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Health Risks Assessment for the Israeli Population following the Sanitary Crisis in Gaza

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The opinions expressed in this report are those of the authors and of EcoPeace Middle East, and do not necessarily reflect the opinions of the Canadian Government.

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Forward

The many years of conflict between Hamas and Israel have taken a severe toll – in lives lost, destruction and suffering. Palestinian communities in Gaza, as well as Israeli communities around Gaza, have suffered, and continue to suffer, from the direct and indirect impact of the conflict.

One of the tragic ways the conflict has impacted Gaza, is in the area of water, health, sanitation and hygiene (WASH). The inherently destructive nature of warfare coupled with difficulties in developing water and sewage facilities under conditions of the blockade as well as electricity shortages, have resulted in a growing crisis in Gaza on WASH issues.

Research carried out in Gaza, such as the *WASH Assessment at the household level in the Gaza Strip** carried out by the WASH cluster (UNICEF) and by the PWA as well as research on *the status of the environmental situation in the Gaza Strip***, by the UNEP, among many others, have looked at the environmental and WASH status and risks to the health of the Palestinian population in the Gaza Strip.

This report focuses on the health risks of the Gaza WASH crisis on the Israeli neighboring communities in the Gaza Envelope. As such, it does not cover the impact of the crisis on the Palestinian population in the Gaza Strip. This is not intended in any way to underplay the clear impact on the Gaza population, but rather to serve as a means to highlight, to the Israeli population and decision makers, the cross-boundary nature of the crisis and the dire need to actively work towards solutions for the health of all peoples involved.

A sensitive issue raised in the report is the growth and spread of antibiotic-resistant bacteria in Gaza and beyond, identified at times in patients from the Gaza Strip whoare treated in Israel. It is important to state that the problem of resistant bacteria is a global issue and should not discourage or prevent the important practice of treatment of Palestinian patients from Gaza in Israeli hospitals.

We hope this paper, and the serious issues it presents, will help raise awareness and lead to the improvement of conditions and reduction of risks to all sides involved in the conflict.

EcoPeace Middle East, Israel Office.

*PWA, UNICEF, WASH assessment at the household level in the Gaza strip, 2017,

https://reliefweb.int/sites/reliefweb.int/files/resources/Gaza_WASH_HH_report_July2017_final.pdf

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1. Executive Summary

The electricity, water and sanitation infrastructures in the Gaza Strip are facing a collapse that will affect the health of the population of Gaza and will also affect the population of Israel in many ways. In this report, which was initiated by the EcoPeace Middle East, we present the main findings of a risk assessment analysis, in order to estimate the health effects in the immediate and long term on the population in Israel, and particularly in the Gaza Envelope, as a result of the sanitation, health, and environmental conditions in the Gaza Strip.

The risk assessment analysis included mapping various types of exposure to negative health influences, such as pollution of water sources, air pollution, spread of infectious diseases and damage to mental health. The various groups in Israel at risk of harm from such exposure were defined, followed by a systematic review of the scientific literature, the study of reports from Israeli and international bodies, and interviews with experts, in order to assess the health risks.

This report first gives an overview of the situation regarding electricity, water and health infrastructures in the Gaza Strip, in order to understand the issues under discussion and learn about the assessments of international bodies regarding future trends.

In view of the situation, the report presents four effects on public health in Israel:

1. **Pollution of sea water, rivers, beaches and drinking water reservoirs in Israel:** Defects in the treatment of sewage in Gaza have in recent years interfered with the operation of the Ashkelon desalination plant and of the Zikim bathing beach, as well as the Shikma facility for groundwater penetration. Studies of sea water pollution have shown that fecal pathogens found in currents flowing northward from Gaza towards Israel might affect the quality of the water even as far as Ashdod. Moreover, pollution in the Shikma River area might increase the danger of West Nile Fever, which is transferred to human beings by mosquitoes that breed in the rivers.

2. **Air Pollution:** Last year's violence on the Gaza Strip border was characterized by the burning tires and the sending of incendiary kites that started many fires in agricultural areas in the Gaza Envelope. The fires caused severe air pollution, according to data from the Ministry of Environmental Protection. This report presents initial data regarding levels of pollution during the "incendiary kites" period compared to the same period in the previous year, and also presents studies currently underway that examine the effect of the air pollution from the border area on respiratory and vascular diseases among residents in the Gaza Envelope. Even during routine periods, unconnected to the recent fighting, the condition of garbage disposal infrastructures in Gaza causes bad odors and air pollution due to the burning of garbage in the many landfills close to the border.

3. **Development of antibiotic resistant pathogens:** The poor condition of Gaza infrastructures affects the various health institutions, which themselves are facing

collapse due to a lack of medical personnel and medicines. Due to this situation many patients from Gaza seek treatment in Israeli hospitals. This report presents data on the development of antibiotic resistant pathogens in Gaza as a result of these defects. Every year dozens of cases of resistant bacteria reach hospitals in Israel causing a grave situation that must be addressed.

4. **Damage to mental health:** The numerous rounds of fighting have had a significant impact on the health of the residents in the Gaza Envelope. The ongoing fighting deepens mental distress and leads to symptoms of post-traumatic stress disorder (PTSD) among up to 43.5% of adolescents in the area, more than four times more than of the Israeli population as a whole. An as yet unpublished study found that there is a clear correlation between each round of fighting and the rise in the number of patients that arrive at the emergency room of Barzilai Hospital for psychiatric care. In addition, this exposure causes more use of addictive substances such as marijuana and alcohol among youth, with an increase in tobacco smoking among the general population. Because of the repeated disturbances to daily life, control of chronic metabolic diseases is also affected, as demonstrated by the fact that patients with type 2 diabetes had less control of their glucose levels during fighting.

In addition to these types of exposure, the report presents **an emergency scenario** in which the absolute collapse of sanitation infrastructure in Gaza leads to a mass migration of residents out of the Strip and into Israeli territory. This possibility must be considered by the Israeli healthcare system and other systems, because it could cause outbreaks of infectious diseases, as well as an increase in violence were a population to cross the border.

Recommendations: The findings of this report must be taken into consideration by various government ministries, not only the Ministry of Health, since the current situation in Gaza has significant impact on many determinants of the health of residents of Israel. It is necessary to improve the exchange of information between different sections of the Ministry of Health – at local, regional and national levels, and between the Ministry and other sectors.

The data presented in this report has strategic importance, with an emphasis on the emergency scenario that is examined. Solutions must be based on a broad view that integrates different sectors, including the municipal level, which also wishes to promote the welfare of residents. The impact of the situation in Gaza on residents of Israel affects not only their security but also their health. Consideration of public health and the environment cannot stop at any border, so it is important to re-evaluate and think outside the box in order to promote solutions that will ultimately benefit all parties and advance good health for all sectors of the population.

To sum up, the current sanitation, environmental and health conditions in Gaza have a multi-dimensional impact on the population of Israel. From a public health point of view, the region must be considered as a whole, for the benefit of all. A continuation of the current situation holds many dangers and constitutes a challenge that goes far beyond the healthcare system; it is an important strategic challenge that requires a multi-disciplinary, multi-sector response.

2. Preface

The purpose of this report is to assess how the sanitation crisis, the deterioration of the healthcare system and the security situation in the Gaza Strip are currently affecting and will continue to affect the health of the population in Israel, with an emphasis on the Gaza Perimeter communities and nearby towns. The report is written at the initiative of EcoPeace Middle East, a unique organization that brings together Jordanian, Palestinian and Israeli environmental activists, with the aim of promoting efforts to preserve the environmental heritage through cooperation between the three peoples.

The risk assessment included a number of stages:

- Definition of the population at risk, broken down by various risk factors (age, chronic illnesses) according to circles of risk.
- Mapping the relevant health outcomes.

  Systematic review of the literature, and interviews with experts, in order to refer to the information that exists with regard to each of the health outcomes and a preliminary assessment of risk levels.

After mapping the relevant health outcomes and consulting with various experts, it was decided to focus on the following issues: water and air quality, infectious diseases, mental health and chronic illnesses. This report examines the current situation and describes the latest research and its implications. We are also trying to assess the development of future trends if the situation in Gaza continues to deteriorate.

The report is based on a broad concept of public health that sees health not just as the absence of illness, but is based on the right to health, with an understanding that economic, social and environmental variables have a broad effect on the health of the population. The aim of the report is to facilitate a re-examination of existing data, so that it can be used by decision makers in Israel and the international community.We hope that it will lead to finding solutions that will not only reduce the impact of these factors on public health in Israel, but also lead to improved health for all populations in the region, on both the Gazan and Israeli side, by means of improving the handling of infrastructures in Gaza, with an emphasis on water and electricity, and by improving the healthcare services available to residents of Gaza.

3. The Sanitation and Health Crisis in the Gaza Strip

For a better understanding of the effect of the situation in the Gaza Strip on the health of the population in Israel, below is a short review of the main issues in the areas of infrastructure, sanitation and healthcare in the Gaza Strip.

The repeated rounds of fighting between Israel and Hamas have caused serious damage to electricity, water and healthcare infrastructures in the Gaza Strip. The renovation of these facilities requires the entry into Gaza of building materials, which is limited by Israel due, inter alia, to the fear the materials will be used to support terror activity. Other restrictions preventing the renovation of infrastructures derive from internal disagreements and rifts among Palestinian factions, and between the Palestinian Authority and the Hamas government. Additionally, there is an economic impact to failing to renew infrastructures, which affects the food security of up to half the households (1). We will first survey the condition of electricity and water systems in the Strip, and then we will elaborate on their effect on the residents' health.

3.1. Electricity Infrastructure in the Gaza Strip

Against an estimated demand for 350 to 450 megawatts per day, the Gaza electricity grid supplies an average of 208 MW per day, from power stations in Israel, Gaza and Egypt (1). In addition to the electricity grid, electricity is also produced by backup generators that are only partially operational. The international community supplies fuel for generators in healthcare institutions, and for treatment of water, wastewater and solid waste. Nevertheless, according to both optimistic and conservative scenarios, the difference between electricity demand and supply in Gaza is expected to increase in the coming years (2).

Indicator	2012	2017	2020 (projection)
Electricity Supply	210 MW	120-142 MW	210-360MW
Electricity Demand	350 MW	450 MW	550 (low-growth) 850 (high-growth)

Figure 1: UN 2017 (2)

3.2. Water Infrastructure in the Gaza Strip

The damage to water infrastructure in Gaza creates two main problems – on one hand, a lack of safe water sources for drinking, cooking and washing, and on the other hand, defective treatment of wastewater. In 2016 the total supply of water for domestic use in the Gaza Strip was 95 million cubic meters per year, largely derived from ground water pumped from local wells. 96.4 percent of the ground water taken from the Gaza coastal aquifer, the main source of

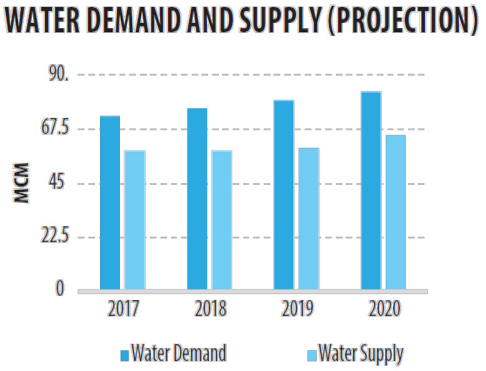

Figure 2: UN 2017 (2)

water in the Strip, is unfit for human use, according to the World Health Organization standard (1). The causes of pollution of drinking water are mainly the increased levels of salinity and nitrate pollution (3). By 2020, the percentage of coastal aquifer water that is safe to drink will be approaching zero and the aquifer will be irreversibly damaged (2).

Over 108,000 cubic meters of untreated sewage water (about 70% of all waste water produced in the Gaza Strip) flows each day into the Mediterranean, creating serious health risks to the people of Gaza and its neighbors (2). The amount of nitrate added to the sea is estimated at about 40,000 tons per year, which ultimately affects the possibility of using the water for desalination purposes (4). By 2020 the amount of untreated, or insufficiently treated, sewage flowing into the sea will reach about 120,000 m3 per day. As the population grows, both the demand for clean water, as well as the amount of sewage produced, are expected to increase (2).

Figure 3: BBC, 2009

3.3. Impact of Infrastructure Defects on Public Health in Gaza

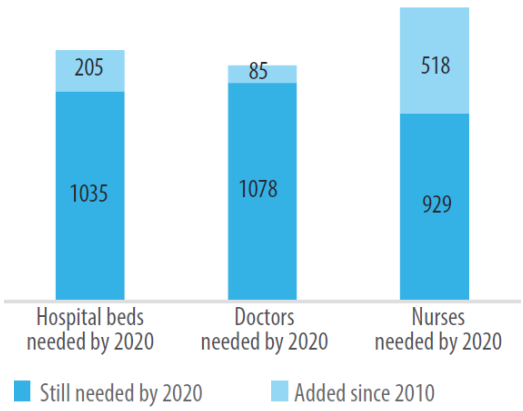

Figure 4: UN 2017

The lack of electricity affects, among other things, public health and the environment. Hospitals operate at partial capacity, and sterilization and cleaning services are reduced. Waste facilities are only partly operational, and many sewage pumping stations are at risk of flooding and pollution. Desalination facilities are not working at full capacity, and therefore the supply of water has been reduced. This in turn increases Gaza's reliance on private and unsupervised water suppliers, whose hygiene standards are low.

Figure 5: A member of the medical staff shows rusty water coming through the water system, Shifa Hospital, Gaza, November 2018
(Source: OCHA) (25)

In addition to the shortage of drinking water, the poor quality of the water is due to both chemical and biological pollution, which have numerous implications for public health. The chemical pollution of drinking water derives from its growing salinity, and is a risk factor for hypertension and for intestinal diseases, which are particularly dangerous for babies, children and pregnant women. The salinity of the water also corrodes the metal pipes and raises the toxicity of the water due to high concentrations of heavy metals (5). The biological pollution of drinking water, which derives from poor treatment of sewage, increases the frequency of intestinal infections from fecal sources. Of which, the high frequency in Gaza of hepatitis A, typhoid fever and meningitis caused by intestinal viruses, bacteria and parasitic infections among kindergarten age children, serves as an example (6). In addition, there is a greater risk of outbreak of diseases that represent high risk to public health, such as polio and cholera (7).

The ability of the healthcare system in Gaza to respond to the needs of the residents is very limited. While the population has doubled since 2000, the number of operational clinics has declined from 56 to 49, and the shortage of electricity affects their ability to provide vaccinations, which are supposed to be stored under refrigeration. The availability of beds, and the number of doctors and nurses per capita, declined between 2010 and 2016, and there is a long term shortage of drugs and medical equipment. The ongoing violence on the border with Israel also exacts a price, the ongoing violence on the border with Israel also exacts a price. A report that was recently published and presented to the Security Cabinet in Israel is predicting the increase in the number of demonstrators turning to hospitals in Gaza for treatment of various kinds of injuries, will lead to the total collapse of the healthcare system, due to the severe shortage of medical staff and medications in the near future (8).

The severe flaws in the healthcare system are liable to affect the situation in Israel as well. First of all, the serious healthcare situation in Gaza brings many patients to seek medical treatment in Israeli hospitals, and in the last ten years the number of people seeking to leave Gaza for medical treatment has tripled (2). As we describe later, this situation is also significant in terms of spread of resistant bacteria, due to problematic antibiotic treatments given in Gaza hospitals (unsuitable types of antibiotics, failure to complete the course of treatment due to shortages). Secondly, treatment of expired medication waste is done at toxic waste treatment sites which operate part time due to electricity shortages, likely increasing the pollution of water resources in Gaza and in the whole area (9).

4. Impact of the Gaza Situation on the Health of the Population in Israel

4.1. The Affected population

In various ways the entire population of Israel is affected by the situation in Gaza. There is still a need to analyze the various circles of impact according to the specific health risk, how it makes an impact, and the nature of the risk.

One way of characterizing the population at risk, is according to geographical distance from the Gaza Strip. In 2007, after some years of terror attacks, the Knesset passed the *Assistance to Sderot and the Western Negev (Temporary Provision) Law, 2007*, which recognizes communities within a radius of 7 km from the border fence surrounding the Gaza Strip (and other places in the region as determined by the Minister of Finance in the bill) as confrontation line communities and grants them special benefits (temporarily until the end of 2008). On 14th June 2007, the Minister of Finance signed a bill recognizing the Gaza Envelope localities as border communities. This recognition grants these localities the right to indirect compensation pursuant to the *Compensation Fund* according to the *Israeli Property Tax Act*. Although this definition is economic, it also expresses the risk of harm and is therefore also relevant for assessing health risks, as it enables us to define the population in the closest circle.

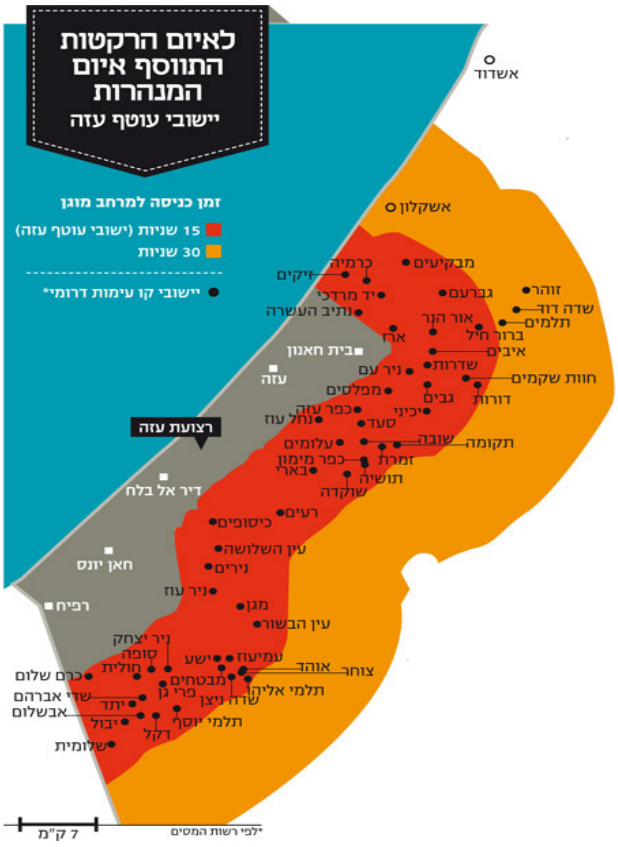

Figure 6: Tax Authority, 2019

The list includes the following communities (according to the Tax Authority (10)):

Avshalom	Zimrat	Nir Yitzhak
Or Haner	Havat	Nir Oz
Erez	Shikmim	Nir Am
Bror Hayil	Holit	Nirim
Ohad	Yevul	Nativ
Ibim	Yad	Ha'asara
Beeri	Mordechai	Sufa
Gevim	Yakhini	Sa'ad
Ein	Yesha	Ein Habessor
Hashlosha	Yated	Sde
Alumim	Kissufim	Avraham
Amioz	Kfar Maimon	Shuva
Pri Gan	Kfar Aza	Sderot
Tsohar	Carmiya	Shukada
Reim	Kerem	Shlomit
Sde David	Shalom	Tushia
Sde Nitzan	Mivtachim	Telamim
Gvaram	Mavki'im	Talmi Eliyahu
Dorot	Magen	Talmei Yosef
Dekel	Miflassim	Tekuma
Zikim	Nachal Oz	

In addition, a report by the Knesset Research and Information Center for 2015 makes it possible to characterize these communities according to their socioeconomic index and the migration balance, showing that despite the uncertain security situation, the migration balance is positive (11):

Regional Council / City (distance from the border of the Tel Aviv Region)	Socio-economic index 2008	Number of localities	No. of residents at end of 2012 (thousands)	Migration balance in 2012 (no. of residents)	No. of residents at end of 2013 (thousands)	Migration balance from 2012 to 2013 (thousands)
Ashkelon Coast (43.8 km)	6	20	14.7	241	15	0.3
Sderot (60.1 km)	4	1	21.6	79-	21.9	0.3
Sha'ar Hanegev (60.7 km)	6	12	6.9	47	7.1	0.2
Sdot Negev (70.4 km)	5	16	8.7	60-	8.9	0.2
Eshkol (91.5 km)	6	32	11.7	159	12	0.3
Total	-	**81**	**63.6**	**308**	**64.9**	**1.3**

Figure 7: Knesset Research and Information Center, 2016 (11)

Another factor that defines populations at risk covers groups that are universally vulnerable to health problems:

- **Pregnant women** are defined as a population at risk mainly because of the developing fetus. The mother provides the fetus with nutrients and oxygen, and therefore it is sensitive to various environmental factors to which she is exposed during the pregnancy. From conception to birth, the fetus goes through several developmental stages. Harm to the fetus during these critical stages is liable to cause it long term damage.

- **Children and adolescents** are defined as a population at risk because their bodies are biologically different from those of adults. Children are therefore more sensitive to the development of diseases and factors that can affect their growth process. The most important factor is that children can expect a long period in life in which they are liable to be significantly exposed continuously to risk factors that can cause damage to their health in the long term.

- **Elderly people** are defined as a population at risk due to various physiological characteristics that affect their immunity and ability to cope with various conditions. For example, reduced vision, hearing and mobility make it more difficult for them to reach shelters quickly in times of emergencies. In addition, there is sometimes also a cognitive decline due to increased fatigue, medication, depression and existing conditions. All these considerably increase their vulnerability to risk factors.

- **People with chronic conditions** are defined as a population at risk, but each illness has its own specific risk factors. For example, air pollution, which we discuss at length later, affects people with lung and heart conditions. Another example is vulnerability to infectious diseases due to a weakened immune system, due to conditions such as AIDS, cancer and various autoimmune diseases, especially when facing antibiotic resistant strains.

Below are a number of examples of breakdown of the population (based on National Insurance Institute data for 2016) in several large cities mentioned above as part of the population at risk due to their geographical location.

Breakdown of the population of the city of Ashkelon from the National Insurance Institute website:

	Population		Breakdown	
	Ashkelon	National	Ashkelon	National
Total population	134,500	8,628,600	100%	100%
Children up to age 18	36,843	2,851,908	27.4%	33.1%
Working age	73,983	4,604,166	55%	53.4%
Elderly	23,630	1,172,517	17.6%	13.6%

Breakdown of the population of the city of Sderot according to the National Insurance Institute website:

	Population		Breakdown	
	Sderot	National	Sderot	National
Total population	24,000	8,628,600	100%	100%
Children up to age 18	6,862	2,851,908	28.6%	33.1%
Working age	14,120	4,604,166	58.8%	53.4%
Elderly	3,033	1,172,517	12.6%	13.6%

Breakdown of the population of the city of Netivot according to the National Insurance Institute website:

	Population		Breakdown	
	Netivot	National	Netivot	National
Total population	32,500	8,628,600	100%	100%
Children up to age 18	13,664	2,851,908	42%	33.1%
Working age	16,406	4,604,166	50.5%	53.4%
Elderly	2,446	1,172,517	7.5%	13.6%

Another population defined as a population at risk are groups with a low socioeconomic status, who are usually fundamentally at a higher risk of exposure to risk factors and have less access to healthcare services. The increased risk for these population groups is derived from factors affecting determinants of health, such as income, occupation, education and housing; social capital, such as level of family support; and characteristics of the healthcare system, such as standard and deployment of healthcare services in peripheral communities.

These factors translate into an increased risk of health crises, with different patterns of morbidity, health behaviors and access to medical assistance, in comparison to the general population (12).

4.2. Impact on Health According to the Various Exposure Factors

Having defined the population at risk, now we will specify the health implications for the population of the Gaza Envelope and the general population of Israel, deriving from the various environmental exposure factors originating in Gaza.

4.2.1. Pollution of Sea, Rivers and Water Sources in Israel Due to Insufficient Sewage Treatment

In the first quarter of 2016, the desalination plant in Ashkelon was closed due to pollution coming from the direction of Gaza. At that time, the sewage system in Gaza was in a state of collapse, causing raw sewage from Beit Lahia (about 200 meters from the border with Israel) to flow into the reservoir of Hof Ashkelon Regional Council. According to a report by the State Comptroller, following this incident, water pollution is the most serious cross-border threat to Israel, because of the damage to groundwater and the risk to public health. The Ministry for Environmental Protection emphasized that "environmental issues do not consider man made borders (1).

In order to investigate these events, the Israel Oceanographic and Limnological Research institution (IOLR) published a detailed report on the extent of seawater pollution originating in Gaza and its impact on Israel. The researchers state that the concentration of fecal bacteria in sea water along the Gaza coast reached a maximum concentration of 10^5 CFU/100mL (whereas according to the standard published by the Ministry of Health the maximum permitted concentration of fecal bacteria is 200 CFU/100mL (13)), with the highest concentration found near the border with Israel, a few kilometers from the Ashkelon power station. They also found that 50% of the bathing beaches in Gaza were unfit for bathing. Using satellite simulations, measurements of water currents, analysis of bacterial cultures from sea water, and building a mathematical model, the study showed that bacterial pathogens are liable to be carried by the sea northward to the coast of Ashkelon and even as far as Ashdod. Moreover, depending on the conditions of the sea water carrying them, some of these bacteria become dormant, able to enter a viable but non-culturable state (VBNC), in which they can penetrate through the membranes of desalination facilities and not be identified using the current methods of drinking water monitoring. These bacteria survive longer in the coastal waters, in which levels of sediments are higher.

The report concludes that the growing pollution in Gaza is affecting the quality of the water entering the Ashkelon desalination facility and that this problem is expected to increase with the growth of the population in Gaza (4):

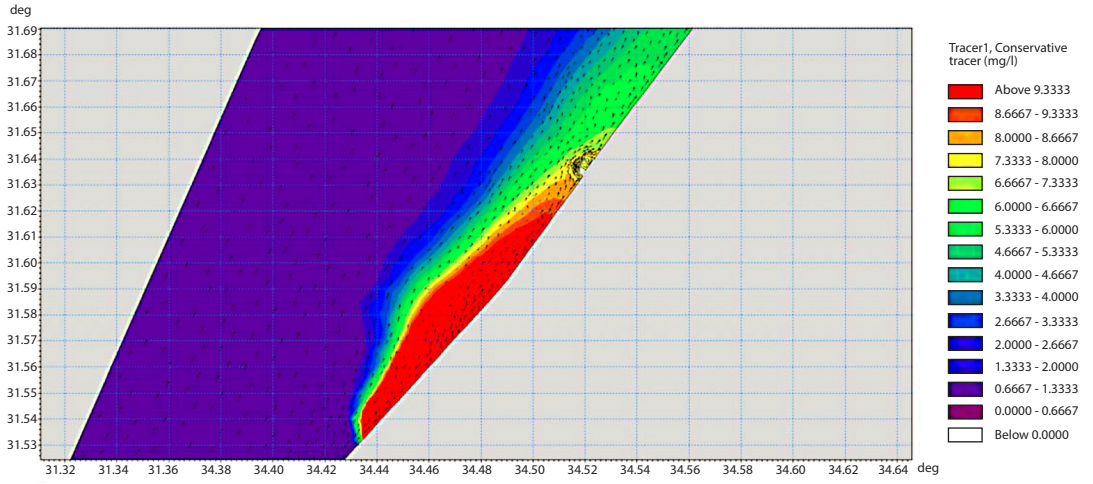

Figure 8: Mathematical model by the IOLR showing the beam of fecal bacteria borne from Wadi Aza to the coast of Ashkelon. The colors indicate bacterial concentrations and the small arrows show the northward and eastward direction of flow from Gaza to Israel

According to the Ministry of Health office for Ashkelon Region, the Ministry has the means to prevent the effects of seawater pollution on the population in Israel, at the current levels, through supervision of water quality in the desalination plant or even by closing the facility in the event of anomalous measurements, and/or prohibiting bathing on declared beaches.

Another problem caused by sewage flowing to Israel from the direction of Gaza is the problem of rivers pollution, in particular Hanun River that passes close to the city of Beit Hanun flowing into the Shikma River in Israel. The sewage treatment plant in the northern Gaza Strip operates intermittently, due to numerous electricity stoppages, and therefore waste water from the plant sometimes reaches Hanun River, with a flow rate of about 2,000 cubic meters per day, with partial or no treatment (14). There is a risk that wastewater that reaches the Shikma River could ultimately flow to the Shikma drinking water injection plant in Israel, causing serious damage. In 2012, raw sewage was witnessed flowing in the Hanun River to the point it meets the Shikma River, which only stopped after three weeks. The flow was due to a breach in a ramp or dam of the Beit Lahiya aeration lagoons (15).

Figure 9: Pollution of Hanun River originating from sewage in Gaza, July 2017. Photo: Roi Idan, ynet

Since November 2018, a sewage delivery line has been operating at full capacity, pumping sewage that flows into Hanun River to the waste treatment plant in Sderot. This represents about a tenth of the overall sewage treated at the Sderot plant (14). According to the Ministry of Health, there is nevertheless a danger of sewage occasionally seeping into ground

water. Fortunately, tests conducted of drilled water used for drinking in this area found no anomalies (16). In spite of the delivery line, sewage does occasionally seep into ground water due to heavy rainfall that raises the water level above the dam, so that some sewage overflows from the facility.

Hanun River is also a water source that is liable to increase the incidence of West Nile Fever in the Gaza Envelope, particularly the Ashkelon coast, due to the incubation of mosquitoes in the river, as already reported by the Ministry of Environmental Protection (15). A 2017 study showed that in the Ashkelon area there is a relatively high incidence of mosquitoes carrying the virus, as well as people whose blood tests showed signs of the infection (16).

4.2.2. Air Pollution Caused by the Ongoing Fighting

Figure 10: Mobile air pollution measuring unit in the Gaza Envelope. Photo: Ilia Mogilevsky

According to the Ministry of Environmental Protection, in the second half of 2018, as a result of fires started in the Gaza Envelope by incendiary kites, extremely abnormal levels of air pollution were monitored. In July 2018, the Ministry set up a mobile unit to monitor air quality at Kibbutz Kissufim, to measure the concentration of small breathable particles (PM2.5), nitrogen oxide, nitrogen dioxide and ozone, as well as wind speed and direction, in order to attribute the sources of the pollution (17).

Sufficient research data has not yet been collected in order to assess the nature and intensity of the air pollution coming from the Gaza Strip into Israel, and its implications for various health outcomes to the residents of the Gaza Envelope. However, two ongoing studies should be noted:

- Researchers at the Clinical Research Center at Soroka Hospital are using satellite data and data from Ministry of Environmental Protection air monitoring stations to map concentrations of breathable particles PM10 and PM2.5, nitrogen dioxide, sulfur dioxide and ozone near the fire areas, comparing them to concentrations in previous years. They are examining whether the difference in concentrations due to fires is affecting health outcomes, such as an increase in COPD (chronic obstructive pulmonary disease) exacerbations, asthma, stroke and heart attacks.
- A similar study is taking place in the Public Health Department of Ashkelon Academic College, to examine the quantity and nature of visits to the emergency room (ER) at Barzilai Hospital by children aged 1-14, following exposure to air pollution due to fires in the Gaza Envelope. The study is particularly examining complaints connected to respiratory diseases.

In order to examine whether there is a basis for the assumption that the Gaza Envelope population was indeed exposed to higher air pollution due to fires on agricultural land started by incendiary kites, we studied the concentration of various air pollutants during the period of May to August 2018, compared to the same period in the previous year, based on data from the air monitoring stations close to the Gaza border, and on data given on the website of the Ministry for Environmental Protection - www.svivaaqm.net. We found that the concentration of small inhalable particles, PM2.5, was far higher in the relevant period in 2018 than the same period in 2017, with greater fluctuations, and reaching a maximum daily average of 51 micrograms per cubic meter. With reference to the category of PM2.5 pollutants and health, this concentration is within the range defined as "unhealthy for the general population" (18).

	Pollutant	2017	2018	Stations
$PM_{2.5}$	Mean ± SD	17.18 ± 4.66	18.90 ± 7.08	Gvaram Sderot
	Minimum	7.65	7.8	
	Maximum	37.25	51	
	Median (IQR)	16.55 (13.74-20.35)	17.80 (14.45-22.62)	

Figure 11: Source of data: Ministry of Environmental Protection, 2018 (19)

In addition, a report by the Ministry of Environmental Protection, dated September 2018, based on data collected at the air monitoring stations in the Gaza Envelope, showed that an examination of hourly concentrations of inhalable PM2.5 particles revealed the impact of the fires in the area on the air pollution. The graph shows anomalies of pollution above the maximum permitted level in the stations at Kissufim and Gvaram, which were measured close to the times of fires in those areas (19).

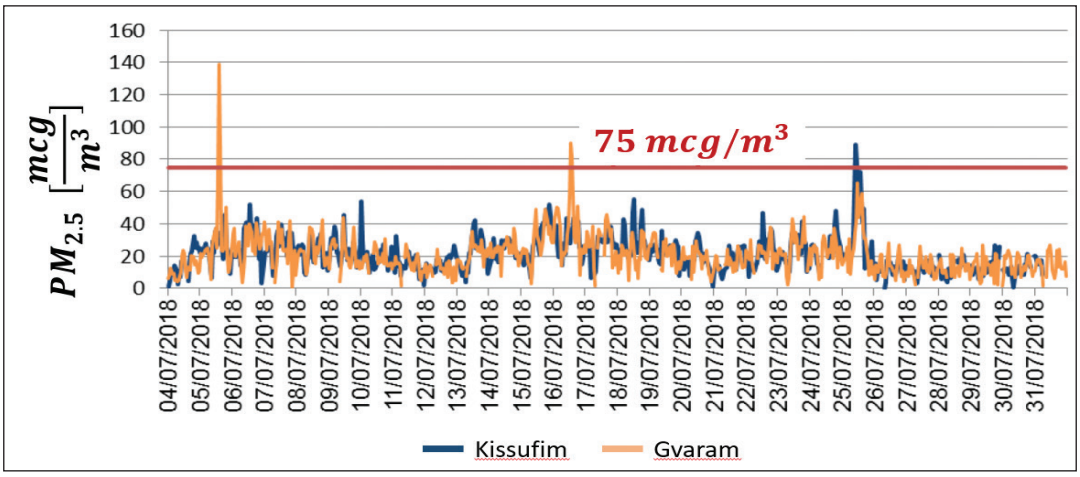

Figure 12: Hourly concentrations of PM2.5 for the period of 4/7/2018 – 31/7/2018

Apart from the air pollution caused by fires in the course of the ongoing fighting near the border, residents of the Gaza Strip also routinely suffer from air pollution due to proximity to waste treatment centers in the Gaza Strip. According to the Department of Geography

at Haifa University, garbage landfill sites in the Strip that are located very close to Israeli populations cause environmental hazards of air pollution, odor and pests nuisances. For example, at the Beit Hanoun garbage disposal site, close to Erez and Netiv Ha'asara, there is constant burning of waste causing hazards of odor and smoke, pests nuisances, and aquifer pollution (20). In 2015 the National Air Pollution Monitoring Center of the Ministry of Environmental Protection published a report on noxious smells at Kibbutz Beeri due to the burning of waste at a garbage dump located northwest of the kibbutz, within the Strip. The report found that the high concentration of PM2.5 breathable particles, according to winds direction, was coming from the Gaza garbage dump (21).

4.2.3. Spread of Contamination with Resistant Bacteria from Gaza to Israel

There is extensive professional literature on the presence of bacteria that are resistant to various types of antibiotics in Gaza, providing evidence for the increase in the phenomenon. This phenomenon already receives exposure beyond the scientific literature. The Bureau of Investigative Journalism recently published statements of healthcare workers in Gaza regarding the increase in infections with antibiotic-resistant bacteria. According to the interviewees, the population in Israel and the international community must begin to address this issue, because antibiotic-resistant organisms do not stop at the border (22).

Sjölander et al. found antibiotic-resistant *Acinetobacter baumannii* and *Pseudomonas aeruginosa* bacteria in Gaza and the Palestinian Authority (23). In Gaza burn treatment centers, methicillin resistant *Staphylococcus aureus* (MRSA) has been found in 60% of patients, in 77.8% of healthcare system employees, and in 90% of samples that were taken from around the hospital (24). One of the reasons for the significant rise in bacteria resistance in Gaza, according to the UN Office for Coordination of Humanitarian Affairs, is the lack of clean water and electricity in Gaza hospitals, which makes it difficult to perform surgery under sanitary conditions. According to this report, the intermittent water supply affects all the processes of sterilizing machines, equipment, beds and rooms, and even when there is water, medical staff are unable to wash their hands due to poor water quality (25). Incorrect use of antibiotics, due to shortages, can also contribute to bacterial resistance.

As mentioned at the start of the report, many residents of Gaza who need medical treatment turn to hospitals in Israel. According to the report from the Knesset Research and Information Center for 2017, in recent years 4,000-5,000 patients residing in Gaza are hospitalized in Israel each year (26):

	2013	2014	2015
Number of permits issued to receive treatment in hospitals in Israel (excluding East Jerusalem)	5,062	5,558	4,073
Number of permits issued to receive treatment in hospitals in East Jerusalem	1,407	1,592	3,776

Figure 13: Knesset Research and Information Center, 2017 (26)

The Ministry of Health National Center for Infection Control and Antibiotic Resistance, based on a conservative estimate, states that many dozens of patients from a Gaza hospital were admitted to hospitals in Israel in 2018 carrying the CPE (Carbapenemase-Producing Enterobacteriaceae) resistant bacteria. A subgenus of these bacteria containing the enzyme OXA-48 – the multidrug-resistant Proteus mirabilis strain producing the carbapenemase OXA-48, which can break down many types of antibiotics – has been isolated in Shifa Hospital in Gaza (27). Recently, a study conducted at Sheba Medical Center, Tel Hashomer, found that exactly this type of bacteria, was first discovered in Palestinian patients, who were hospitalized in Israel, some of whom are from Gaza, caused infections among dozens of Israeli patients in the intensive care unit in 2016-2017 (28).

4.2.4 Effects of the Fighting on Mental Health, Addictive Substance Abuse, and Metabolic Diseases

In 2018, following work done by the Sderot Social Rights Center in collaboration with the NGO Physicians for Human Rights, the National Insurance Institute recognized the continuing trauma state, experienced by residents of the Gaza Envelope, as hostile action casualties. According to Dr. Zeev Weiner, a psychiatrist volunteering at the NGO: "There are residents in some parts of the State of Israel under constant threat from rockets regularly experiencing traumatic events. And due to the reality of the war, these events keep recurring over the years. In this chain of events, there is no single defining event that causes the mental disturbance, but a series of direct personal events: witnessing injuries and damage to others, and the general war-like environment that causes stress." (29).

Researchers from Ben Gurion University of the Negev are currently examining the impact of the recent rounds of fighting in Gaza – "Cast Lead", "Pillar of Smoke", and "Protective Edge" – on various health outcomes of residents of the Gaza Envelope and the southern coastal plain. Their aim is to assess the effect of the fighting on hospitalization rates in the course of the six years between the Operations, due to psychiatric disorders and due to coronary heart disease that is liable to be aggravated by psychiatric disorders, at Barzilai University Medical Center in Ashkelon. The initial results of this study demonstrate a clear statistical significance between each round of fighting and a rise in patients arriving to the ER due to psychiatric disorders such as depression, anxiety and post-traumatic stress disorder (30).

Researchers in the field of psychology at Tel Aviv University examined the effect of the four weeks of fighting during Operation "Cast Lead" on the appearance of PTSD symptoms in children aged 3-6. The researchers found very high incidence of PTSD symptoms suffered by the children, of up to 14%. It was also found that multiple exposure to events relating to fighting increased the symptoms (31). An additional study, involving youth who are residents of Sderot in grades 7-8, found that they also exhibited high incidence of PTSD related symptoms of 43.5% (32).

A study carried out at the Brookdale Institute examined the emotional difficulties and needs of children and adolescents in Sderot following intensive rocket barrages on localities in the

Gaza Envelope in 2006, and on other population groups in northern Israel in consideration of the Second Lebanon War. Among the groups examined, the study found that children in Sderot were dealing with higher rates of mental problems, and were most in need of mental treatment (33).

The professional literature in the field of psychiatry recognizes the tight link between anxiety and other psychiatric disorders, and addictive substances use (34). A study published in 2018 used focus groups of adolescents in Ofakim to examine the effects of increased exposure to rocket fire during Operation "Protective Edge". The study found that the exposure caused mental stress and led to use of addictive substances such as alcohol, tobacco, cannabis and cannabis-like synthetic substances, as well as changes in eating habits and in quality of sleep (35). Similarly, a survey done by the Israeli national center for disease control found that residents of the Gaza Envelope smoked more during "Cast Lead", and even during periods of calm the percentage of smokers in the Gaza Envelope is higher than in the general population of Israel. They also found that during the actual fighting, the residents smoked more often inside their homes, thus causing increased passive exposure to the other residents. Also found was a strong correlation between smoking at home and disrupted ability to go to work, and that 50% of the people questioned had stopped working to some extent or even completely during the operation (36).

The ongoing exposure to rocket fire from Gaza not only causes psychiatric disorders but also affects the control of metabolic diseases, such as type 2 diabetes. Accordingly, a study found that in the years following "Cast Lead", glucose blood levels (represented by glycated hemoglobin HgA1C) of residents of the Gaza Envelope suffering from Type 2 diabetes, increased in relation to a control group of diabetic patients outside the Gaza Envelope. It was also found that during the fighting, levels of LDL cholesterol (the cholesterol that is hazardous to health) in the blood of residents of the Gaza Envelope increased, and that irrespective of the fighting, diabetic patients in the Gaza Envelope were at higher risk of complications due to LDL and BMI (Body Mass Index) values that were higher than in the control population (37).

4.2.5. Extreme Scenario of Mass Migration ("Environmental Refugees") from Gaza to Israel and Neighboring Countries

One of the risks with the most dramatic impact that may occur due to the continuous deterioration of the sanitary, environmental and health conditions in the Gaza Strip is a scenario in which the Gaza population experiences a major collapse of the health and sanitary situation causing unwillingness to continue living in the environment, perceived as being dangerous. In current public health and environmental literature this situation is described as an "**environmental refugees**" situation. It has been studied more in connection with climate change, looking at how climate-related environmental stressors affect health related pathways:

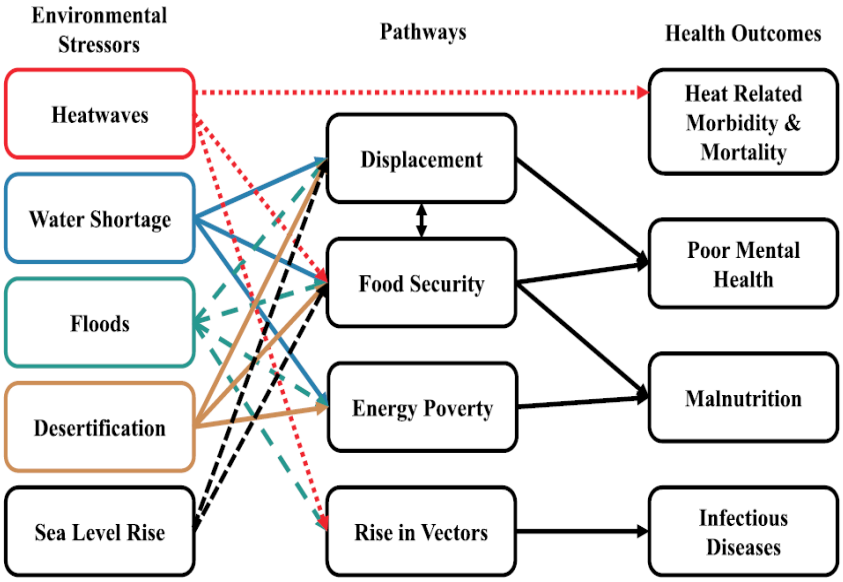

Figure 14: Negev et al., 2019 – Climate-related environmental stressors and the main pathways to health outcomes in sub-Saharan Africa (49)

According to an article published by Negev et al. (2019) (49), which discusses the population of sub-Saharan Africa, environmental stressors are liable to lead to waves of migration that must be taken into consideration by the healthcare systems. This situation is not confined to Africa, but could also affect the Middle East and Europe, in light of the waves of migration that will continue and probably even increase, as long as the environmental changes that also affect the political situation in the various countries continue.

The environmental situation in the Gaza Strip has similar characteristics to the situation demonstrated in the diagram above. According to the Ma'an Development Center, climate change is leading to an increase in average temperatures in Gaza in all seasons, to an increase in frequency of extreme temperature events, to a rise in sea level and an increase in heavy sedimentation. The Gaza population efforts to contend with these changes results in increased demand for electricity to regulate the temperature, and increased use of water that does not originate from the main water supply network, for drinking and irrigation (38). If the sanitation, health and environmental situation in Gaza continues to deteriorate, a scenario may arise in which residents are afraid to remain living in conditions that endanger themselves and will begin a mass move out of the Strip. This scenario is extreme but is certainly described in the literature in other contexts, and must be taken into consideration.

If the processes described in the previous sections continue and intensify, the collapse in the Gaza Strip will be caused by a failure of the sewage system or the water supply in the Strip, or due to a total failure of the healthcare system– a situation that could lead to an outbreak of infectious diseases, and ultimately reach a stage where the population "has nothing to lose" and will take extreme measures including crossing the borders to neighboring countries or participating in violent actions.

A scenario in which Israel has to contend with hundreds of thousands of Gazans gathering on the borders or entering Israeli territory is an extreme scenario which has significance far beyond the health implications – it would have complex security and international consequences which must be addressed by government systems far beyond the healthcare system.

5. Initial Assessment of Risks to Public Health

In light of all of the above, it is required to try to assess the health implications of the various scenarios. As we wrote at the beginning of this report, it is possible to define the various populations at risk in view of specific risk factors. The following sections describe the various health risks arising from each type of exposure, and the relevant population.

5.1. Health Risk Due to Air Pollution

As stated, air pollution in the Gaza Envelope region is also caused by warfare, including for example the fires started on agricultural land in Israel by incendiary kites, but also by the routine of tension, in which tires are set alight during demonstrations near the border, and even by defective treatment of garbage at landfills in Gaza that are in proximity to Israeli communities. Air pollution is liable to affect health negatively in a number of ways. According to the World Health Organization, air pollution is responsible for 29% of deaths due to lung cancer, 43% of deaths due to COPD, in addition to the less well known to the public fact that air pollution is also responsible for about a quarter of deaths due to stroke and ischemic heart disease (39). The effects of air pollution due to geographical proximity to Gaza, whether or not actual fighting is taking place, and on health outcomes for the local population, are currently being studied. So, at present, it is not possible to give a precise numerical assessment of the extent of the phenomenon and its implications. However, it is clear that this is a significant issue that must be addressed. The populations most at risk from exposure can be identified:

Children and adolescents spend a large part of their time outside the home in the presence of pollutants; they inhale more air per kilogram of body weight than adults, and are less aware of symptoms due to the effect of pollutants, such as chest pressure. Even unborn fetuses are at high risk from air pollution, because any event that deprives the mother of sufficient oxygen can cause serious developmental damage.

The elderly are also at risk from air pollution because they are more vulnerable to infections stemming from impaired airways. They suffer more from chronic respiratory illnesses and heart problems which exacerbate the effects of air pollutants.

People engaged in physical activity, particularly cyclists and runners who engage in intensive activity within cities, are a third group at risk, because their activity itself increases their respiratory rate and thus their intake of air pollutants.

Asthmatics, who are liable to suffer choking attacks due to increasing exposure to a range of air pollutants because of heightened inflammatory response of their airways that characterizes their illness, are another group at risk.

The last risk group are **people suffering from diseases that are linked to or cause a lack of oxygen**, such as heart diseases, vascular diseases, and respiratory diseases, in which the

supply of oxygen to the body organs is low. This group is at high risk of exposure in particular to carbon monoxide, which decreases the effective supply of oxygen to the body even more (40).

5.2. The Mental Health Risks for Residents of the Gaza Envelope

The studies presented above dealing with mental health in the Gaza Envelope region show that one of the main effects of living near the Gaza Strip during periods of fighting is the rise in the levels of mental disturbances due to emotional distress, and particularly post-traumatic stress disorder (PTSD). The groups most at risk of PTSD are those who have had prior traumatic experiences, people who lack social support, women, and people with dangerous professions, such as the military, police and fire fighters. PTSD is a condition that has comorbidity with many other mental disorders, such as major depression, addictive substance abuse, obsessive-compulsive disorders, panic attacks and social anxiety (41).

Missiles Attacks from Gaza: Alarm Zones Map

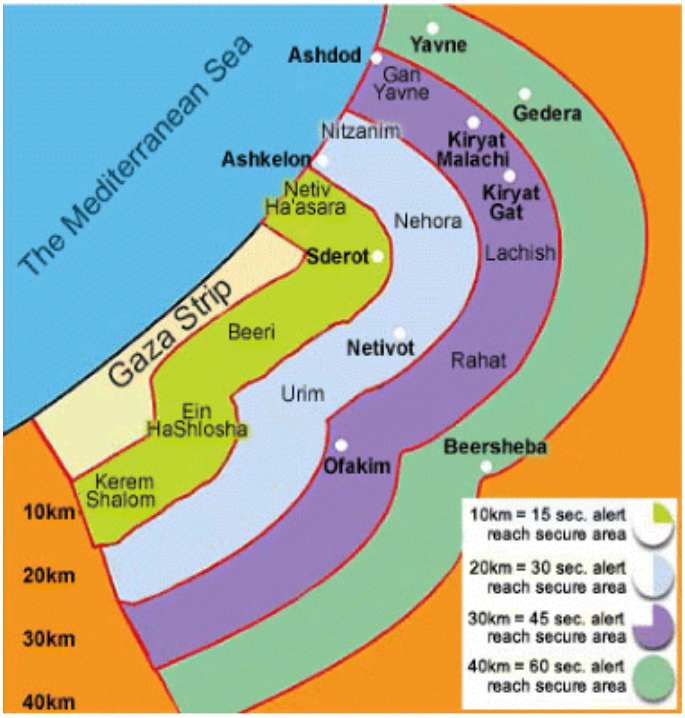

Figure 15: Pruginin et al., 2018

Among other things, the effect on mental health also depends on the intensity of the exposure itself, which is mainly a function of distance from rocket fire. The following diagram maps out the various localities in the Gaza Envelope and beyond in terms of distance from rocket fire. It is taken from an article by Pruginin et al. (35), who examined the effects of emotional stress due to exposure to rocket fire on addictive substance abuse.

5.3. Health Risks Due to the Spread of Resistant Bacteria

As currently known, the main factor in the spread of resistant bacteria from Gaza to Israel are Gazans who come to hospitals in Israel for medical treatment. The effects of air pollution due to geographical proximity to Gaza, whether or not actual fighting is taking place, and on health outcomes for the local population, are currently being studied. So, at present, it is not possible to give a precise numerical assessment of the extent of the phenomenon and its implications. Our numerical estimates on this subject are only partial, and comprehensive research is needed in order to assess the extent of this phenomenon. Moreover, it is not

possible to define the population most at risk by geographical location, such as the Gaza Envelope, because patients from Gaza have been admitted to many hospitals in Israel, mostly in the Central and Jerusalem regions, and thus the entire Israeli population is at risk of exposure.

The most vulnerable population groups in terms of health risks as a result of exposure to resistant bacteria are patients with a medical history of infections by such bacteria, patients who were recently treated with antibiotics, patients who were recently hospitalized, patients with other chronic conditions, patients with immune system disorders, and patients receiving dialysis. Additionally, there are other risk factors deriving from the existence of a "fertile ground" for the growth of resistant bacteria, such as: wounds, treatment with invasive instruments, and chronic respiratory conditions (such as COPD) (42).

5.4.4. Health Risks Due to Pollution of Sea Water, Beaches, and the Shikma Reservoir

In the chapter discussing the pollution of sea water, coasts and drinking water reservoirs, we presented studies showing the implications of defective treatment of sewage in Gaza on the quality of sea water, which affects the health of bathers on Israel's beaches, as well as the quality of water entering the desalination facility in Ashkelon, and may also penetrate into the Shikma ground water injection plant. It is encouraging that Israel has very advanced capabilities to monitor water quality, and therefore the chances for penetration of pathogens carried on sewage from Gaza, into the various facilities, without the knowledge of the supervising authorities, are low. As previously stated, when there is a warning of water pollution, it is possible to stop water entering the Ashkelon desalination plant, and to notify the public of the danger of bathing in the sea. However, it appears that the danger of sewage flowing into rivers in Israel, and even into the Shikma drinking water reservoir, has not been completely resolved. It may be assumed that the trends described in this report, such as the widening gap between demand and supply of electricity in the Gaza Strip, which could affect the operation of the waste treatment facilities in the Strip and increase the quantities of sewage flowing into Israel, as well as the increasing quantities of sewage produced in Gaza due to the growing population, could ultimately lead to greater quantities of sewage flowing into Israel and polluting the sea water, coasts and rivers. Also, in an emergency scenario, of Gaza waste treatment facilities collapsing completely, it seems that Israeli infrastructures will be unable to handle this hazard.

We are not able to estimate which populations will be more affected by drinking polluted water, or the extent of the pollution, because Israel's reservoirs are fed by several sources such as desalination plants, penetration facilities and natural sources, carried all over the country and monitored constantly at all stages of production. However, with respect to bathing in sea water polluted by sewage, research shows that the greater the concentration of fecal bacteria in the water, the greater the risk of gastro-intestinal infections, as well as skin diseases, and eye and ear infections (43) (44) (45). The population groups at high risk

of these types of disease are those who bathe on the southern Mediterranean beaches, particularly between Ashkelon and Gaza. The risk is higher for the groups mentioned above, being populations generally more at risk, that is, children, women, the elderly and people with immune system deficiencies. Currently the Ministry of Health has a methodical system for monitoring sea water at beaches but the monitoring is not continuous.

In addition, it should be noted that water pollution in Israel also has a high economic impact. For example, the Ashkelon desalination plant supplies 115 million m^3 of desalinated water to the economy each year, about 20% of all desalinated water, and is the third largest such plant in Israel (46). The facility was shut down twice in 2016 due to high levels of pollution in the sea water, requiring the plant to pay a fine of hundreds of thousands of shekels to the Water Authority (47). The plant is continuously monitored and the results are sent to the Ministry of Health. In view of past incidents and the fear that without intervention the state of water pollution will deteriorate, further shutdowns are possible, with serious economic consequences.

6. Summary

The purpose of this report is to stir further debate amongst decision makers. The continuing deterioration of the sanitation situation in Gaza is a threat to the health of the region's residents – both in Gaza and in Israel. In this report we have assessed the risks in view of the currently existing information. It is essential to continue epidemiological and environmental research with an emphasis on the issues we have surveyed, including a more thorough examination of health outcomes, increased morbidity and mortality due to exposure, and the economic impact. Our risk assessment included a mapping of the various exposures to negative health influences, such as pollution of water sources, air pollution, spread of infectious diseases, and the effect on mental health. Of course, an improvement in overall environmental planning can also improve health and economic outcomes for both sides.

The findings of this report must be taken into consideration by various government ministries, not only the Ministry of Health, since the current situation in Gaza has significant health impact on many aspects of the lives of citizens of Israel. The transfer of information must be improved within the Ministry of Health – between local, regional and national levels, and between different sections of the Ministry – and outside it.

In our assessment, the significance of the data goes far beyond the subject of health in the limited sense. The various scenarios also have strategic implications, with an emphasis on the emergency scenario of mass migration ("environmental refugees") from Gaza to Israel due to the collapse of systems and a sense of "nothing to lose" – this is indeed an extreme scenario, but certainly possible, and has been discussed elsewhere in the world where there is a danger of environmental collapse.

The solutions to the health risks presented in this report must take into account the whole system and involve many different sectors, including the municipal level, which also shares an interest in promoting the welfare of its residents. The impact of the Gaza situation on residents of Israel is not only on aspects of security, but also on aspects of health. Public health issues, like environmental issues, are not restrained by borders, so it is vital to "think outside the box" to promote solutions that will ultimately benefit both sides and promote public health for everyone.

Finally, the current sanitation, environmental and health situation in Gaza has a multi-dimensional impact on the population of Israel. In terms of public health, it is vital to look at the region as a whole, for the benefit of all populations in the region. Continuation of the current situation incurs many risks, and presents a strategic challenge that goes far beyond the healthcare system, and requires a multi-disciplinary and multi-sectoral solution.

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