

2023 INTERNATIONAL CONGRESS OF ACTUARIES



BRIDGE TO TOMORROW

28 MAY – 1 JUNE 2023 • SYDNEY





Long-Term Drivers of Future Mortality

May 31, 2023

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Agenda

- **Introduction**
 - Purpose of paper and presentation
 - How to use the paper
- **Driver 1 – Lifestyle**
 - Positive (Mortality improvement) and Negative (Mortality Deterioration)
- **Driver 2 – Technological Advances**
 - Positive (Mortality improvement) and Negative (Mortality Deterioration)

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Introduction



Recognitions / Thank yous

- **Yair Babad**,
my co-author
- **10 authors from 7 countries** from the former IAA MWG drafted the original paper
- **Reviewers** of current paper

IAA MWG	CURRENT PAPER
Yair Babad	Steven Haberman
Assia Billig	Andrew Naugle
Simon Brimblecombe	Dominic Patacsil
Matthew Edwards	Bruce Pyenson
Michael Eves	Dov Raphael
Sam Gutterman	Daniel Sharon
Al Klein	Marc Tardif
Mika Makinen	
Lars Pralle	
Marianne Purushotham	



Long-Term Drivers of Future Mortality

- Nine drivers were studied
- Each driver has multiple sub-drivers

BROAD DRIVERS	SUB-DRIVER EXAMPLES
Aging	Frailty, Loneliness
Lifestyle	Diet, Exercise, Stress
Inequality	Education, Med. care
Diseases	Infectious, Chronic, New
Healthcare	Models, Treatments
Medical Advances	Medications, Genetics
Technological Advances	AI, Nanotechnology
Environment	Pollution, chemicals
Catastrophes	Natural, Man-made



Purpose of Paper and Presentation

- **Purpose of paper**
 - Provide reader with wide range of potential drivers of future mortality
 - Can be used to predict future mortality, estimate changes in mortality over time, spot trends in mortality, etc.
 - Focus on mortality/morbidity, not financial/business issues
- **Considerations when using paper**
 - Overlap among drivers
 - Most of drivers have both a positive and negative impact on mortality
 - Impact of drivers will vary by population, purpose of analysis, and many other factors
- **Purpose of presentation**
 - Explain how to use the paper
 - Provide examples of some of detail contained in drivers
- **Notes**
 - Time constraints allow only limited material from the paper to be covered
 - Some of what is presented may be unique to this presentation and not in the paper



How to use the paper

- **10 chapters – Introduction and chapter for each of 9 drivers**
 - Detailed analysis of issues and impacts of drivers
 - Illustrations, tables, and references provided in addition to text
 - Paper is available
- **Determine topics most relevant to your situation and quantify impact**
- **End of each chapter – Table summarizing our opinions on impacts**
 - Didn't always agree, but results shown represent our consensus agreement



Example of Summary Table - Aging

- First column => main driver and sub drivers
- Second column => near term
- Third column => longer term
- Fourth column => comments
- Red arrow up => mortality deterioration
- Yellow arrow both ways => Neutral opinion
- Green arrow down => mortality improvement
- Single arrow => small change
- Triple arrow => large change

SUMMARY TABLE for FUTURE MORTALITY - Chapter 2 - AGING			
Sub Driver	Near Term (1-5 years) Impct	Longer Term Future Impact	Comments
Overall			Short-term slow increase in life expectancy and quality of life, but overall increase in chronic diseases and dementia
Biological Aging			Slow mortality decrease due to medical and technological advances, but longer-term limited in its extent
Chronic Maladies			Impact due to growing aging population, increasing life expectancy, and keeping chronic patients alive
Psychological and Mental			Lonliness, depression, and mental stress increasing for both young and aged
Social Interaction			Social networks, and the stress of less clear future life expectations, negatively affect human connections
Physical Activity			There is an active research, with a promise of a longer-term realization
Age Slowing / Reversing			There is an ongoing active research, with a promise of a longer-term realization
Note: The evaluations reflect the authors' opinion, rather than a scientifically measurable comparison.			
Mortality Legend:	Increasing: high low ; Decreasing: high low ; or		

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Driver 1 - Lifestyle



Lifestyle The Positive





How to achieve a longer & healthier life

- **Blue Zones**
 - Okinawa (Japan), Sardinia (Italy), Nicoya (Costa Rica), Icaria (Greece), Loma Linda (CA)
- **Have a purpose in life**
 - Estimated to increase life expectancy by 7 years
- **Lifestyle**
 - Make family a priority
 - Community important too
 - Belong/social – Drink red wine
- **Diet**
 - Eat until you are 80% full
 - Eat more fruits and vegetables than meat
- **Exercise**
 - Move naturally
- **Manage stress**



Diet and Exercise – What is good?

- **Diet**

- Sugar – Fruits are good and sugars in them are fine, however, most other sugars are unhealthy , e.g., in grains, pasta, etc.
- Fats – Natural fats are generally good and man-made fats are generally bad
- Salt - Needed for one to survive, but too much is bad
- Processed foods are bad, loaded with chemicals, preservatives, and salt

- **Exercise**

- Walking, gardening, etc. are generally good
- Running a marathon and other exercise that overstresses the body are bad
- Interval training may be the best form of exercise



Smoking

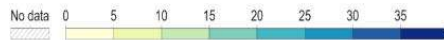
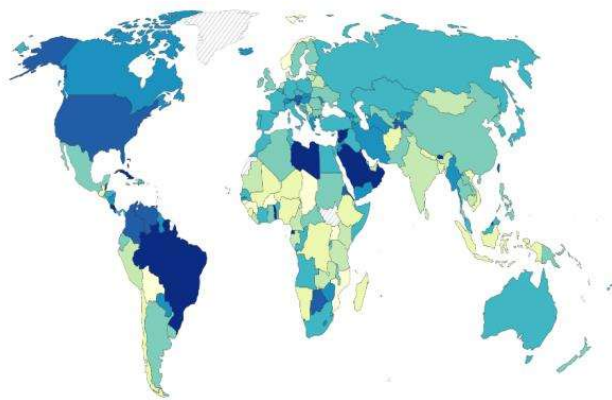
- **According to Our World in Data:**
 - Nearly one-quarter of adults smoke, but only 1 in 10 women smoke
- **Prevalence of smoking**
 - Decreasing for some countries



Daily Cigarette Consumption Worldwide (1980, 1996, 2012)

Daily cigarette consumption per smoker, 1980

Average cigarette consumption per smoker per day (all ages and both sexes combined).

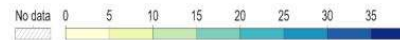
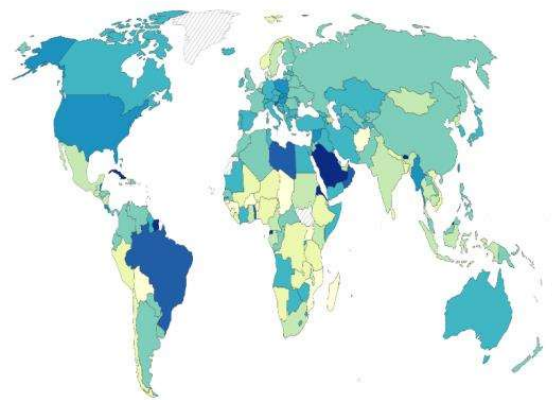


Source: Institute for Health Metrics and Evaluation (IHME)

OurWorldInData.org/smoking • CC BY

Daily cigarette consumption per smoker, 1996

Average cigarette consumption per smoker per day (all ages and both sexes combined).

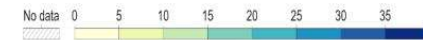
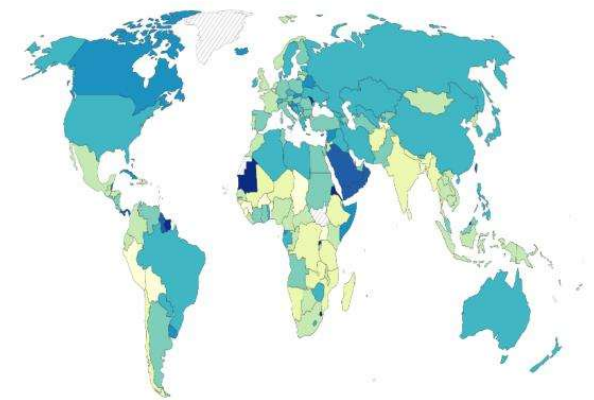


Source: Institute for Health Metrics and Evaluation (IHME)

OurWorldInData.org/smoking • CC BY

Daily cigarette consumption per smoker, 2012

Average cigarette consumption per smoker per day (all ages and both sexes combined).



Source: Institute for Health Metrics and Evaluation (IHME)

OurWorldInData.org/smoking • CC BY

- Smoking prevalence decreased and increased, depending on country, Source: Our World in Data



Lifestyle The Negative

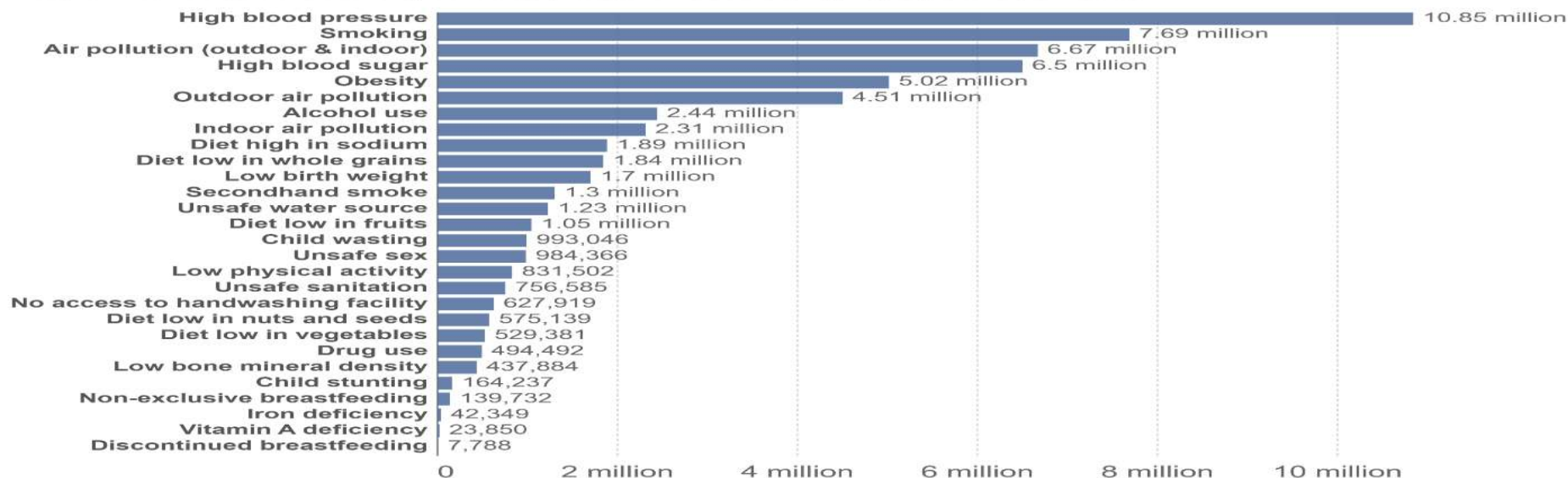




Seven of Top 10 Causes of Death Worldwide are Related to Lifestyle

Number of deaths by risk factor, World, 2019

Total annual number of deaths by risk factor, measured across all age groups and both sexes.



Source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/causes-of-death • CC BY



Top Seven Lifestyle Causes of Death

1. High blood pressure
2. Smoking
4. High blood sugar
5. Obesity
7. Alcohol and drug abuse and addiction
9. Diet high in sodium
10. Diet low in whole grains



High Blood Pressure – COD Driver of #1

- **Typically caused by stress**
 - Can be mental or physical
 - Affects people differently
 - Can lead to high blood pressure, heart disease, more
- **Despite improvements over time**
 - Heart disease still leading COD in many countries



Death Rate from High BP Worldwide (1990, 2005, 2019)

Death rate from high blood pressure, 1990

Estimated annual number of deaths attributed to high blood pressure¹ per 100,000 people.



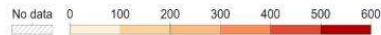
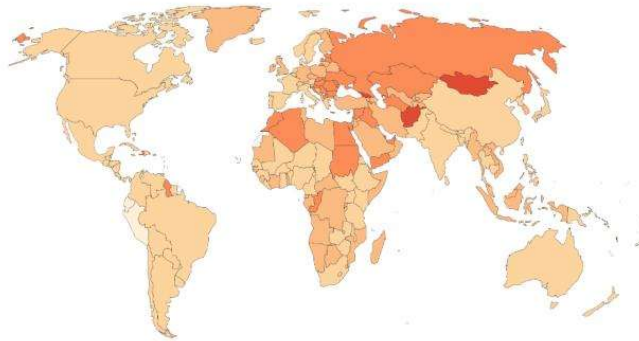
Death rate from high blood pressure, 2005

Estimated annual number of deaths attributed to high blood pressure¹ per 100,000 people.

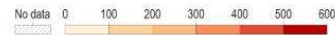
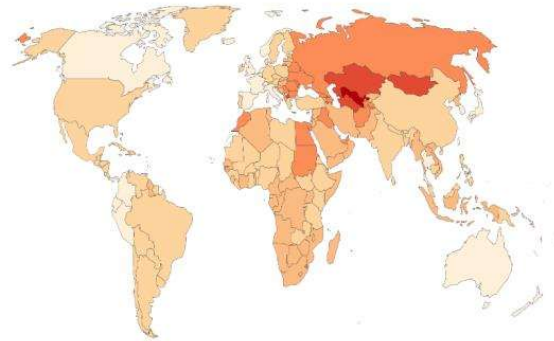


Death rate from high blood pressure, 2019

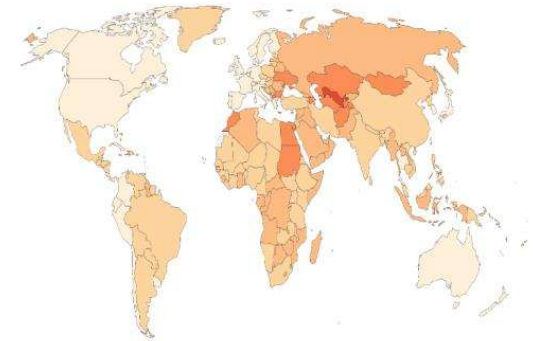
Estimated annual number of deaths attributed to high blood pressure¹ per 100,000 people.



Source: IHME, Global Burden of Disease (2019) OurWorldInData.org/causes-of-death • CC BY
 Note: To allow comparisons between countries and over time this metric is age-standardized.



Source: IHME, Global Burden of Disease (2019) OurWorldInData.org/causes-of-death • CC BY
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Source: IHME, Global Burden of Disease (2019) OurWorldInData.org/causes-of-death • CC BY
 Note: To allow comparisons between countries and over time this metric is age-standardized.

1. High blood pressure: High blood pressure, also called hypertension, is blood pressure that is higher than normal. Blood pressure is recorded as two numbers. The first (systolic) represents the pressure in blood vessels when the heart contracts or beats. The second (diastolic) represents the pressure in the vessels when the heart rests between beats. High blood pressure is diagnosed if, when it is measured on two different days, the systolic blood pressure readings on both days is ≥ 140 mmHg, or the diastolic blood pressure readings on both days is ≥ 90 mmHg. High blood pressure increases the likelihood of a person suffering from cardiovascular disease.

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- Deaths from high blood pressure generally decreased between 1990 and 2019. Source: Our World in Data



Smoking (COD Driver #2)

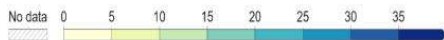
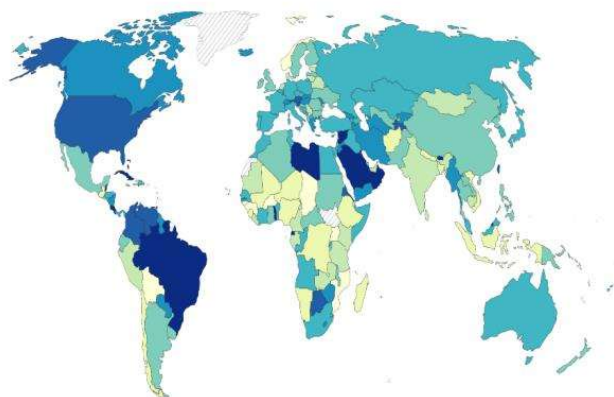
- **Tobacco and other chemicals**
 - Whether cigarettes, vaping, or other delivery systems, can lead to cancer and other diseases, e.g., respiratory
- **Despite improvements over time**
 - Cancer still second leading COD in many countries and leading cause at some ages



Daily Cigarette Consumption Worldwide (1980, 1996, 2012)

Daily cigarette consumption per smoker, 1980

Average cigarette consumption per smoker per day (all ages and both sexes combined).

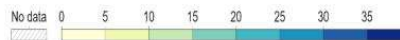
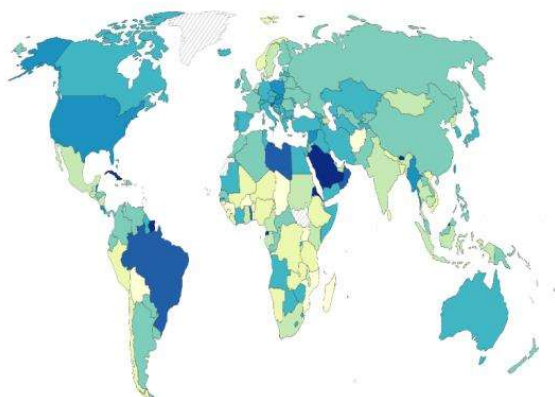


Source: Institute for Health Metrics and Evaluation (IHME)

OurWorldInData.org/smoking • CC BY

Daily cigarette consumption per smoker, 1996

Average cigarette consumption per smoker per day (all ages and both sexes combined).

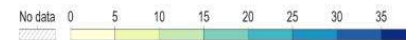
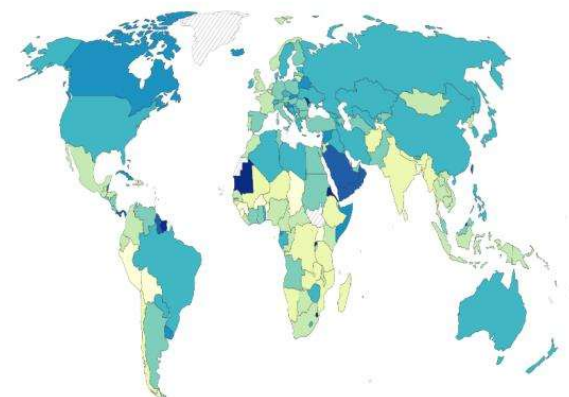


Source: Institute for Health Metrics and Evaluation (IHME)

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Daily cigarette consumption per smoker, 2012

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- Smoking prevalence decreased and increased, depending on country, Source: Our World in Data



Diet and exercise

(COD Drivers # 4 Sugar, 5 Obesity, 9 Sodium, 10 Grains)

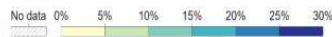
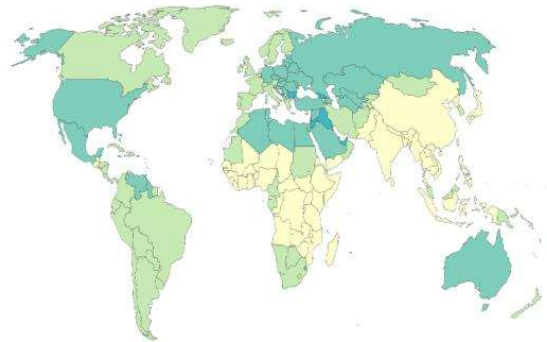
- **Poor diet and lack of exercise**
 - Can lead to obesity and other diseases, e.g., diabetes, high blood pressure, and heart disease
- **Diet**
 - Many don't know what is good to eat
 - Food companies don't help
- **Exercise**
 - In addition to lack of exercise, type of exercise is important



Growth in Obesity Worldwide (1990, 2005, 2019)

Share of deaths attributed to obesity, 1990

Obesity is defined as having a body-mass index (BMI) equal to or greater than 30. BMI is a person's weight in kilograms divided by their height in meters squared. Shown is the share of total deaths, from any cause, with obesity as an attributed risk factor.

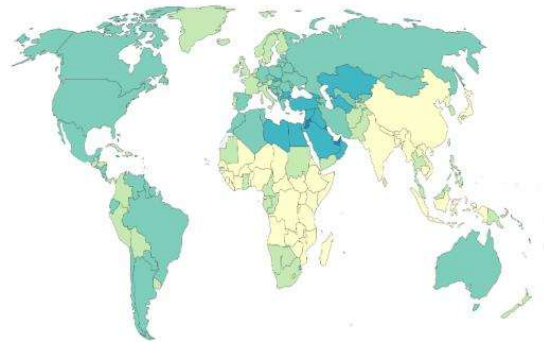


Source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/obesity • CC BY

Share of deaths attributed to obesity, 2005

Obesity is defined as having a body-mass index (BMI) equal to or greater than 30. BMI is a person's weight in kilograms divided by their height in meters squared. Shown is the share of total deaths, from any cause, with obesity as an attributed risk factor.

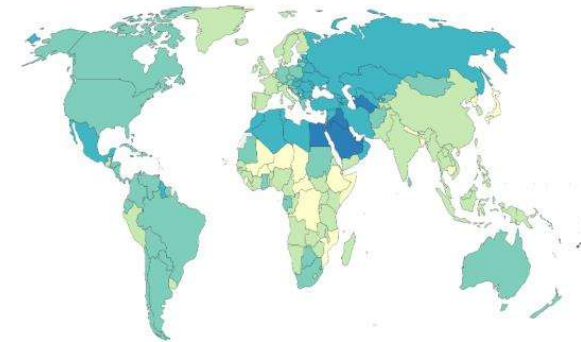


Source: IHME, Global Burden of Disease (2019)

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Source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/obesity • CC BY

- Obesity generally increasing
- Globally, 8% of deaths in 2017 were the result of obesity, an increase from 4.5% in 1990. Source: Our World in Data



Deaths from Low Physical Activity Worldwide (1990, 2005, 2019)

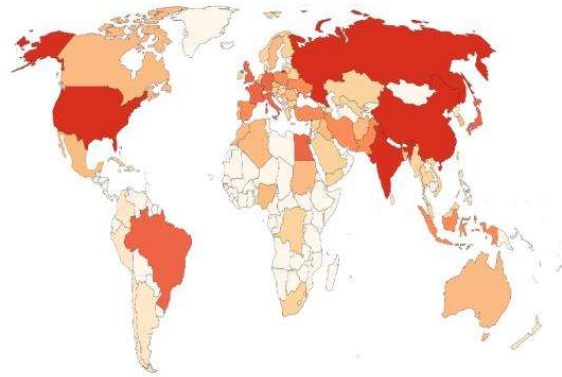
Deaths due to low physical activity, 1990
Estimated annual number of deaths attributed to low physical activity.



Deaths due to low physical activity, 2005
Estimated annual number of deaths attributed to low physical activity.

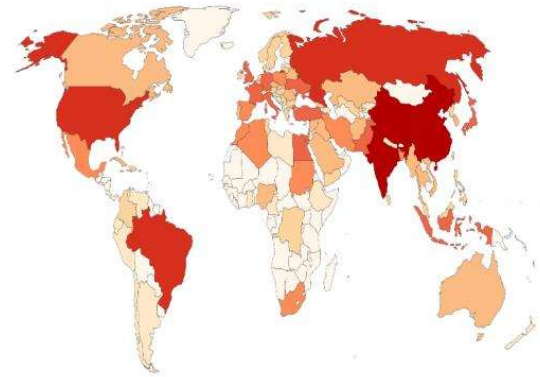


Deaths due to low physical activity, 2019
Estimated annual number of deaths attributed to low physical activity.



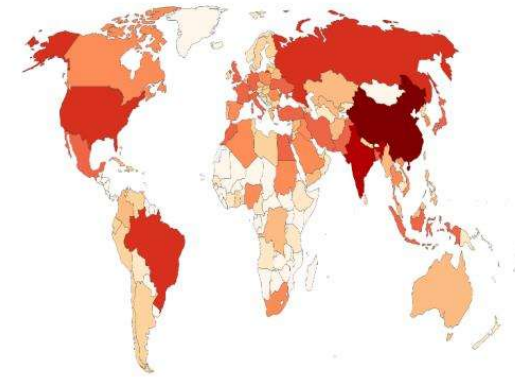
Source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/causes-of-death • CC BY



Source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/causes-of-death • CC BY



Source: IHME, Global Burden of Disease (2019)

OurWorldInData.org/causes-of-death • CC BY

- Deaths from low physical activity have been increasing, Source: Our World in Data



Alcohol and drug abuse (COD Driver #7)

- **Alcohol and drugs**
 - While the data here shows an increase in some countries, the data is before COVID-19
 - There has been an even larger increase in these deaths since COVID
- **Opioids**
 - Opioid overdoses have become a major problem in some countries



Opioid Death Rate Worldwide (1990, 2005, 2019)

Death rate from opioid overdoses, 1990

Death rates from opioid use disorders are measured as the number of deaths per 100,000 individuals.



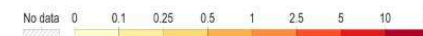
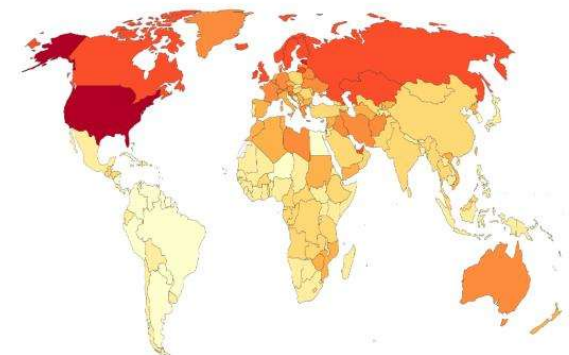
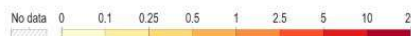
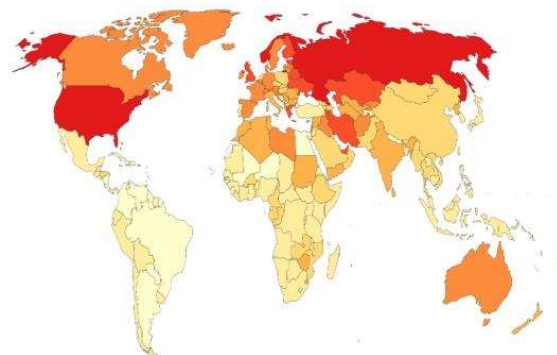
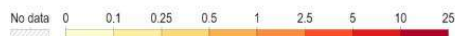
Death rate from opioid overdoses, 2005

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Source: IHME, Global Burden of Disease (2019)
 Note: To allow comparisons between countries and over time this metric is age-standardized.

OurWorldInData.org/illcic-drug-use • CC BY

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Source: IHME, Global Burden of Disease (2019)
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OurWorldInData.org/illcic-drug-use • CC BY

- Opioid death rates decreased and increased, depending on country. Source: Our World in Data



Summary of Driver 1 – Lifestyle Drivers

Sub Driver	Near Term (1-5 years) Impct	Longer Term Future Impact	Comments
Overall			Increased recognition / support may slow aging processes; however, requires personal resolve / stamina
Diet and Obesity			More industrialized diet will increase obesity and related maladies
Physical Activity			On an individualized basis, shorter-term increased activity which is countered by more sedantary life style, and longer-term reduced physical demand due to robotics, electronics and other work-environment changes
Smoking			Smoking prevalence expected to decrease, but effects of long-term smoking may take long time to be noticed
Addiction			Addiction to drugs, alcohol, and overconsumption of medications will likely increase
Stress			Social, economical, and workplace stresses are on the rise, and even more noteworthy among youth
Note: The evaluations reflect the authors' opinion, rather than a scientifically measurable comparison.			
Mortality Legend:	Increasing: high low ; Decreasing: high low ; or		

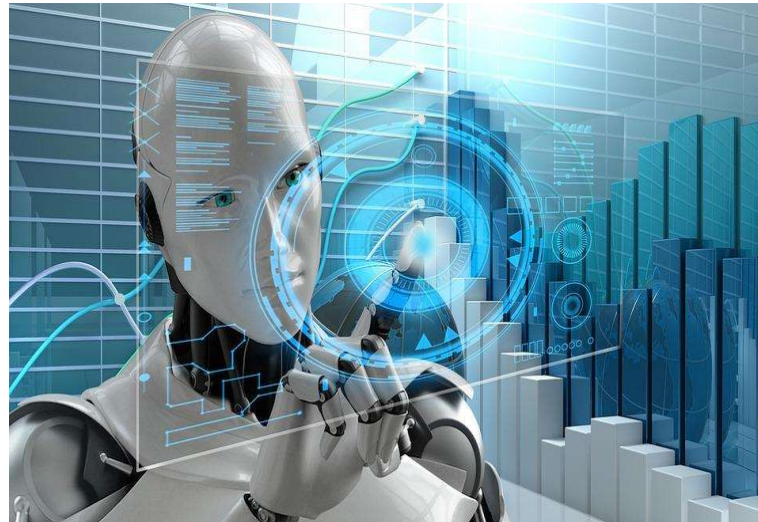
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Driver 2 – Technological Advances



Technological Advances The Positive





Technological Advances Positive Topics Covered

- **Wearables and personal electronics**
 - **Nanotechnology**
 - **Artificial intelligence**
 - **Robotics**
-
- Focus is on use of technologies for health- and medical-related issues



Wearables and personal electronics

- **“Smart phones”**
 - Fitness tracker
 - Heart rate monitor
 - Sleep monitor
 - Medication reminder
 - Optical tool for telemedicine “visit”
- **“Smart clothing”**
 - Cooling the body
 - Fitness tracker
 - Connect to Smart phone apps





Nanotechnology

- **Nanoparticles**
 - Inorganic and typically metallic or metal oxide particles
 - Could also take other forms
- **Uses**
 - Disease diagnosis
 - Drug design and delivery
- **More specific applications**
 - Fluorescent analysis/MRI contrast enhancement
 - Diagnosis and treatment of atherosclerosis
 - Detection of pathogens
 - CRISPR, a gene editor



Artificial Intelligence (AI)

- **Applications**

- Patient diagnosis and enhancing patient experience
- Determining best treatment/outcomes given patient's condition and genetics
- Beginning to be used to determine molecules best for developing new and most effective medications



Robotics

- **Elderly**
 - Appointment and medication reminder
 - Combat loneliness/sadness - play favorite song
 - Help to pick up after a fall
- **Disabled, e.g., limited mobility**
 - Exoskeleton (upper right)
- **Surgeries** (lower right)
 - More accurate, e.g., steady arm
 - Can be performed remotely with the use of other new technologies, the wider bandwidth and speed of interconnectivity





Technological Advances The Negative





Technological Advances Negative Topics Covered

- **Adoption**
- **Vulnerability**
- **Bad outcomes**



Adoption of new technologies

- **Will the technology work as intended?**
 - Was there sufficient testing?
 - Must weigh the positives and potential negatives
- **Adoption can be slow**
 - Complexities of technology
 - Interest in the technology – Marketing, ease of use
 - Often initially only available to those who can afford it



Vulnerabilities in technologies

- **Privacy**
 - Sensitive medical/personal data
 - If stolen, can cause extreme stress because of the personal time and energy spent to rectify stolen identity
- **Cyber attacks**
 - Have been many recent break ins
 - Business disruptions that impact one's well-being
 - Endangering lives and support systems



Bad outcomes

- **Psychological impacts of some technologies**
 - Can lead to isolation, depression, anxiety, death
 - Particularly among young/teens involvement with social media
- **Texting while driving/distracted driving deaths up**
- **Cancer Immunotherapy and genetic editing**
 - Deaths have occurred in testing of these



Summary of Driver 2 – Technological Advances

Sub Driver	Near Term (1-5 years) Impct	Longer Term Future Impact	Comments
Overall	—	—	Technological advances impact society and expectations with spurts of innovation. Hard to predict the rate and directions of advances
Connectivity	—	—	Advances in connectivity, via internet, storage and processing "clouds", will enhance Electronic Health Records, medical data sharing, telemedicine, improved HC, and better utilization of resources
Telemedicine	—	—	Connectivity advances will speed up diagnosing, treatments and improve outcomes
Wearable and Personal Technology	—	—	Supports personal medicine, telemonitoring, and overview and reporting of personal health
Bioelectronics and Biomedicine	—	—	New medical opportunities, such as "personally tailored" sensors and medical controllers. Understanding of genetics, biomedicine, and other breakthroughs is expected to continue
Nanotechnology	—	—	Enables medicine at the cell and molecular level, but hard to predict when will be widely available
Robotics	—	—	Used for new advances in surgery, as well as in handicap and elderly support
Predictive Analytics (PA)	—	—	PA and artificial intelligence will replace or improve many medical advancements and decisions, utilization of resources, and quality of HC



The End

Questions



Thank you

- Al Klein, FSA, MAAA,
al.klein@milliman.com
- Yair Babad, PhD, CPA, FILAA,
ybabad@uic.edu