**IPCC 2018 1.5°C Report**

**3.4.7 Human Health**

Climate change adversely affects human health by increasing exposure

and vulnerability to climate-related stresses, and decreasing the

capacity of health systems to manage changes in the magnitude and

pattern of climate-sensitive health outcomes (Cramer et al., 2014; Hales

et al., 2014). Changing weather patterns are associated with shifts in

the geographic range, seasonality and transmission intensity of selected

climate-sensitive infectious diseases (e.g., Semenza and Menne, 2009),

and increasing morbidity and mortality are associated with extreme

weather and climate events (e.g., K.R. Smith et al., 2014). Health

detection and attribution studies conducted since AR5 have provided

evidence, using multistep attribution, that climate change is negatively

affecting adverse health outcomes associated with heatwaves,

Lyme disease in Canada, and Vibrio emergence in northern Europe

(Mitchell, 2016; Mitchell et al., 2016; Ebi et al., 2017). The IPCC AR5

concluded there is high to very high confidence that climate change

will lead to greater risks of injuries, disease and death, owing to more

intense heatwaves and fires, increased risks of undernutrition, and

consequences of reduced labour productivity in vulnerable populations

K.R. Smith et al., 2014).

3.4.7.1 Projected risk at 1.5°C and 2°C of global warming

The projected risks to human health of warming of 1.5°C and 2°C,

based on studies of temperature-related morbidity and mortality,

air quality and vector borne diseases assessed in and since AR5, are

summarized in Supplementary Material 3.SM, Tables 3.SM.8, 3.SM.9

and 3.SM.10 (based on Ebi et al., 2018). Other climate-sensitive

health outcomes, such as diarrheal diseases, mental health issues

and the full range of sources of poor air quality, were not considered

because of the lack of projections of how risks could change at 1.5°C

and 2°C. Few projections were available for specific temperatures

above pre-industrial levels; Supplementary Material 3.SM, Table

3.SM.7 provides the conversions used to translate risks projected for

particular time slices to those for specific temperature changes (Ebi

et al., 2018).

**Temperature-related morbidity and mortality:** The magnitude of

projected heat-related morbidity and mortality is greater at 2°C than

at 1.5°C of global warming (very high confidence)(Doyon et al., 2008;

Jackson et al., 2010; Hanna et al., 2011; Huang et al., 2012; Petkova

et al., 2013; Hajat et al., 2014; Hales et al., 2014; Honda et al., 2014;

Vardoulakis et al., 2014; Garland et al., 2015; Huynen and Martens,

2015; Li et al., 2015; Schwartz et al., 2015; L. Wang et al., 2015;

Guo et al., 2016; T. Li et al., 2016; Chung et al., 2017; Kendrovski

et al., 2017; Mishra et al., 2017; Arnell et al., 2018; Mitchell et al.,

2018b). The number of people exposed to heat events is projected

to be greater at 2°C than at 1.5°C (Russo et al., 2016; Mora et al.,

2017; Byers et al., 2018; Harrington and Otto, 2018; King et al.,

2018). The extent to which morbidity and mortality are projected

to increase varies by region, presumably because of differences in

acclimatization, population vulnerability, the built environment,

access to air conditioning and other factors (Russo et al., 2016; Mora

et al., 2017; Byers et al., 2018; Harrington and Otto, 2018; King et

al., 2018). Populations at highest risk include older adults, children, women,

those with chronic diseases, and people taking certain medications

 (very high confidence). Assuming adaptation takes place

reduces the projected magnitude of risks (Hales et al., 2014; Huynen

and Martens, 2015; T. Li et al., 2016).

In some regions, cold-related mortality is projected to decrease with

increasing temperatures, although increases in heat-related mortality

generally are projected to outweigh any reductions in cold-related

mortality with warmer winters, with the heat-related risks increasing

with greater degrees of warming (Huang et al., 2012; Hajat et al., 2014;

Vardoulakis et al., 2014; Gasparrini et al., 2015; Huynen and Martens,

2015; Schwartz et al., 2015).

**Occupational health:** Higher ambient temperatures and humidity levels

place additional stress on individuals engaging in physical activity. Safe

work activity and worker productivity during the hottest months of the

year would be increasingly compromised with additional climate change

(medium confidence) (Dunne et al., 2013; Kjellstrom et al., 2013, 2018;

Sheffield et al., 2013; Habibi Mohraz et al., 2016). Patterns of change may

be complex; for example, at 1.5°C, there could be about a 20% reduction

in areas experiencing severe heat stress in East Asia, compared to

significant increases in low latitudes at 2°C (Lee and Min, 2018). The costs

of preventing workplace heat-related illnesses through worker breaks

suggest that the difference in economic loss between 1.5°C and 2°C could

be approximately 0.3% of global gross domestic product (GDP) in 2100

(Takakura et al., 2017). In China, taking into account population growth

and employment structure, high temperature subsidies for employees

working on extremely hot days are projected to increase from 38.6 billion

yuan yr–1 in 1979–2005 to 250 billion yuan yr–1 in the 2030s (about 1.5°C)

(Zhao et al., 2016).

**Air quality:** Because ozone formation is temperature dependent,

projections focusing only on temperature increase generally conclude

that ozone-related mortality will increase with additional warming, with

the risks higher at 2°C than at 1.5°C (high confidence) (Supplementary

Material 3.SM, Table 3.SM.9; Heal et al., 2013; Tainio et al., 2013;

Likhvar et al., 2015; Silva et al., 2016; Dionisio et al., 2017; J.Y. Lee

et al., 2017) . Reductions in precursor emissions would reduce future

ozone concentrations and associated mortality. Mortality associated

with exposure to particulate matter could increase or decrease in the

future, depending on climate projections and emissions assumptions

(Supplementary Material 3.SM, Table 3.SM.8; Tainio et al., 2013;

Likhvar et al., 2015; Silva et al., 2016).

**Malaria:** Recent projections of the potential impacts of climate

change on malaria globally and for Asia, Africa, and South America

(Supplementary Material 3.SM, Table 3.SM.10) confirm that weather

and climate are among the drivers of the geographic range, intensity of

transmission, and seasonality of malaria, and that the relationships are

not necessarily linear, resulting in complex patterns of changes in risk

with additional warming (very high confidence) (Ren et al., 2016; Song

et al., 2016; Semakula et al., 2017). Projections suggest that the burden

of malaria could increase with climate change because of a greater

geographic range of the Anopheles vector, longer season, and/or

increase in the number of people at risk, with larger burdens at higher

levels of warming, but with regionally variable patterns (medium to

high confidence). Vector populations are projected to shift with climate

change, with expansions and reductions depending on the degree of

local warming, the ecology of the mosquito vector, and other factors

(Ren et al., 2016).

***Aedes* (mosquito vector for dengue fever, chikungunya, yellow**

**fever and Zika virus)**: Projections of the geographic distribution of

Aedes aegypti and Ae. albopictus (principal vectors) or of the prevalence

of dengue fever generally conclude that there will be an increase in the

number of mosquitos and a larger geographic range at 2°C than at

1.5°C, and they suggest that more individuals will be at risk of dengue

fever, with regional differences (high confidence) (Fischer et al., 2011,

2013; Colon-Gonzalez et al., 2013; 2018; Bouzid et al., 2014; Ogden

et al., 2014a; Mweya et al., 2016). The risks increase with greater

warming. Projections suggest that climate change is projected to

expand the geographic range of chikungunya, with greater expansions

occurring at higher degrees of warming (Tjaden et al., 2017).

**Other vector-borne diseases:** Increased warming in North

America and Europe could result in geographic expansions of

regions (latitudinally and altitudinally) climatically suitable for West

Nile virus transmission, particularly along the current edges of its

transmission areas, and extension of the transmission season, with

the magnitude and pattern of changes varying by location and level

of warming (Semenza et al., 2016). Most projections conclude that

climate change could expand the geographic range and seasonality

of Lyme and other tick-borne diseases in parts of North America and

Europe (Ogden et al., 2014b; Levi et al., 2015). The projected changes

are larger with greater warming and under higher greenhouse gas

emissions pathways. Projections of the impacts of climate change on

leishmaniosis and Chagas disease indicate that climate change could

increase or decrease future health burdens, with greater impacts

occurring at higher degrees of warming (Gonzalez et al., 2014;

Ceccarelli and Rabinovich, 2015).

**In summary,** warming of 2°C poses greater risks to human health than

warming of 1.5°C, often with the risks varying regionally, with a few

exceptions (high confidence). There is very high confidence that each

additional unit of warming could increase heat-related morbidity and

mortality, and that adaptation would reduce the magnitude of impacts.

There is high confidence that ozone-related mortality could increase if

precursor emissions remain the same, and that higher temperatures

could affect the transmission of some infectious diseases, with

increases and decreases projected depending on the disease (e.g.,

malaria, dengue fever, West Nile virus and Lyme disease), region and

degree of temperature change.