and narrowing health disparities.

In May 2018, the government formed an inter-ministerial team with representatives from MoH, MoF (IPA), the Ministry of Environmental Protection (MoEP), the Ministry of Energy (MoE) and MoT and tasked it with formulating and implementing a methodology for examining the health aspects of mining and quarrying projects. MoH contends that every plan relating to national infrastructure projects—such as power plants, airfields, or quarries—should require an HIA on the part of the planning organization.
Since 2017, two planning professionals have joined MoH and the ministry’s contribution to planning procedures at all levels has expanded. However, in several national planning institutions MoH representatives are substitutes or observers without voting rights; therefore, their ability to lead and exert influence in planning policy is limited.

IPA is promoting a strategic national master plan for the energy sector, TAMA 41. The goal of the plan is to establish planning principles and rules for building and protecting infrastructure for energy generation facilities and dealing with the energy produced. The goal is to create a framework for energy infrastructure planning from an integrative, sustainable, and long-term perspective. Concurrently, the program emphasizes limiting the impact of energy facilities on the environment and on public health. Energy sector plans such as TAMA 41 have a decisive impact on public health because energy facilities can pollute air, water, and soil, and affect different populations, especially vulnerable ones.

In 2018, the Minister of Energy announced a vision for ending coal use for energy generation within a decade. His statement was followed by work at MoE on energy alternatives in order to attain the goal. Acting in accordance with the Electricity Sector Law, 1996, the minister approached the Public Electricity Commission for professional consultation on defining policy principles toward shutting down the country’s coal-fired plants or converting them to natural gas. In 2020, the Minister of Energy decided to stop using coal to generate electricity, to retain this capability only as an emergency option and to convert plants from coal to natural gas. This transition is scheduled for implementation by the middle of the next decade.

In recent years, electricity generation in Israel has been shifting from coal and polluting fuels to natural gas and renewable sources (Figure 2), bringing about a dramatic reduction in emissions of local pollutants and a decrease in emissions of carbon.
Importantly, however, natural gas is a fossil energy source that pollutes the air and contributes to greenhouse gas emissions; thus, an effort to reduce its use should be made. Indeed, along with the decision to stop using coal to generate electricity, consideration is being given to expanding the target for electricity generation from renewable sources from 17% to 25%–30% by 2030. If this is done, emissions and air pollution are expected to decline significantly.

The Changing Mix of Fuels in 2010–2019 and Forecast for 2025

MoEP estimates the annual external cost of the health effects of traffic-related air pollution at over NIS 12 billion.\textsuperscript{11}

Recent years have seen growing use of private vehicles—including hybrids—in Israel. Details of the country’s transportation situation at the end of 2019 are presented below:\textsuperscript{11–13}:

- There are about 3,600,600 motor vehicles in Israel, including approximately 3,085,300 private vehicles.
- From 2018 to 2019, the national fleet of motor vehicles grew by 3% and that of private vehicles by 3.6%.
- 14.2% of motor vehicles and 5.4% of private vehicles are diesel-fueled.
- There are about 175,200 private hybrid vehicles in Israel, in addition to 1,642 hybrid taxis—45% more than in 2018.
• The motorization rate in Israel rose from 390 vehicles per 1,000 residents in 2018 to 394 in 2019, this rate is low compared to other developed countries.
• Only eighty-four electric buses, fewer than 1% of all buses, are currently operating in Israel. In 2019, the number of private electric cars surged (655 in 2018, 1,196 in 2019).
• According to MoEP data, an urban diesel bus generates NIS 86 million per year in cumulative external costs (adverse health effects from air pollution) as against NIS 30 million per year from an electric bus.

Analysis of data reported from car manufacturers shows that the percentage of high-emission vehicles has decreased.

In light of the data presented above, there is clearly a need to improve the efficiency of public transportation and develop interfaces between public transportation systems. Plans for additional light rail lines in Jerusalem and metropolitan Tel Aviv have been promoted in recent years. Plans for bus rapid transit (BRT) lines are also moving ahead and dedicated lanes are being allocated for high-capacity vehicles and cars with at least two passengers. In addition to improvements in the efficiency of public transportation, however, traffic congestion charges and decrease in parking allocations are needed.4

**Future Challenges**

Urban planning has a significant impact on public health at all stages of life, including early childhood. It is imperative to develop guidelines to prevent, whenever possible, siting of kindergartens and schools in close proximity to main roads. Due to the shortage of available land for development in Israel, however, some kindergartens and schools will be located near main roads. In these cases, detailed plans should require greenery or open public space along the roads, with classrooms kept at a greater distance.

All aspects of planning should aim to maximize the amount of green, open, high quality public spaces in cities and enable multiple uses of these areas—for example, the use of areas on school grounds by the general public. In this context, it is important to introduce the concept of a “healthy city.” A healthy city seeks to continually improve its physical and social environment in order to mitigate health inequality and emphasize health as a primary value and goal at all levels. The “healthy city” approach is closely linked to that of a “sustainable city”14 and is conducive to promoting policies aimed at reducing emissions of heat, radiation, and greenhouse gases. There is a need to develop a methodology and set criteria in Israel for defining a “healthy city.”

In light of the major challenges posed by climate change, it is increasingly important to include health considerations at all levels of urban planning. This includes, for example, construction that integrates walking paths in open and shaded public spaces, adapting planning to a reality
in which more and more people are in homes (to avoid extreme temperatures), placing commerce in shaded settings or storefronts that include colonnades, and also distributing, and dividing business hours so that they suit the climate. Such planning also includes amending plans for water and sewage infrastructure in order to prevent flooding, reducing energy consumption, and pursuing renewable energy solutions. The final shutdown of the coal-fired power plants in Hadera and Ashkelon is a welcome and important step, but the alternative—using natural gas—should be closely examined in order to avoid making it a permanent solution in Israel. Natural gas, while less of a polluter than coal, still pollutes. MoE and the Israel Electricity Authority should promote a transition plan for energy generation from renewable sources and for construction of energy storage facilities.

In March 2020, the National Council for Planning and Construction recommended that the Minister of Finance issue planning and construction regulations that adopt Israeli Standard 5281 for sustainable construction (green building). All new buildings—residences, offices, stores, healthcare facilities, schools, public institutions, etc.—will be required to comply with the regulations starting from a target date that has yet to be determined. The standard encourages construction near centers of public transportation but does not sufficiently promote walking in the public sphere, within buildings, and in open spaces. A challenge for the coming years is to address additional relevant issues for sustainable construction and sustainable environment that the standard omits, such as making drinking fountains and public toilets more accessible, using landscaping that is economical in terms of water use and waste (cuttings), and encouraging the installation of solar energy production units on rooftops.

An additional challenge is to promote urban planning that incorporates public transportation (transit-oriented development). The ability to link different means of public transportation depends on the ability to bring public transportation to within 500 meters of the places where people live, work, or engage in recreation. Guidelines for integrating public transportation infrastructure and urban development were published. IPA is considering making such guidelines mandatory, meaning that a district committee or the National Committee for Preferred Areas for Housing (VATMAL) would not approve any plan that lacks a commitment by the developer to integrate public transportation into the plan.

At the beginning of 2018, the National Council for Planning and Construction called for the preparation of TAMA 49—a national master plan for the healthcare system that updates policy for healthcare system structures and spatial deployment of healthcare services by the year 2040. The challenge for the coming years is to prepare and approve the plan in order to outline the healthcare system's development needs. This includes the land needed for building healthcare institutions, promotion of strategic social principles in healthcare institutions (for example, reducing inequality in access to healthcare services), and designing the hospital complex to include urban nature as a means of shortening recovery times and creating a pleasant work environment.
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In the context of environmental health, vulnerable populations include various groups that are more likely than the general population to experience adverse health effects following exposure to environmental contaminants. This vulnerability can be characterized by two types of factors: (a) intrinsic factors that usually cannot be altered, such as age, pregnancy, gender, ethnicity, and genetic polymorphisms, and (b) extrinsic factors that usually can be altered, such as socioeconomic status (SES), health status, eating habits, lifestyle, and geographic proximity to sources of exposure.

The main population groups affected by intrinsic factors are fetuses, infants, children, pregnant women, the elderly, and people with a specific genetic polymorphism or a chronic illness such as cardiac or pulmonary disease. Population groups affected by extrinsic factors include people of low SES, who generally have higher smoking rates, less access to high quality healthcare services, and work conditions that are hazardous to health; people with poor nutrition; people who live near sources of exposure to potential contaminants such as agricultural fields, heavy industry, contaminated sites or highways; workers in chemical-intensive industries and people who do not reside in permanent structures.

Environmental health policy in Israel aims to protect vulnerable populations and takes them into account when setting standards for air, drinking water, and food. Furthermore, in cases of severe air pollution, the Ministry of Environmental Protection (MoEP) and Ministry of Health (MoH) issue advisories and recommendations for the general public as well as specific recommendations for vulnerable populations. Many mandatory consumer product standards in Israel target products intended for infants and children, including toys, baby bottles, beds, mattresses, eating utensils, and children's jewelry.
Progress relevant to vulnerable populations has been achieved in many areas of environmental health in Israel. Standards that limit heavy metal content in children’s jewelry and lead in paint, including paint used for playground equipment, have been approved as mandatory. Biomonitoring research pertinent to vulnerable populations, such as children and pregnant women, has seen significant progress. (See the “Human Biomonitoring” and “Chemicals in Consumer Products” chapters.) A survey on lead and other heavy metals in tap water in educational institutions throughout Israel was conducted in 2018. (See the “Chemical Parameters in Drinking Water” chapter).

**Progress since 2017**

The *Environmental Health in Israel 2017* report defined challenges related to Vulnerable Populations. Progress achieved in this area during the past three years is outlined below.

**The challenge: Enhance collaboration between government ministries and civil society organizations to improve the flow of information regarding environmental hazards and to promote mechanisms of public participation**

| In short: MoH and MoEP engage in collaborative efforts vis-à-vis civil society organizations. | Challenge for the coming years: Intensify collaboration, including joint funding of research and projects. |

Following an open call for proposals, the Environment and Health Fund (EHF) and MoH are jointly funding the National Biomonitoring Program, including an assessment of children’s exposure to environmental contaminants. (See the “Human Biomonitoring” chapter.) In another collaborative project, EHF and the Israel National Council for the Child are promoting a legislative framework designed to protect infants, toddlers, and children from exposure to chemicals in consumer products. (See the “Chemicals in Consumer Products” chapter.)

There is also collaboration between MoEP and civil society organizations on environmental issues relevant to vulnerable populations. For example, MoEP and the Jewish National Fund (KKL-JNF) launched the “Easy to Breathe” national environmental program in 2017, designed to reduce pollution and environmental hazards and improve air quality in Israel. The program provides NIS 390 million in funding for four green transportation projects, including investment in electric public transport, hybrid vehicles, and installation of particle filters on garbage trucks. It also funds green energy projects (energy efficiency) and planning initiatives (renovating housing and installing solar energy infrastructure).
Recent studies in Israel that are helpful in identifying vulnerable populations are presented in Table 1.

There has been little research on genetic variability and vulnerable populations in recent years. Researchers from the University of Haifa examined the association between exposure to environmental tobacco smoke (ETS) and genetic variability (polymorphisms of the N-Acetyl-transferase 2 enzyme), and the risk of breast cancer among Israeli Arab women.¹

**The challenge**: Conduct research on genetic variability and other vulnerability predictors in order to identify vulnerable populations

**In short**: One study was published on this topic.

In short: Several studies that are helpful in identifying vulnerable populations have been conducted in recent years. However, no specific goals and objectives have been defined for these groups in the context of the national plan.

**Challenge for the coming years**: Translate the research findings into specific objectives and activities of government ministries.

**Research on Vulnerable Populations in Israel**

Many environmental health studies address vulnerable populations, focusing mostly on pregnant women and newborns, children, and residents of various geographic areas. Some address other vulnerable populations in Israel, such as the Arab population and low SES groups (Figure 1 and Table 1).

**Environmental Health Research Studies on Vulnerable Populations in Israel, by Sub-population, 2017–2020**

![Figure 1](https://example.com)
<table>
<thead>
<tr>
<th>Table 1 Israel Ministry of Health</th>
</tr>
</thead>
</table>

### Environmental Health Research Studies on Vulnerable Populations in Israel, by Sub-population, 2017–2020

<table>
<thead>
<tr>
<th>Population</th>
<th>Research Topic</th>
<th>Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnant women, nursing mothers, and newborns</td>
<td>Effect of traffic-related air pollution on risk of pregnancy loss</td>
<td>Ambient air quality</td>
</tr>
<tr>
<td></td>
<td>Effect of air pollution on fetal development</td>
<td>Ambient air quality</td>
</tr>
<tr>
<td></td>
<td>Association between prenatal and postnatal exposure to particulate matter and autism spectrum disorder</td>
<td>Ambient air quality</td>
</tr>
<tr>
<td></td>
<td>Effect of air pollution on head circumference of newborns in the Haifa Bay area</td>
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</tr>
<tr>
<td></td>
<td>Association between exposure of pregnant women and infants up to the age of nine months to air pollutants, and autism spectrum disorder</td>
<td>Ambient air quality</td>
</tr>
<tr>
<td></td>
<td>Contribution of green infrastructure to mitigating risk of adverse birth outcomes</td>
<td>Ambient air quality</td>
</tr>
<tr>
<td></td>
<td>Association between exposure of pregnant women to particulate matter and risk of congenital transient hypothyroidism (CTH) among newborns</td>
<td>Ambient air quality</td>
</tr>
<tr>
<td></td>
<td>Effect of exposure to ambient and indoor air pollution during pregnancy and early childhood on respiratory morbidity</td>
<td>Indoor air quality</td>
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<tr>
<td></td>
<td>Effect of ambient and indoor air pollution on fetal development, focusing on the Haifa Bay area</td>
<td>Indoor air quality</td>
</tr>
<tr>
<td></td>
<td>Effect of using aluminum-based deodorant on aluminum concentration in breast milk</td>
<td>Chemicals in consumer products</td>
</tr>
<tr>
<td></td>
<td>Measuring concentrations of phthalates and phenols in urine of pregnant women</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td></td>
<td>Effect of exposure to phthalates on fertility treatment outcomes</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td></td>
<td>Association between expression of miRNA molecules in follicular fluid and urinary concentrations of phenols and phthalates among women of reproductive age</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td></td>
<td>Exposure of pregnant women and newborns to organophosphate pesticides</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td></td>
<td>Exposure of pregnant women and newborns to ETS</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td></td>
<td>Biomonitoring of heavy metals, pesticides and flame retardants among pregnant women in the Negev</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td></td>
<td>Correlation between intrauterine exposure to polychlorinated biphenyls (PCBs) and 1) thyroid hormone levels among pregnant women and newborns and 2) neonatal anogenital distance</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td>Population</td>
<td>Research Topic</td>
<td>Chapter</td>
</tr>
<tr>
<td>------------------------------------------------</td>
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</tr>
<tr>
<td>Pregnant women, nursing mothers, and newborns</td>
<td>Biomonitoring of heavy metals (lead, mercury, and cadmium) and organic pollutants (BTEX) in pregnant women, newborns, and fathers</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td></td>
<td>Effect of temperature on fetal development[^1]</td>
<td>Climate change</td>
</tr>
<tr>
<td></td>
<td>Effect of temperature on risk of high blood pressure in pregnancy[^2]</td>
<td>Climate change</td>
</tr>
<tr>
<td>Children</td>
<td>Assessment of exposure to volatile organic compounds in daycare centers in the Haifa Bay area, and the relationship between indoor and outdoor air pollutants</td>
<td>Indoor air quality</td>
</tr>
<tr>
<td></td>
<td>Parents’ perceptions of their children’s exposure to ETS[^21]</td>
<td>Environmental tobacco smoke</td>
</tr>
<tr>
<td></td>
<td>Exposure to ETS and SES[^22]</td>
<td>Human biomonitoring</td>
</tr>
<tr>
<td></td>
<td>Assessment of children’s exposure to organophosphate pesticides in Israel[^23]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effect of rising environmental temperature on Campylobacteriosis among young children[^24]</td>
<td>Climate change</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td>Effect of SES and ambient temperature on campylobacter and salmonella infection[^25]</td>
<td>Climate change</td>
</tr>
<tr>
<td>Arab population</td>
<td>Effect of a green environment with negligible concentrations of carbon dioxide on the heart rate of Jewish and Arab women[^26]</td>
<td>Ambient air quality and Planning</td>
</tr>
<tr>
<td></td>
<td>Effect of ETS exposure and genetic polymorphism (the N-Acetyl-transferase 2 enzyme) on the risk of breast cancer[^1]</td>
<td>Environmental tobacco smoke</td>
</tr>
<tr>
<td></td>
<td>ETS exposure in Arabs compared with Jews[^27]</td>
<td>Environmental tobacco smoke</td>
</tr>
<tr>
<td></td>
<td>Effect of exposure to organochlorine pesticides on non-Hodgkin’s lymphoma morbidity among Jewish and Arab populations[^28]</td>
<td>Pesticides</td>
</tr>
<tr>
<td></td>
<td>Effect of short visits to outdoor urban environments on psychological, physiological, and cognitive indicators among Jewish and Arab women[^29]</td>
<td>Planning</td>
</tr>
<tr>
<td>Geographic areas</td>
<td>Effect of exposure at age seventeen to air pollutants in the Haifa Bay area on cancer morbidity in adulthood</td>
<td>Ambient air quality</td>
</tr>
<tr>
<td></td>
<td>An economic assessment of impact of air pollution in the Haifa Bay area</td>
<td>Ambient air quality</td>
</tr>
<tr>
<td></td>
<td>Biomonitoring of air pollutants in blood donors residing in the Haifa Bay area</td>
<td>Ambient air quality and Human biomonitoring</td>
</tr>
</tbody>
</table>
Future Challenges

The population in Israel is growing rapidly despite limited land resources, and is expected to increase by 48% between 2035 and 2100. Consequently, new residential neighborhoods are being built in locations close to agricultural fields and airfields. The people who move into these neighborhoods are likely to become vulnerable populations in the context of environmental health. Communities living near agricultural fields, for example, may have higher exposure to pesticides sprayed on the ground or from the air, and communities living near airports may face increased exposure to noise and, possibly, to air pollution.

Along with the expected increase in the size of the general population, the elderly population is expected to grow dramatically (by 117%). For this reason and in view of the limited research in Israel on the health impacts of environmental pollution on the elderly, data on the burden of disease from environmental pollution among this population are needed, as are steps to reduce this burden.

The air monitoring network in Israel has expanded and covers broader geographical areas than in the past. However, there are still some populated areas, especially in the periphery, including Bedouin settlements in southern Israel, that are not regularly monitored. Consideration should be given to expanding the monitoring network to cover these areas.

Other vulnerable populations include the migrant and refugee populations in Israel. These populations are generally characterized by relatively low SES, less access to medical services, and the likelihood of exposure to various environmental contaminants such as ETS. They should be included in plans to promote environmental health and reduce exposure to environmental pollutants.

Consideration should be given to establishing an interdisciplinary inter-ministerial committee to develop a national intervention plan on environmental health among vulnerable populations, on the basis of findings from recent research in Israel and abroad.
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Berlin, M., Barchel, D., Brik, A., Kohn, E., Keidar, R., Livne, A., ... Berkovitch, M. (2019). *Intrauterine exposure to polychlorinated biphenyls (PCBs) and thyroid hormones in Israeli women: Data from EHF-Assaf Harofeh-Ichilov birth cohort.* Poster presented at Environment and Health Fund annual conference, Environment and Health: Complex Interactions, Tel Aviv, Israel.


Environmental Health Indicators and Trends

Exposure to environmental pollutants can adversely affect quality of life and can cause morbidity and mortality. Environmental risk factors include ambient and indoor air pollution, drinking water and soil contaminants, environmental tobacco smoke (ETS), heavy metals, pesticides, and endocrine disrupting chemicals (EDCs).

Environmental health indicators are important tools for monitoring potential risks to human health from environmental pollution and for guiding policymaking. Reflecting the association between environmental factors and health outcomes, they include exposure indicators (for example, the concentration of an environmental pollutant or the percentage of the population exposed to a pollutant) and health indicators (for example, incidences of morbidity, hospitalization, and medication use). The selected indicators are generally associated with an environmental issue that significantly affects the health of the general population or a particular sub-population. Environmental health indicators should be based on available data published regularly and frequently and should be sensitive enough to reflect changes in trends. They should also be consistent enough to allow international comparisons and study of trends over time. Therefore, environmental health indicators are very important for monitoring trends in environmental exposure and health outcomes related to environmental hazards and exposures, comparing environmental health status among countries and among sub-populations within a country, monitoring the effectiveness of policy measures and other intervention programs in the field of environmental health, and raising awareness of environmental health issues.

Many professional organizations—the World Health Organization (WHO), the U.S. Centers for Disease Control and Prevention (CDC), and the European Environment and Health Information System (ENHIS) in the WHO European Region, among others—have compiled lists of selected environmental health indicators. Several countries, including the U.S. and New Zealand, have created environmental health indicator programs that include databases available to the public and to decision-makers. The program enables, for example, identification of populations at risk of developing diseases associated with environmental pollution, as well as trends in morbidity or in exposure to environmental pollution.
A wealth of environmental and health data are collected in Israel. Environmental data are collected and monitored continuously, periodically or in surveys of contaminants in the air, water, and food. The health data are collected in national databases and registries that allow tracking and monitoring of selected diseases (cancer, stroke, diabetes, kidney disease including dialysis and transplants, congenital anomalies, and infectious diseases). A perinatal registry records data on low birth weight (less than 1,500 grams) and on emergency room visits and hospitalizations. There are also data on the health status of adolescents (age seventeen) who are candidates for military service. Copious data are stored in the electronic databases of the country’s four HMOs. The National Program for Quality Indicators in Community Healthcare (QICH) publishes data on twenty-eight quality indicators including asthma rates, cancer screening, cardiovascular health, pediatric health, diabetes, and immunization among the elderly.

Despite this wealth of data, however, Israel has no databases that combine environmental and health data to help identify possible causal associations. In addition, there are few published assessments in Israel of the burden of disease resulting from exposure to environmental pollution. Various global projects—the Global Burden of Disease (GBD), State of Global Air, Global Alliance on Health and Pollution, and the WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene, among others—provide useful data that can support the planning and assessment of measures to reduce the burden of disease in Israel.

### Progress since 2017

The *Environmental Health in Israel 2017* report defined challenges related to Environmental Health Indicators and Trends. Progress achieved in this area during the past three years is outlined below.

<table>
<thead>
<tr>
<th>The challenge: (1) Formulate integrated environmental health indicators</th>
<th>(2) Collect and publish data on various environmental health indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>In short: Israel has yet to produce a final list of environmental health indicators. Progress has been made in collecting and publishing data on several candidate indicators.</td>
<td>Challenge for the coming years: Formulate a final list of environmental health indicators; continue to collect data.</td>
</tr>
</tbody>
</table>

The *Environmental Health in Israel 2017* report defined and categorized candidate indicators for environmental health in Israel on the basis of indicators developed by WHO, CDC, and ENHIS: exposure, chronic disease, and climate change indicators as well as those relating to early childhood. In recent years, data for numerous indicators—primarily related to exposure to lead in drinking water, children’s exposure to ETS, and adults’ exposure to organophosphate (OP) pesticides—have been synthesized and published. For other indicators, however, such as the
prevalence of asthma and allergies in children, no data have been synthesized in recent years, partly due to the lack of regular and periodic collection and synthesis of data on environmental health indicators. Table 1 displays these indicators, the year when the relevant data for each indicator was last updated, and primary findings in recent years.

### Candidate Indicators for Environmental Health, Data Availability Status

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Year in which Latest Published Data was Collected</th>
<th>Primary Findings</th>
<th>Plans for Future Data Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead in drinking water (tap)</td>
<td>2018 – Educational institutions (see “Chemical Parameters in Drinking Water” chapter)</td>
<td>99.6% of water samples in educational institutions meet the standards for lead concentrations</td>
<td>—</td>
</tr>
<tr>
<td>Exposure to indoor air pollutants in schools</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Percentage of infants and children exposed to ETS</td>
<td>—</td>
<td>—</td>
<td>2020</td>
</tr>
<tr>
<td>Intake of heavy metals in food among adults</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Percentage of population with concentrations of urinary OP metabolites above level of quantification</td>
<td>2015–2016 (see “Human Biomonitoring” chapter)</td>
<td>A statistically significant decrease in concentrations of most OP metabolites in urine in adults</td>
<td>2020</td>
</tr>
<tr>
<td>Incidence of certain types of cancer, including childhood leukemia</td>
<td>2018</td>
<td>—</td>
<td>Ongoing collection</td>
</tr>
<tr>
<td>Asthma hospitalizations among children and adults</td>
<td>2018</td>
<td>—</td>
<td>Ongoing collection</td>
</tr>
<tr>
<td>Deaths from vector-borne disease</td>
<td>2018</td>
<td>—</td>
<td>Ongoing collection</td>
</tr>
<tr>
<td>Heat-stress hospitalizations</td>
<td>2019</td>
<td>In 2019, there were over 3,500 emergency room visits for heat stress and dehydration, with peak numbers in July and August</td>
<td>Ongoing collection</td>
</tr>
<tr>
<td>Prevalence of certain congenital anomalies</td>
<td>2014</td>
<td>—</td>
<td>Ongoing collection</td>
</tr>
<tr>
<td>Number of poisonings reported among children under the age of five</td>
<td>2018</td>
<td>—</td>
<td>Ongoing collection</td>
</tr>
<tr>
<td>Prevalence of asthma and allergies in children</td>
<td>2015</td>
<td>—</td>
<td>Collaboration between the Ministry of Health and Clalit Health Services to synthesize available data</td>
</tr>
</tbody>
</table>
Data on Risk Factors and Trends

As noted, despite the importance of up-to-date and long-term data for examining environmental health indicators, no environmental health indicators program has been established in Israel. Such a program would be instrumental, for example, in integrating and managing data of relevance to all of the indicators in Table 1. Some data, however, are available on several exposure indicators, chronic disease indicators (cancer rates, asthma hospitalization), and vector-borne diseases, allowing for time trend analysis. In addition, the GBD project facilitates the study of principal risk factors for morbidity and mortality in various countries and of trends in the burden of morbidity and mortality. The GBD database provides information on chronic morbidity indicators, sanitation- and hygiene-related health risks, and vector-borne diseases in Israel. According to these data, exposure to particulate air pollution is one of the ten leading risk factors for mortality in Israel (Figure 1).
Exposure to Air Pollution in Israel

Exposure to air pollution is associated with respiratory diseases such as asthma and chronic obstructive pulmonary disease, cardiovascular morbidity, specific malignancies, adverse neurodevelopmental effects, adverse birth outcomes, Type 2 diabetes, obesity, and cognitive disorders.

According to the GBD database, cardiovascular disease is the primary disease burden caused from particulate air pollution in Israel, while chronic respiratory disease is the primary disease burden from ozone (Figure 2).4

Mortality Attributable to Particulate Matter and Ozone by Disease Type in Israel

Exposure to Environmental Tobacco Smoke

According to the GBD database, exposure to ETS is responsible for about 500 deaths in Israel every year and a loss of some 14,500 Disability-Adjusted Life Years (DALYs). As Figure 3 shows, part of the disease burden caused by ETS falls on children.4

Years Lived with Disability due to Exposure to ETS, by Age
Asthma Morbidity

Exposure to a range of environmental factors inside or outside the home, including particulate matter, ozone, ETS, dust mites, mold and allergens can lead to development or aggravation of asthma.

In 2018, the Ministry of Health (MoH) published data on trends in the hospitalization rate of children due to asthma in 1996–2015. The data show a decrease in the asthma hospitalization rates of infants, toddlers, and children up to age fifteen (Figure 4). Higher rates of hospitalization were found only in the Haifa, Kinneret, and Golan districts. The authors of the report hypothesized that the higher rates in Haifa can be explained by environmental exposures whereas those in the Kinneret and Golan districts can be explained by a lack of primary care pulmonary experts, leading to higher hospitalization rates.\(^5\)


According to a report published in 2019 by QICH, the incidence of persistent asthma among people aged 5–45 remained constant in 2016–2018 (0.8%–0.9%). The rate was twice as high among those of high socioeconomic status (SES) than among those of low SES (1.0% and 0.5%, respectively).\(^6\)

Researchers from the University of Haifa and the Israel Defense Forces (IDF) studied the incidence of asthma in relation to place of residence among about 13,800 boys aged 16–19. The asthma rates found were 7.1% among the research population (with 3.8% suffering moderate-to-severe persistent illness), 8.76% in Tel Aviv, 6.96% in Haifa, and 6.09% in Hadera. The researchers concluded that exposure to industrial and traffic-related air pollution is associated with asthma prevalence.\(^7\) The disparity between the estimate reported in the study and the QICH findings apparently stems from differences in data collection methodology and in the type of asthma included in the estimate.
Researchers from Shaare Zedek Medical Center and the IDF, examining the incidence of asthma in people born in Israel in 1976–1990, found an increase in rates of mild persistent asthma among those born in 1976–1980 and a decrease in these rates among those born in 1980–1990. The incidence of moderate-to-severe asthma, however, was low among the 1976–1980 birth cohort and very high in the 1986–1990 group. The study also found an association between moderate-to-severe asthma and obesity in boys and girls, an association between underweight males and mild asthma, and a correlation between living in a rural environment and mild asthma.\(^8\)

**Cancer Morbidity**

Environmental and occupational risk factors are associated with specific malignancies—primarily lung cancer, non-Hodgkin's lymphoma, leukemia, and mesothelioma.

The cancer rate in Israel exceeds the world average but ranks last among fifty countries with the highest rates. According to MoH data, there was a decrease in the incidence of leukemia (in all groups) and mesothelioma (among men) in Israel between 1996 and 2017 (Figure 5).\(^9\)

**Trends in Rates of Selected Malignancies, by Gender and Population Group, Israel, 1996–2017**

**Lung Cancer**

![Graph showing trends in lung cancer rates for different groups.]
Non-Hodgkin's Lymphoma

Leukemia
Diabetes

Exposure to air pollution (PM$_{2.5}$) is a known risk factor for diabetes. In addition, exposure to EDCs is associated with Type 2 diabetes and pre-diabetic disturbances. For example, exposure to high levels of dioxins is associated with an increased risk of diabetes stemming from metabolic disturbances or altered glucose metabolism. There is evidence that the prevalence of autoimmune disorders, including Type 1 diabetes, is increasing around the world and that environmental factors may be implicated.

According to the aforementioned QICH report, the incidence of diabetes among children ages 2–17 was stable (0.1%) in 2014–2018. Morbidity and mortality resulting from Type 1 diabetes trended down in 1990–2017 in Israel and in other OECD countries. Morbidity and mortality from Type 2 diabetes increased in the OECD countries. In Israel, despite an increase in these rates prior to the year 2000, morbidity and mortality decreased in the following years (perhaps due to improved treatment). Still, it should be emphasized that the mortality rate per 100,000 from Type 2 diabetes in Israel surpasses the OECD average (Figures 6 and 7). Given that different countries follow different rules for coding diabetes as the cause of death, the disparities in diabetes mortality rates between Israel and other countries may trace to different coding practices.
Disability Adjusted-Life Years (DALYs) Associated with Diabetes, Israel and OECD Countries, 1990–2015

Diabetes Mortality Rates, Israel and OECD Countries, 1990–2015
Early Childhood Health Indicators

Several studies have found an association between early childhood health indicators, including congenital anomalies and autism spectrum disorder (ASD), and environmental exposures, with emphasis on exposure to air pollution.\textsuperscript{10, 11}

In a report on congenital anomalies in Israel based on data collected in 2000–2014, MoH researchers found a downward trend in the rate of congenital anomalies reported in Israel, from 14.8 per 1,000 live births in the year 2000 to 11.1 per 1,000 live births in 2014. It should be emphasized that many prenatal diagnoses are made in Israel that lead to pregnancy termination, meaning that the decrease may be associated with the termination of pregnancies following the detection of fetal malformations. In the first half of the 2000s, an increase in congenital anomalies was observed. However, the trend reversed in 2006. An increase was seen in rates of malformations of the heart, blood vessels, genital organs, eyes, urinary system, and the abdominal wall, and in the rates of genetic anomalies. The rates of malformations in the nervous system, muscles, skeleton, respiratory system and digestive system, and in the rates of chromosomal anomalies, all showed declines.\textsuperscript{12}

Researchers from MoH, Bar-Ilan University, the University of Haifa, and Ben-Gurion University of the Negev, examining data on more than two million singleton births in 2000–2014 and tracking trends in birth outcomes during that period, identified an upward trend in newborn weight and a downward trend in the birth of underweight newborns.\textsuperscript{13}

Researchers from the Hebrew University of Jerusalem, the National Insurance Institute (NII) and Harvard University, using NII data to study the prevalence of ASD in children, found a prevalence of 0.64\% in eight-year-olds. An increase in prevalence among children born before 2009 leveled off afterwards. The researchers found that ASD incidence was higher in higher-income families.\textsuperscript{14}

Vector-borne Diseases

Environmental factors such as climate change as well as infrastructure problems in water systems may increase the risk of vector-borne diseases.

Researchers from MoH, Tel Aviv University, and several medical centers (Assaf Harofeh, Barzilai, Meir, Kaplan, HaEmek, Laniado, and Sheba), analyzing the 2015 outbreak of West Nile fever, found an association between the disease outbreak and extreme heat waves that year (Figure 8).\textsuperscript{15}
Future Challenges

Rapid urbanization and an increase in population density in Israel are leading to accelerated construction, growing traffic congestion, and destruction of green spaces—all posing risks to health. Therefore, it is important to establish environmental health indicators such as distance of homes from green spaces and main traffic arteries, exposure to noise, and the amount of time Israel residents spend on the roads. Adding cognitive indicators such as trends in ASD and in Attention Deficit Hyperactivity Disorder (ADHD) would also be useful.

Most environmental health indicators are based on analyses of direct health databases (birth, hospitalization, morbidity, and mortality data). But it is also possible to learn about environmental health trends on the basis of indirect databases that include data on physician visits, medication use, or social media traffic. Accordingly, additional indicators based on indirect databases should be formulated.

In Israel, causes of death are recorded by the Central Bureau of Statistics. These records, however, like those in other countries, are not sensitive enough to monitor mortality caused by environmental exposure or climate change. Monitoring causal associations with mortality is challenging because environmental exposures generally cause morbidity, which, in turn, may increase mortality risk; in addition there is frequently a lag between the environmental

Figure 8: Cases of West Nile Fever in Israel in Relation to Maximum, Minimum, and Average Weekly Temperatures in 2015

Legend: ■ Number of cases  ■ Max temperature ■ Average temperature ■ Min temperature
exposure and the increase in mortality. Even in cases of extreme air pollution and extreme heat, it is challenging to monitor associations between environmental exposures and mortality. Only the direct cause of death is recorded—with the exception of very extreme events, such as the significant upturn in mortality that was occasioned by exceptionally low temperatures in the winter of 1992. Therefore, epidemiological research is needed to cross-check exposure data with mortality data in a way that would accurately reflect the association between these two variables.

The GBD project publishes data on the burden of disease in Israel resulting from exposure to environmental pollutants, including air pollution and ETS. Also necessary are assessments of the burden of disease in Israel caused by exposure to pesticides, EDCs, and heavy metals—a challenging task in view of the limited and evolving literature on these topics. Given the special vulnerability of children to environmental pollutants, efforts to collect data on the burden of disease and environmental health indicators should focus on this population.
References

(1) Environmental Health Indicators New Zealand, Massey University. What are environmental health indicators? https://www.ehinz.ac.nz/indicators/overview/about-the-indicators/ (retrieved July 2020).


Environmental Health in Israel 2020 clearly demonstrates the improvements in environmental health that have occurred in Israel not only since the 2017 report but even more so since the first report in 2014. Scientific research has led to many important new findings. The establishment of several prospective longitudinal birth cohorts is the first step in understanding the health of the Israeli public and the long-term impacts of environmental exposures. Many of these new studies involve multiple Israeli institutions, both academic and governmental, and several involve international collaborations. Israel has been regarded as a powerhouse in scientific research for many years, but its environmental health research is now gaining recognition. Presentations at international meetings and publication in top-tier journals have played a significant role.

Much progress has been made in both the implementation of the national plan to prevent and reduce air pollution in the past three years, as well as an increase in stationary monitoring sites. There is recognition that more are needed, especially in the north of Israel. While ozone, NOx, and both PM$_{10}$ and PM$_{2.5}$ are being monitored, there are other ambient air pollutants which should be followed such as lead and carbon monoxide. The decrease in sulfur oxides is good news and does likely reflect the reduction in the use of dirty coal from China. The environmental targets for Israel should be put in context of international ones, such as WHO or the EU. In some cases, such as PM$_{10}$ which can be elevated because of dust, the targets should be related to other countries with desert areas.

Conclusions and Recommendations

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Scientist in Residence, Nicholas School of the Environment, Duke University
The good news is that levels of PM$_{2.5}$ are decreasing, but the levels of NO$_2$ are still too high, and there seems no improvement in ozone. Monitoring and epidemiological studies need to be conducted in many places in Israel, not only in Haifa which has had problems with ambient pollution due to the concentration of industrial sites near the port and the Carmel mountains creating a bowl effect. Ambient air pollution is associated with a plethora of adverse health effects—nearly every organ system is impacted, and the developmental and obesogenic effects clearly would benefit from more attention. Additional attention to source apportionment and economic impacts are warranted.

There has been some improvement since 2017 in addressing the role of indoor air pollution in environmental health in Israel. This is good news as not only do most people, even in Israel, spend much of their time indoors, but indoor air pollution is a significant contributor to ambient levels as well. Measuring VOC levels in schools is a step in the right direction, but all types of air pollution need to be looked at in a variety of indoor environments, including day care centers, senior citizen residences, healthcare facilities, and so on. Indoor air also contributes to the presence of contaminants in dust, which are significant sources of oral, dermal, and inhalation exposure and should be examined. No progress has been made in this area. The role of indoor air in the transmission of SARS-CoV-2 is gaining appreciation worldwide and has implications to indoor exposure to other microbial pathogens. It is disappointing that there has been no progress in making indoor air quality a priority within the structure of the Israeli government agencies.

So long as people smoke, there will be concern with environmental tobacco smoke. Children and pregnant women are uniquely vulnerable to second-hand smoke. Thus, enforcement of the smoking ban in schools is essential, as it is in public places. Continued monitoring of urinary cotinine as a biomarker of smoking exposure should be expanded as Israeli government scientists now have that capability. Anti-smoking campaigns should be expanded, with special attention to vulnerable communities. More attention should be given to the use of electronic cigarettes as serious health consequences of vaping are being recognized. It is likely that young people have adopted this practice as cigarette smoking has declined.

Israel is a leader in desalination to provide safe drinking water. The recognition that there are critical minerals removed by this process has led to significant research efforts to understand the potential health consequences of drinking water without adequate magnesium, calcium, and iodide. Investigation of possible adverse cardiac effects needs to be continued, as do studies of thyroid status in pregnant women. An educational campaign encouraging the use of iodized salt would be appropriate to consider. The effects of using desalinated water in agriculture requires investigation. There are many chemicals which contaminate drinking water, in addition to lead and other heavy metals, which should be examined. These include products of disinfection, e.g., trihalomethanes (both chlorinated and brominated), personal care products, pharmaceuticals, pesticides, and per- and polyfluoroalkyl substances (PFAS). There are literally thousands of PFAS so it is important that more than just PFOA and PFOS be measured. If the drinking water comes from an area near a military site, it is likely there will be increased contamination.
Israel is also a leader in the use of reclaimed wastewater (RWW), but this requires regulations. Israel could be the first country in the world to develop such regulations as well as methods to remove contaminants, both chemical and microbial, from RWW. There is ample evidence that certain contaminants are taken up by plants, and thus can serve as an exposure source to people. This is not limited to pharmaceuticals, but applies to a multitude of chemicals, including PFAS, brominated flame retardants, and legacy POPs. Biosolids produced during wastewater treatment can also serve as a source of contamination in agriculture and should be examined. A readily searchable database should be developed for the contaminants present in RWW.

Pesticides are used extensively in Israel. Re-evaluation of their registration is a good idea, but it is concerning that so many pesticides used in Israel are not registered in the EU. Organophosphate pesticides continue to be used, and the exposure of pregnant women is of great concern and should be studied. Israel is a small country and as long as chlorpyrifos is used in agriculture, children living nearby will be exposed. Chlorpyrifos is clearly of concern, but so are many other pesticides. Many of their adverse effects on children are associated with in utero exposure. It appears that most of the government concern is for acute pesticide exposure in workers, but there are also long-term effects of many different pesticides associated with low-dose exposure during vulnerable periods of life. Israel may wish to reconsider its use of glyphosate. Additional studies are needed on pesticide exposure from multiple sources (e.g., drinking water, house dust, diet) and the impact of exposure to many different pesticides that are still used in Israel as well as those more recently introduced, such as pyrethroids and neonicotinoids. Ongoing monitoring of residue levels in the food supply is essential, as is biomonitoring of children living in agricultural areas. Establishment of a national database of pesticide poisonings in Israel is required. The lack of progress on enforcement of sale and use of agricultural pesticides is problematic, as is the lack of a plan for monitoring pesticides near schools and homes.

Food can be contaminated by many chemicals and contamination may occur at every step of food production. Periodic surveys of food contamination, including microbial, metal, pesticides, POPs, pharmaceuticals, and so on, are needed. Contaminants of special concern seem to be mycotoxins, aluminum, arsenic, pesticides, and dioxins. Attention should also be paid to chemicals such as phthalates and PFAS that are used in food packaging and can migrate into prepared foods. To date, much of the focus appears to be on baby formula; this attention needs to be expanded to all kinds of baby food (including human breast milk) as well as fresh fruit and vegetables, fish, meat, and dairy for children and adults. Conduct of a Total Diet Study is essential and it is disappointing that this has not yet been achieved.

Some of the same kinds of chemicals that can contaminate food—metals, phthalates, phenols, PFAS, flame retardants, etc.—are present in consumer goods. Consumers are entitled to know what chemicals are present in the products they purchase. There has been some improvement in this area but greater transparency is needed. While there have been some additional regulations concerning consumer products, the length of time for regulations to be implemented needs
to be shortened. This could be further improved through closer cooperation among multiple
government ministries and, especially, the inclusion of the Ministry of Health. Attention
needs to be paid to imported products to ensure that they meet, or exceed, the regulatory
requirements of Israel.

There have been several significant achievements in human biomonitoring during the past
three years. One is the involvement of Israel in a major EU consortium (HBM4EU); the other is
the establishment of its own national biomonitoring program. This has been facilitated by the
establishment of a national human biomonitoring laboratory. This capability should continue
to develop so there is additional capacity as well as enhanced measurement capabilities.
Monitoring of nutritional biomarkers needs to be added to that of chemical contaminants. The
laboratory should have the ability to monitor for a wide variety of compounds in blood, urine,
and breast milk. The national commitment to this resource needs to be ongoing – the need will
not disappear in ten years. There should be more involvement of the public as well as academics
and government in choosing what to monitor and in whom. The numbers of people monitored
should be increased and their diversity in terms of age, sex, ethnicity, SES, and so on must be
ensured. Clear communication among scientists, regulators, and citizens needs to be developed
and expanded.

Israel is a leader in research on non-ionizing radiation (NIR). Its extensive monitoring is appropriate
but should be expanded as 5G comes online. While the science is not conclusive regarding adverse
non-thermal health effects of NIR, a precautionary approach would be the most appropriate.
Overuse of digital equipment by children and regulation of such use is a societal issue.

Climate change is the existential threat of the 21st century. Mitigation involves more than just
climate mitigation, and adaptation is not only technological. Israel needs to make a greater effort
to meet the sustainable development goals of the UN. There is no reason that Israel is not moving
more rapidly toward renewable energy given its climate and amount of sunshine. As the planet
warms, disease vectors will be found in different locations, and attention is needed to food security
as the nutritional value of crops will decrease with increasing CO₂. Approaches to agriculture
beyond just using more or different pesticides should be explored. Heat waves are becoming
more frequent, as are extreme weather events, including flooding and droughts—both of which
have been recently seen in Israel. While there is much research on climate change in Israel, health
needs to be brought into the picture. This could be facilitated by a national database on exposure
metrics and health indicators.

Greater understanding of, and appreciation for, the built environment is essential. Mass transit
and biking need to be encouraged both by economic incentives and by physical opportunities.
Health should be a key player in environmental impact assessments and in planning new buildings
and roads. Recent studies clearly show the importance of “greenness” around places where people
live and work—for mental as well as physical health.
There are different kinds of vulnerability: age, sex, SES, ethnic, religious, genetic, and so on. Similar environmental exposures may have varied impacts on different populations. Israel needs to determine for itself the level of protection that it wants, and for whom. Given the different ethnic groups of which the Israeli population is composed, there are multiple biological variables to be examined. Genetic variability may play a major role in differential vulnerability. Infants, children, and the elderly are often the most vulnerable members of society. It appears that there is extensive research in Israel on ambient air pollution and biomonitoring in relation to the country's vulnerable populations, and clear research opportunities exist to deepen our understanding of the impacts of indoor air, climate change, and pesticides on them. Enhanced involvement of various advocacy groups as well as scientific and government groups should improve plans related to vulnerability in environmental health in Israel.

The public is entitled to have information on the trends in environmental health. Readily accessible databases would benefit everyone, including researchers who would gain more support. Environmental health requires clean air, clean water, and clean soil. Israel really must formulate a list of environmental health indicators. The burden of disease from all environmental problems needs to be measured and communicated broadly.

The COVID-19 pandemic has brought much of the world to a halt. Israel is no exception. Several studies clearly demonstrate how air pollution increases both susceptibility to, and the severity of, COVID-19. What about other kinds of environmental pollution? And what about overuse of antibiotics in treating the associated pneumonias? Will this lead to an increase in antibiotic resistant microbes? What about the use of antimicrobial disinfectants, which are toxic by themselves? And what about the increased use of plastics that now contaminate our entire world and all of us? We have much to learn as we go forward in relating our health to that of our environment.
## Progress since 2017 and Future Challenges

### Chapter 1
**Ambient Air Quality**

<table>
<thead>
<tr>
<th>Progress on Challenges presented in <em>Environmental Health in Israel 2017</em></th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop a strategy for regular sampling of contaminants that cannot be monitored continuously</td>
<td>![Progress indicator]</td>
</tr>
<tr>
<td>Full implementation of the National Plan for the Prevention and Mitigation of Air Pollution</td>
<td>![Progress indicator]</td>
</tr>
<tr>
<td>Reduce ambient concentrations of PM$_{10}$ and ozone in metropolitan areas in which concentrations exceed environmental values</td>
<td>![Progress indicator]</td>
</tr>
<tr>
<td>Update target and environmental values for a range of air pollutants</td>
<td>![Progress indicator]</td>
</tr>
<tr>
<td>Improve the spatial distribution of air monitoring stations</td>
<td>![Progress indicator]</td>
</tr>
<tr>
<td>Improve planning of sustainable transport</td>
<td>![Progress indicator]</td>
</tr>
<tr>
<td>Integrate epidemiological data from studies conducted in Israel in the assessment of burden of disease from air pollution and associated costs</td>
<td>![Progress indicator]</td>
</tr>
<tr>
<td>Collect data on the contribution of different sources to air pollution in Israel, using source apportionment techniques</td>
<td>![Progress indicator]</td>
</tr>
</tbody>
</table>

### Future Challenges

<table>
<thead>
<tr>
<th>Future Challenges</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continue to monitor gas rig emissions along with other air pollutants along Israel’s coastline</td>
<td></td>
</tr>
<tr>
<td>Conduct Health Impact Assessments on pollution emitted from trigeneration plants and from new waste incineration facilities due to their proximity to population centers</td>
<td></td>
</tr>
<tr>
<td>Monitor air quality and conduct studies on the impact of livestock farms on air pollutant emissions</td>
<td></td>
</tr>
</tbody>
</table>

### Legend:
- Significant progress
- Some progress
- Little or no progress
### Chapter 2
**Indoor Air Quality**

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct a pilot study on indoor air pollution in schools</td>
<td></td>
</tr>
<tr>
<td>Study the health impacts of indoor air quality and the relationship between ambient air pollution and indoor air quality</td>
<td></td>
</tr>
<tr>
<td>Formulate and publish recommendations for the public on ways to reduce exposure to indoor air contaminants</td>
<td></td>
</tr>
<tr>
<td>Establish a central national authority to address indoor air quality</td>
<td></td>
</tr>
<tr>
<td>Conduct research on residential dust</td>
<td></td>
</tr>
</tbody>
</table>

**Future Challenges**

- Address indoor air quality considerations in green building standards

### Chapter 3
**Environmental Tobacco Smoke**

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Validate analytical techniques to measure cotinine levels in blood, urine and saliva</td>
<td></td>
</tr>
<tr>
<td>Measure urinary cotinine levels in children</td>
<td></td>
</tr>
<tr>
<td>Measure urinary cotinine levels in pregnant women</td>
<td></td>
</tr>
<tr>
<td>Enforce legislation banning smoking in schools</td>
<td></td>
</tr>
<tr>
<td>Collect and publish national data on the prevalence of asthma in children and on asthma medication use</td>
<td></td>
</tr>
<tr>
<td>Enforce legislation banning smoking in public places</td>
<td></td>
</tr>
</tbody>
</table>

**Future Challenges**

- Study the long-term impact of the smoking legislation enacted in December 2018
- Update the National Tobacco Control Plan of 2011 to include environmental tobacco smoke (ETS) from cigarettes, electronic cigarettes and heat-not-burn tobacco products
- Design targeted interventions to reduce environmental tobacco smoke exposure in high-risk populations

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Appendix 1: Progress since 2017 and Future Challenges
## Chapter 4
### Chemical Parameters in Drinking Water

<table>
<thead>
<tr>
<th>Progress on Challenges presented in <em>Environmental Health in Israel 2017</em></th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct an updated survey to examine lead levels in tap water in residences and institutions, including schools</td>
<td><img src="https://example.com/green_icon.png" alt="Green" /></td>
</tr>
<tr>
<td>Develop requirements to limit the lead content of products in contact with drinking water</td>
<td><img src="https://example.com/green_icon.png" alt="Green" /></td>
</tr>
<tr>
<td>Study the public health effects of consuming desalinated drinking water with low-mineral content</td>
<td><img src="https://example.com/orange_icon.png" alt="Orange" /></td>
</tr>
<tr>
<td>Establish a central database of emerging contaminants in drinking water</td>
<td><img src="https://example.com/green_icon.png" alt="Green" /></td>
</tr>
<tr>
<td>Assess the impact of discontinuing fluoridation on children's dental health, especially among children of low socioeconomic status</td>
<td><img src="https://example.com/yellow_icon.png" alt="Yellow" /></td>
</tr>
<tr>
<td>Develop a model to estimate mineral content (iodine and magnesium) at central mixing junctions and at points of consumption</td>
<td><img src="https://example.com/red_icon.png" alt="Red" /></td>
</tr>
</tbody>
</table>

### Future Challenges

- Complete the pilot study on adding magnesium to desalinated water and translate the findings into policy
- Set a stricter standard for lead content in drinking water in Israel and ensure that all localities monitor lead in the supply network
- Collect data on haloacetic acid disinfectant by-products and per- and polyfluoroalkyl substances (PFAS) in drinking water and consider adoption of new standards for these contaminants
- Reduce trihalomethane concentrations and chlorite and chlorate concentrations in drinking water, and reassess the standards for these substances

## Chapter 5
### Reclaimed Wastewater

<table>
<thead>
<tr>
<th>Progress on Challenges presented in <em>Environmental Health in Israel 2017</em></th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct additional studies on potential exposure to pharmaceuticals and other contaminants via produce irrigated with reclaimed wastewater</td>
<td><img src="https://example.com/green_icon.png" alt="Green" /></td>
</tr>
<tr>
<td>Create a database that integrates chemical and microbial monitoring in sewage, reclaimed wastewater, in the field, and in agricultural produce</td>
<td><img src="https://example.com/green_icon.png" alt="Green" /></td>
</tr>
<tr>
<td>Conduct a risk assessment on chemical contaminants in reclaimed wastewater</td>
<td><img src="https://example.com/red_icon.png" alt="Red" /></td>
</tr>
</tbody>
</table>

### Future Challenges

- Improve the infrastructure for sewage treatment and reclaimed wastewater storage so that it has capacity for the increasing volume of sewage and reclaimed wastewater
- Improve oversight of micro-pollutant concentrations in industrial sewage, especially in the pharmaceutical industry
- Perform risk assessments that address combined exposure to a large number of chemicals and pharmaceuticals via reclaimed wastewater
- Monitor PFAS and other persistent organic pollutants in reclaimed wastewater and sludge
### Chapter 6

**Pesticides**

<table>
<thead>
<tr>
<th>Progress on Challenges presented in <em>Environmental Health in Israel 2017</em></th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Challenge</strong></td>
<td><strong>Progress</strong></td>
</tr>
<tr>
<td>Conduct periodic re-evaluation of all active ingredients approved for plant protection</td>
<td>✅</td>
</tr>
<tr>
<td>Conduct biomonitoring of organophosphates</td>
<td>✅</td>
</tr>
<tr>
<td>Conduct risk assessment on pesticides based on children’s diet</td>
<td>✅</td>
</tr>
<tr>
<td>Establish a national database on pesticide poisoning in Israel</td>
<td>✅</td>
</tr>
<tr>
<td>Improve enforcement of sale and use of agricultural pesticides</td>
<td>✅</td>
</tr>
<tr>
<td>Monitor pesticides in the air near schools and residences</td>
<td>✅</td>
</tr>
<tr>
<td>Advance uniform and comprehensive legislation on registration and use of all types of pesticides (including the establishment of an umbrella committee on pesticide registration and/or unification of registration committees)</td>
<td>✅</td>
</tr>
</tbody>
</table>

### Future Challenges

- Ban the use of chlorpyrifos
- Introduce a rapid registration process for less toxic or substitute formulations that are already registered in developed countries (primarily in Europe and the U.S.)
- Expand the use of biomonitoring and risk assessment tools for assessing exposure to additional pesticide groups, including pyrethroids and neonicotinoids, and to additional vulnerable groups

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### Chapter 7

**Chemical Food Contaminants**

<table>
<thead>
<tr>
<th>Progress on Challenges presented in <em>Environmental Health in Israel 2017</em></th>
<th>Progress</th>
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</thead>
<tbody>
<tr>
<td><strong>Challenge</strong></td>
<td><strong>Progress</strong></td>
</tr>
<tr>
<td>Conduct a survey of aluminum in baby food</td>
<td>✅</td>
</tr>
<tr>
<td>Conduct a survey of phthalates in baby food</td>
<td>✅</td>
</tr>
<tr>
<td>Create a database of food consumption based on periodic national health and nutrition surveys, and conduct more accurate exposure assessments for the general population and for sub-populations such as children and pregnant women</td>
<td>✅</td>
</tr>
<tr>
<td>Establish a Total Diet Study (TDS) project in Israel</td>
<td>✅</td>
</tr>
</tbody>
</table>

### Future Challenges

- Conduct exposure and risk assessments for contaminants such as heavy metals, based on foodstuff monitoring data, nutritional survey data, and biomonitoring data
- Increase transparency and publish periodic surveys on chemical food contaminants
- Update and significantly expand the existing legislation concerning mycotoxins
- Conduct new surveys and exposure assessments on dioxins and PFAS in food
### Chapter 8
**Chemicals in Consumer Products**

<table>
<thead>
<tr>
<th>Progress on Challenges presented in <em>Environmental Health in Israel 2017</em></th>
<th>Progress</th>
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</thead>
<tbody>
<tr>
<td><strong>Challenge</strong></td>
<td><strong>Progress</strong></td>
</tr>
<tr>
<td>Improve regulatory enforcement for consumer products (enforcement in markets and not only at point of import)</td>
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<tr>
<td>Require labeling of selected consumer products indicating that they meet the standard</td>
<td></td>
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<tr>
<td>Re-evaluate the role of the Ministry of Health in guaranteeing the adoption and implementation of standards that protect public health</td>
<td></td>
</tr>
<tr>
<td>Advance comprehensive regulation of chemicals in consumer products</td>
<td></td>
</tr>
<tr>
<td>Conduct additional surveys of chemicals in consumer products in the market in Israel; conduct a systemic review of requirements pertaining to chemicals in consumer products abroad versus those in Israel</td>
<td></td>
</tr>
<tr>
<td>Shorten the bureaucratic process of declaring new or revised standards mandatory</td>
<td></td>
</tr>
</tbody>
</table>

| **Future Challenges** |  |
| Initiate public service campaigns to reduce the potential risk to consumer safety and health from online purchases of products |  |
| Study the potential impact of the cosmetics reform on the public's exposure to chemicals in cosmetics |  |
| Study potential exposure to PFAS via consumer products in Israel and evaluate potential regulatory measures |  |

### Chapter 9
**Human Biomonitoring**

<table>
<thead>
<tr>
<th>Progress on Challenges presented in <em>Environmental Health in Israel 2017</em></th>
<th>Progress</th>
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</thead>
<tbody>
<tr>
<td><strong>Challenge</strong></td>
<td><strong>Progress</strong></td>
</tr>
<tr>
<td>Join a regional or international human biomonitoring project</td>
<td></td>
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<tr>
<td>Develop laboratory capacity for human biomonitoring</td>
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<tr>
<td>Establish and fund a government framework for human biomonitoring</td>
<td></td>
</tr>
<tr>
<td>Develop a framework for using human biomonitoring data in quantitative risk assessment</td>
<td></td>
</tr>
<tr>
<td>Expand the process of selecting and prioritizing chemicals for human biomonitoring by including representatives from academia, government, and the public</td>
<td></td>
</tr>
</tbody>
</table>

| **Future Challenges** |  |
| Full implementation of the National Biomonitoring Program |  |
| Monitor nutritional biomarkers in coordination with the National Biomonitoring Program |  |
| Examine the clinical use of human biomonitoring (for example, in asthma or well-baby clinics) as a tool for identifying infants or children who are exposed to environmental tobacco smoke |  |
| Monitor PFAS exposure in the framework of the National Biomonitoring Program |  |
### Chapter 10
Non-Ionizing Radiation

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitor devices emitting non-ionizing radiation (such as transformers and power lines) in public spaces</td>
<td>-</td>
</tr>
<tr>
<td>Re-evaluate standards in light of new findings regarding health outcomes of exposure to non-ionizing radiation</td>
<td>-</td>
</tr>
<tr>
<td>Increase public awareness of the potential adverse health outcomes of non-ionizing radiation, the need to reduce exposure, and the potential risks from exposure</td>
<td>-</td>
</tr>
<tr>
<td>Establish mandatory regulations regarding permissible levels of non-ionizing radiation</td>
<td>-</td>
</tr>
</tbody>
</table>

**Future Challenges**

- Control growing exposure to radiation from the increasing volume of data consumed by cellular communication
- Expand the scientific knowledge on the potential adverse effects of LED lighting and translate the findings into policy
- Expand research on the use of digital media by children and adolescents as a scientific basis for recommendations concerning limitations on screen time exposure

### Chapter 11
Climate Change

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement the National Plan to Combat Cutaneous Leishmaniasis</td>
<td>-</td>
</tr>
<tr>
<td>Develop a national action plan to cope with climate change</td>
<td>-</td>
</tr>
<tr>
<td>Develop specific climate change indicators</td>
<td>-</td>
</tr>
<tr>
<td>Strengthen collaboration between the Israel Meteorological Service and the Ministry of Health in order to prepare for extreme climate events</td>
<td>-</td>
</tr>
<tr>
<td>Create a national database that includes exposure metrics and health indicators related to climate change</td>
<td>-</td>
</tr>
</tbody>
</table>

**Future Challenges**

- Expand epidemiological research in the field of climate as well as research in economics, the social sciences, and health systems management in the context of climate change
- Pass a “Climate Law”

---

**Appendix 1**

Progress since 2017 and Future Challenges
### Chapter 12
#### Planning

**Progress on Challenges presented in *Environmental Health in Israel 2017***

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Promote shading in open public spaces</td>
<td></td>
</tr>
<tr>
<td>Promote plans for paving bicycle paths</td>
<td></td>
</tr>
<tr>
<td>Conduct Health Impact Assessments on large-scale projects</td>
<td></td>
</tr>
<tr>
<td>Give representatives of the Ministry of Health broader powers in the planning committees</td>
<td></td>
</tr>
<tr>
<td>Develop policies to reduce emissions of heat, radiation, and greenhouse gases</td>
<td></td>
</tr>
<tr>
<td>Improve the efficiency of public transportation</td>
<td></td>
</tr>
</tbody>
</table>

**Future Challenges**

- Establish guidelines for planning of schools in relation to main roads
- Develop a methodology and a set of criteria for defining a “healthy city”
- Improve planning of water and wastewater infrastructure to prevent flooding

### Chapter 13
#### Vulnerable Populations

**Progress on Challenges presented in *Environmental Health in Israel 2017***

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhance collaboration between government ministries and civil society organizations to improve the flow of information regarding environmental hazards and to promote mechanisms of public participation</td>
<td></td>
</tr>
<tr>
<td>Identify vulnerable populations in Israel and adapt specific goals and objectives to them (in the context of the National Environmental Health Plan)</td>
<td></td>
</tr>
<tr>
<td>Conduct research on genetic variability and other vulnerability predictors to identify vulnerable populations</td>
<td></td>
</tr>
</tbody>
</table>

**Future Challenges**

- Collect data on the burden of disease from environmental pollution among the elderly
- Expand the air monitoring network to cover populated areas, especially in the periphery, that are not regularly monitored, including Bedouin settlements in southern Israel

### Chapter 14
#### Environmental Health Indicators and Trends

**Progress on Challenges presented in *Environmental Health in Israel 2017***

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Formulate environmental health indicators</td>
<td></td>
</tr>
<tr>
<td>2. Collect and publish data on various environmental health indicators</td>
<td></td>
</tr>
<tr>
<td>Publish data collected by the authorities on environmental pollutants and health outcomes and make them accessible to researchers, policymakers, and the public in a timely fashion</td>
<td></td>
</tr>
</tbody>
</table>
Environmental Health and COVID-19

Environmental Health in Israel 2020 was written in the first half of 2020, at the beginning of the worldwide outbreak of the coronavirus (COVID-19) pandemic. This global crisis, believed to have resulted from human pressure on the environment and the consequent increase in risk of zoonotic disease, has been described by the World Health Organization (WHO) as the greatest global shock in decades, affecting many aspects of our lives including environmental health.

The topics covered in this report reflect the traditional issues that come under the heading of environmental health—topics that have been on both the scientific and the regulatory agendas for many years in Israel, as well as in other countries. The coronavirus pandemic, in contrast, is novel and, as of this writing, ongoing. Knowledge regarding its health effects and its possible connections with the environment and environmental pollution is being updated continuously and rapidly.

Some of the earliest reported impacts of the pandemic on environmental health were the result of the lockdowns that were imposed and the consequent lifestyle changes. Social distancing and travel restrictions, for example, highlighted the importance of urban green spaces and the need for urban planning that provides pedestrians and bikers with dedicated spaces and paths, especially in densely populated cities. As a result, more and more cities worldwide, including Tel Aviv, are promoting the replacement of some roads and car parks with green spaces and infrastructure for bikers and pedestrians. While the crisis may carry the potential of urban changes that would promote physical activity, it has also led to a drastic and lengthy reduction in the use of public transportation and greater reliance on private vehicles.
In Israel, the coronavirus crisis has highlighted a problematic regulatory gap: Even as the use of disinfectants became compulsory in closed public spaces including schools and kindergartens, Israel, unlike the U.S. and Europe, has no regulatory framework within which these disinfectants may be approved. Disinfectant tunnels were installed at the entrances of several public buildings in Israel. While the Israel Ministry of Health has discouraged this potentially dangerous use of disinfectants, it lacks the regulatory authority to ban the practice.

We have yet to understand the full environmental health implications of the pandemic, such as the impact of ambient air pollution and exposure to immunotoxic environmental chemicals on COVID-19 vulnerability, morbidity, and mortality; the potential contribution of the pandemic to antibiotic resistance due to the unnecessary use of harmful antimicrobial chemicals; the impact of long-term changes in remote work and learning on the reduction of commuting and traffic, and the effect of the crisis on political attention to and action regarding climate change.

In its manifesto on healthy and green recovery from the pandemic, the WHO laid down the following principles:

- Protect and preserve nature, the source of human health—including mitigating climate change, preventing air pollution, and implementing chemical management.
- Invest in essential services, from water and sanitation to clean energy in healthcare facilities.
- Ensure a quick healthy transition to renewable energy sources.
- Promote healthy, sustainable food systems.
- Build healthy, livable cities.
- Stop using taxpayers’ money to fund pollution.

A report of the Ministry of Environmental Protection reinforced these guidelines and noted the opportunity, when coming out of the coronavirus crisis and the subsequent economic crisis, to strengthen the ecological system by avoiding projects that harm nature.

The EU has already unveiled a proposed recovery plan from the crisis that takes the opportunity to strengthen both health systems and environmental sustainability. There are early signs that in Israel the pandemic and the consequent economic crisis might result in the weakening of pollution regulations based on the claim that such steps will help businesses affected by the crisis. This is unfortunate, given that the pandemic has highlighted the economic implications of poor public health (chronic diseases and the environmental exposures that contribute to them) and poor public health infrastructure as well—both of which have direct consequences for the economy. It is time for Israel to develop the ability to analyze the economic benefits of mitigating exposures to environmental hazards, thereby improving public health as a strategy to strengthen the economy. Improving environmental health should also be part of a broader strategy to improve public health, public resilience, and preparedness for future national, regional, or global shocks.
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(3) Municipality of Tel Aviv Yaffo. 11 additional streets around the city will be closed to motorized traffic and remain open solely for pedestrians and cyclists (Hebrew). https://www.tel-aviv.gov.il/Pages/MainItemPage.aspx?WebID=3af57d92-807c-43c5-8d5f-6fd455eb2776&ListID=81e17809-311d-4bb9-9b61-2363bb9de6cd&ItemID=1054 (retrieved July 2020).


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