Driverless Cars and Public Health

Resource Pack

2018

Overview

This resource pack was curated by the Global Health Education and Learning Incubator at Harvard University to coincide with "SELF-DRIVING CARS: Pros and Cons for the Public's Health" presented jointly by the Forum at Harvard T.H. Chan School of Public Health and NBC News Digital on May 4, 2018. The multidisciplinary materials may be suitable for educators, students, and policy-makers who want to learn more about the risks and opportunities that accompany this new technology.

The Forum's "SELF-DRIVING CARS: Pros and Cons for the Public's Health" event is described as follows:

> *No longer the stuff of science fiction, driverless cars already are being tested in numerous U.S. markets. These autonomous vehicles may revolutionize the automotive world, removing human error from driving, reshaping transportation systems and transforming the country's roadway infrastructure. In fact, existing technology such as collision avoidance systems and vehicle backup cameras represent steps towards a more automated future. Yet such progress also raises questions regarding regulations, ethics and safety management. In this Forum, experts will review current technology, realistic long-term plans, and the risks and benefits of a driverless future to the public.*

The Forum at Harvard T.H. Chan School of Public Health is a live webcasting series that provides decision-makers with a global platform to discuss policy choices and scientific controversies across the world.

Selected resources include:

- Major Reports and Articles
- Fact Sheets and Country Profiles
- News and Blogs
- Organizations and Topic Portals
- Data Publications, Portals, and Interactives
- Multimedia and Teaching Materials

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Selected Resources – At a Glance

	MAJOR REPORTS AND ARTICLES
*	**Report.** Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies. The National Academies Press 2017. DOI: https://doi.org/10.17226/24872.
*	**Article.** Crayton TJ, Meier BM. Autonomous Vehicles: Developing a Public Health Research Agenda to Frame the Future of Transportation Policy. Journal of Transport & Health 2017; 6: 245-252. DOI: https://doi.org/10.1016/j.jth.2017.04.004.
	Article. Fraade-Blanar L, Kalra N. Autonomous Vehicles and Federal Safety Standards: An Exemption to the Rule? RAND Corporation 2017. https://www.rand.org/pubs/perspectives/PE258.html.
*	**Article.** Fleetwood J. Public Health, Ethics, and Autonomous Vehicles. American Journal of Public Health 2017; 107 (4): 532-537. DOI: https://doi.org/10.2105/AJPH.2016.303628.
	Article. Holstein T. The Misconception of Ethical Dilemmas in Self-Driving Cars. In Proceedings of the "Digitalisation for a Sustainable Society." Multidisciplinary Digital Publishing Institute Proceedings 2017; 1(3): 174. DOI: http://dx.doi.org/10.3390/IS4SI-2017-04026.
	Report. Kalra N, Groves DG. The Enemy of Good: Estimating the Cost of Waiting for Nearly Perfect Automated Vehicles. RAND Corporation 2017. https://www.rand.org/pubs/research_reports/RR2150.html.
	Report. Kalra N, Groves DG. RAND Model of Automated Vehicle Safety (MAVS): Model Documentation. RAND Corporation 2017. https://www.rand.org/pubs/research_reports/RR1902.html.
*	**Article.** Kelley B. Public Health, Autonomous Automobiles, and the Rush to Market. Journal of Public Health Policy 2017; 38(2): 167-184. DOI: https://doi.org/10.1057/s41271-016-0060-x.
*	**Article.** Pettigrew S. Why Public Health Should Embrace the Autonomous Car. Australian and New Zealand Journal of Public Health 2017; 41: 5-7. DOI: https://doi.org/10.1111/1753-6405.12588.
*	**Report.** Smith A, Anderson M. Automation in Everyday Life. Pew Research Center 2017. http://www.pewinternet.org/2017/10/04/automation-in-everyday-life.
*	**Report**. Anderson JM et al. Autonomous Vehicle Technology: A Guide for Policymakers. RAND Corporation 2016. http://www.rand.org/pubs/research_reports/RR443-2.html.
*	**Article.** Bonnefon J et al. The Social Dilemma of Autonomous Vehicles. Science 2016; 352(6293): 1573-1576. DOI: https://doi.org/10.1126/science.aaf2654.
	Article. Harper CD et al. Estimating Potential Increases in Travel with Autonomous Vehicles for the Non-Driving, Elderly and People with Travel-Restrictive Medical Conditions. Transportation Research Part C: Emerging Technologies 2016; 72: 1-9. DOI: https://doi.org/10.1016/j.trc.2016.09.003.
*	**Report.** Kalra N, Paddock SM. Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability? RAND Corporation 2016. https://www.rand.org/pubs/research_reports/RR1478.html.
*	**Article.** Nyholm S, Smids J. The Ethics of Accident-Algorithms for Self-Driving Cars: An Applied Trolley Problem? Ethical Theory and Moral Practice 2016; 19 (5): 1275-1289. DOI: https://doi.org/10.1007/s10677-016-9745-2.
*	**Report.** Richland J et al. Steering Autonomous Vehicle Policy: The Role of Public Health. Altarum Institute 2016. https://altarum.org/our-work/autonomous-vehicles-and-public-health.
*	**Report.** Global Status Report on Road Safety 2015. World Health Organization 2015. http://www.who.int/violence_injury_prevention/road_safety_status/2015/en.
	FACT SHEETS AND COUNTRY PROFILES
*	**Fact Sheet.** Autonomous Vehicles and Public Health. Altarum Institute 2018. https://altarum.org/our-work/autonomous-vehicles-and-public-health.
*	**Country Profiles.** Global Status Report on Road Safety 2015: Country Profiles. World Health Organization 2015. http://www.who.int/violence_injury_prevention/road_safety_status/2015/country_profiles/country_profiles/en.
	NEWS AND BLOGS

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	News and Blogs. Barkenbus J. The Government Is Pushing for Self-Driving Cars — but the Public May Not Be Ready for Them. Business Insider 2018; Jan 6. http://www.businessinsider.com/the-public-may-not-be-ready-for-the-push-for-self-driving-cars-2018-1.
	News and Blogs. Black J. Self Driving Cars 'Game Changing' for FBI… & ISIS. The Cipher Brief 2018; Jan 3. https://www.thecipherbrief.com/article/exclusive/international/self-driving-cars-game-changing-fbi-isis.
	News and Blogs. Batchelder S. Public Health and the Ethics of Self-Driving Cars: Developing a Framework. Healthify 2017; Aug 2. https://www.healthify.us/healthify-insights/public-health-and-the-ethics-of-self-driving-cars-developing-a-framework.
	News and Blogs. Conroy G. Self-Driving Cars Could Make Moral Decisions like Humans with a Simple Algorithm. Science Alert 2017; Jul 6. https://www.sciencealert.com/self-driving-cars-may-soon-be-making-moral-decisions-like-humans.
	News and Blogs. King I. Intel Proposes System to Make Self-Driving Cars Blameless. Bloomberg News 2017; Oct 17. https://www.bloomberg.com/news/articles/2017-10-18/intel-proposes-system-to-make-self-driving-cars-blameless.
	News and Blogs. Lin P. Robot Cars and Fake Ethical Dilemmas. Forbes 2017; Apr 3. https://www.forbes.com/sites/patricklin/2017/04/03/robot-cars-and-fake-ethical-dilemmas.
	News and Blogs. Plungis J. Faster Rollout of Self-Driving Cars Would Save Lives, Study Says. Consumer Reports 2017; Nov 7. https://www.consumerreports.org/autonomous-driving/faster-rollout-self-driving-cars-would-save-lives.
	News and Blogs. Plungis J. Most Americans Don't Think Self-Driving Cars Are Safe. Consumer Reports 2017; Mar 7. https://www.consumerreports.org/autonomous-driving/americans-dont-think-self-driving-cars-safe.
	News and Blogs. Plungis J. Self-Driving Cars: Driving Into the Future. Consumer Reports 2017; Feb 28. https://www.consumerreports.org/autonomous-driving/self-driving-cars-driving-into-the-future.
	News and Blogs. Cheng M. Autonomous Cars and Mathematical Traffic Models Could Improve Driving Fluidity. FutureCar 2016; Nov 15. http://www.futurecar.com/article-425-1.html.
	News and Blogs. Shariff A et al. Whose Life Should Your Car Save? The New York Times 2016; Nov 6. https://www.nytimes.com/2016/11/06/opinion/sunday/whose-life-should-your-car-save.html.
	News and Blogs. Wilson L. How Maths and Driverless Cars Could Spell the End of Traffic Jams. The Conversation 2016; Aug 30. http://theconversation.com/how-maths-and-driverless-cars-could-spell-the-end-of-traffic-jams-63462.
	News and Blogs. Achenbach J. Driverless Cars Are Colliding with the Creepy Trolley Problem. The Washington Post 2015; Dec 29. https://www.washingtonpost.com/news/innovations/wp/2015/12/29/will-self-driving-cars-ever-solve-the-famous-and-creepy-trolley-problem.
	News and Blogs. Lafrance A. Self-Driving Cars Could Save 300,000 Lives Per Decade In America. The Atlantic 2015; Sep 29. https://www.theatlantic.com/technology/archive/2015/09/self-driving-cars-could-save-300000-lives-per-decade-in-america/407956.
	News and Blogs. Ramey C. America's Unfair Rules of the Road: How Our Transportation System Discriminates against the Most Vulnerable. Slate 2015; Feb 27. http://www.slate.com/articles/news_and_politics/politics/2015/02/america_s_transportation_system_discriminates_against_minorities_and_poor.html.
ORGANIZATIONS AND TOPIC PORTALS	
*	**Topic Portal.** Automated Vehicles for Safety. National Highway Traffic Safety Administration. United States Department of Transportation. https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety.
	Topic Portal. Google's Autonomous Vehicle. http://googlesautonomousvehicle.weebly.com.
	Organization. National Highway Traffic Safety Administration. United States Department of Transportation. https://www.nhtsa.gov.
	Organization. United States Department of Transportation. https://www.transportation.gov.
DATA PUBLICATIONS, PORTALS, AND INTERACTIVES	
	Data Portal. Databases and Software. National Highway Traffic Safety Administration. United States Department of Transportation. https://www.nhtsa.gov/research-data/databases-and-software.
*	**Data Interactive.** Moral Machine. Scalable Cooperation, MIT Media Lab, Massachusetts Institute of Technology. http://moralmachine.mit.edu.

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	Data Interactive. Autonomous Vehicle Safety Scenario Explorer. RAND Corporation 2017. https://www.rand.org/pubs/tools/TL279/tool.html.
*	**Data Interactive**. Initiative on Cities and Autonomous Vehicles. Bloomberg Aspen Initiative on Cities and Autonomous Vehicles. Bloomberg.org Group 2017. https://avsincities.bloomberg.org.
	Data Publication. Schoettle B, Sivak M. Motorists' Preferences for Different Levels of Vehicle Automation. Sustainable Worldwide Transportation – The University of Michigan 2016. http://www.umich.edu/~umtriswt/PDF/SWT-2016-8.pdf.
	Data Interactive. Wang U. Self-Driving Cars are Coming, and the Technology Promises to Save Lives. The Guardian 2015. https://www.theguardian.com/technology/2015/dec/17/self-driving-cars-safety-future-interactive.
MULTIMEDIA AND TEACHING MATERIALS	
	Video. Isaac Asimov: The Three Laws of Robotics. https://www.youtube.com/watch?v=AWJJnQybZlk.
	Online Learning. Decision-Making for Autonomous Systems. ChalmersX, edX 2018. https://www.edx.org/course/decision-making-for-autonomous-systems.
	Online Learning. Self-Driving Cars: Pros and Cons for the Public's Health. The Forum. Harvard T.H. Chan School of Public Health 2018; May 4. https://theforum.sph.harvard.edu/events/self-driving-cars.
	Lesson/Module. Case Study: Autonomous Cars. ICS 314: Software Engineering I. University of Hawai'i 2017. http://courses.ics.hawaii.edu/ReviewICS314/morea/ethics/experience-se-ethics-case-study-autonomous-cars.html.
*	**Videos**. TED Collection: Driverless Cars. TED 2017. https://www.ted.com/topics/driverless+cars.
	Online Learning. Rawls NP. 4 Thought-Provoking Questions to Spark Conversation. TED 2017. https://ideas.ted.com/4-thought-provoking-questions-to-spark-conversation.
*	**Video**. Rahwan I. What Moral Decisions Should Driverless Cars Make? TEDx Cambridge 2016. https://www.ted.com/talks/iyad_rahwan_what_moral_decisions_should_driverless_cars_make.
	Video. Whitaker B. Hands Off the Wheel. 60 Minutes. CBS Interactive 2015; Dec 6. https://www.cbsnews.com/news/self-driving-cars-google-mercedes-benz-60-minutes-bill-whitaker.
	Interactive Simulation. Driverless Car. CK-12 Foundation 2014. https://interactives.ck12.org/simulations/physics/driverless-car/app/index.html.

*** indicates resource listed in GHELI's online resource repository**

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Annotated Bibliography

MAJOR REPORTS AND ARTICLES

Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies
Report. Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies. The National Academies Press 2017. DOI: https://doi.org/10.17226/24872.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12144
This report from the National Academies of Sciences, Engineering, and Medicine examines autonomous vehicles (AV) and connected vehicles (CV) and their projected impact on traffic crashes, congestion, pollution, land development, and mobility, with a focus on older adults, youth, and individuals with disabilities. The report suggests that governments implement policies—such as adopting policy changes that advocate and enforce extensive testing, training, and public education—in order to reduce negative social effects and mitigate potential risks in AV and CV use.

Autonomous Vehicles: Developing a Public Health Research Agenda to Frame the Future of Transportation Policy
Article. Crayton TJ, Meier BM. Autonomous Vehicles: Developing a Public Health Research Agenda to Frame the Future of Transportation Policy. Journal of Transport & Health 2017; 6: 245-252. DOI: https://doi.org/10.1016/j.jth.2017.04.004.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12131
This article explores the public health benefits and harms of autonomous vehicle technology on both individual and population levels. It discusses the developing relationship between technological innovations in transportation and public health, conceptualizes automated transportation as a disruptive technology that elicits a public policy response, and defines a research agenda to examine the public health implications of autonomous vehicle policy.

Autonomous Vehicles and Federal Safety Standards: An Exemption to the Rule?
Article. Fraade-Blanar L, Kalra N. Autonomous Vehicles and Federal Safety Standards: An Exemption to the Rule? RAND Corporation 2017. https://www.rand.org/pubs/perspectives/PE258.html.
This article from the RAND Corporation explores developments in the Federal Motor Vehicle Safety Standard that are being made to address autonomous vehicles (AVs). It suggests that adapting existing exemptions is not efficient to AV methods and instead recommends gradually introducing AVs as they meet performance-based benchmarks. Important to implementing this is determining the target benchmarks and the number of vehicles allowed at each benchmark. The authors explore a mathematical relationship between these variables to illustrate the balance needed to measure AV safety performance.

Public Health, Ethics, and Autonomous Vehicles
Article. Fleetwood J. Public Health, Ethics, and Autonomous Vehicles. American Journal of Public Health 2017; 107 (4): 532-537. DOI: https://doi.org/10.2105/AJPH.2016.303628.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12128
This article from the *American Journal of Public Health* explores the public health and safety implications of using autonomous vehicles. Automated vehicles have the potential to reduce crashes and save up to 30,000 lives per year in the United States alone. This publication examines government regulation, forced-choice algorithms, and ethical dilemmas of using autonomous vehicles. The authors encourage technological innovation in the transportation sector along with community engagement, strong regulation, analyses of ethical issues, and constant measurement of outcomes and effectiveness.

The Misconception of Ethical Dilemmas in Self-Driving Cars
Article. Holstein T. The Misconception of Ethical Dilemmas in Self-Driving Cars. In Proceedings of the "Digitalisation for a Sustainable Society." Multidisciplinary Digital Publishing Institute Proceedings 2017; 1(3): 174. DOI: http://dx.doi.org/10.3390/IS4SI-2017-04026.
This article proposes a conceptual ethical model for identifying realistic, specific ethical challenges for self-driving cars. Connecting components, systems, and stakeholders, the conceptual model aims to move away from abstract thought experiments currently defining the ethical debate around self-driving cars to brainstorming potential solutions.

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The Enemy of Good: Estimating the Cost of Waiting for Nearly Perfect Automated Vehicles
Report. Kalra N, Groves DG. The Enemy of Good: Estimating the Cost of Waiting for Nearly Perfect Automated Vehicles. Rand Corporation 2017. https://www.rand.org/pubs/research_reports/RR2150.html.
This report from the RAND Corporation uses the RAND Model of Automated Vehicle Safety to examine road fatalities under different conditions to determine whether highly automated vehicles (HAVs) should be safer before they are released to consumers. The researchers calculated fatalities over time under two policy conditions determining the release of HAVs to consumers—in one, HAVs could be used by consumers when their safety performance was 10 percent better than that of the average human driver; in the second, HAV safety had to be 75 to 90 percent better than the average human driver's. They found that waiting for significant HAV safety gains would not result in fewer fatalities over the long term as the delay in HAVs' release has high human costs. This evidence can be used to inform policy- and decision-makers on HAV safety.

RAND Model of Automated Vehicle Safety (MAVS): Model Documentation
Report. Kalra N, Groves DG. RAND Model of Automated Vehicle Safety (MAVS): Model Documentation. RAND Corporation 2017. https://www.rand.org/pubs/research_reports/RR1902.html.
This report by the RAND Corporation explores the factors that shape highly automated vehicle (HAV) safety. It describes a model that can be used to measure safety data, such as injuries and crashes. Comparing an HAV and non-HAV future, the model estimates how many lives would be lost each year. Through these comparisons, the model allows exploration of which factors play a significant role in changing safety outcomes. This modeling data can be useful in shaping policy decisions surrounding autonomous vehicle safety.

Public Health, Autonomous Automobiles, and the Rush to Market
Article. Kelley B. Public Health, Autonomous Automobiles, and the Rush to Market. Journal of Public Health Policy 2017; 38(2): 167-184. DOI: https://doi.org/10.1057/s41271-016-0060-x.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12137
This article explores motor vehicle safety as a public health problem in the United States and describes how innovative developments of autonomous vehicles can help to overcome this challenge. While there are clear risks and benefits to autonomous vehicles, government regulation will play a large role in determining overall public safety.

Why Public Health Should Embrace the Autonomous Car
Article. Pettigrew S. Why Public Health Should Embrace the Autonomous Car. Australian and New Zealand Journal of Public Health 2017; 41: 5-7. DOI: https://doi.org/10.1111/1753-6405.12588.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12129
This article discusses the health-related outcomes that are likely to result from society's embrace of automated vehicles (AV), ranging from preventing vehicle accidents to limiting the impact of vehicles on climate change, promoting an inclusive society, and more. It looks at the investments that are being made by both industry and governments to enhance design and infrastructure that are required to implement AVs. The article articulates a role for public health in offering evidence-based recommendations to policy makers and the civil sector to ensure that the health-related, societal, and environmental impacts of AV are measured and monitored, and that the move to automation improves overall health and minimizes adverse outcomes.

Automation in Everyday Life
Report. Smith A, Anderson M. Automation in Everyday Life. Pew Research Center 2017.
http://www.pewinternet.org/2017/10/04/automation-in-everyday-life.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12141
This report from the Pew Research Center examines public sector response to automated technologies, including autonomous vehicles (AVs). Surveys conducted in May 2017, utilizing four different scenarios, found that a majority of Americans anticipate changes in their lives from the advancement of various automated technologies. Surveys found that more respondents expect positive outcomes but are concerned about the effects of technology on society overall.

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Autonomous Vehicle Technology: A Guide for Policymakers
Report. Anderson JM et al. Autonomous Vehicle Technology: A Guide for Policymakers. RAND Corporation 2016. http://www.rand.org/pubs/research_reports/RR443-2.html.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12138
This report from the RAND Corporation explores advances in automotive technology, particularly the emergence of autonomous vehicles, in order to guide policy decision-making. It dissects policy issues, communication, regulation, and liability issues surrounding the recent growth of "self-driving" vehicle technologies, and cautiously recommends that such technology be allowed and even encouraged once automated vehicles illustrate superior performance in comparison to a human driver.

The Social Dilemma of Autonomous Vehicles
Article. Bonnefon J et al. The Social Dilemma of Autonomous Vehicles. Science 2016; 352(6293): 1573-1576. DOI: https://doi.org/10.1126/science.aaf2654.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12132
This article from *Science* explores the social and ethical challenges of autonomous vehicles (AVs). The AV field faces significant difficulty in defining the algorithms that program AVs to make moral decisions, such as whether to sacrifice the passenger for the greater good or protect the passenger at all costs. Using six online surveys, the Amazon Mechanical Turk studies examined reactions to using utilitarian AVs compared to protective AVs. Public opinion and social pressure have proven that moral algorithms for building ethical AVs pose a significant challenge in artificial intelligence.

Estimating Potential Increases in Travel with Autonomous Vehicles for the Non-Driving, Elderly and People with Travel-Restrictive Medical Conditions
Article. Harper CD et al. Estimating Potential Increases in Travel with Autonomous Vehicles for the Non-Driving, Elderly and People with Travel-Restrictive Medical Conditions. Transportation Research Part C: Emerging Technologies 2016; 72: 1-9. DOI: https://doi.org/10.1016/j.trc.2016.09.003.
This article estimates the how much more mobility could be afforded to non-driving, elderly, and people with travel-restrictive medical conditions with the increase of autonomous vehicles. In particular, the authors' estimates also help identify which groups could have the greatest increase in annual vehicle miles traveled (VMT). Findings indicate non-drivers could increase miles travel by as much as nine percent, while drivers could increase vehicle miles traveled by as much as 2.6 percent.

Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability?
Report. Kalra N, Paddock SM. Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability? RAND Corporation 2016. https://www.rand.org/pubs/research_reports/RR1478.html.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12143
This report by the RAND Corporation discusses policy questions surrounding the safety of autonomous vehicles (AVs), such as how safe AVs should be before they are available for consumers, how safety is determined, and who determines safety. This report evaluates the feasibility of test-driving AVs to assess their safety before making them available to consumers, and explores how many miles would have to be driven without failure to determine a benchmark failure rate and how that can be compared to a human driver failure rate.

The Ethics of Accident-Algorithms for Self-Driving Cars: an Applied Trolley Problem?
Article. Nyholm S, Smids J. The Ethics of Accident-Algorithms for Self-Driving Cars: An Applied Trolley Problem? Ethical Theory and Moral Practice 2016; 19 (5): 1275-1289. DOI: https://doi.org/10.1007/s10677-016-9745-2.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12139
This article identifies complex ethical issues in the programming of self-driving cars. Although self-driving cars are seemingly safer than manually driven cars, collisions cannot be entirely avoided and the risks and challenges of accident scenarios must be considered. The authors compare the ethics of accident-algorithms with the so-called "trolley problem" thought experiment, identifying three key differences between them, which concern the basic decision-making situation of those who program the self-driving cars to deal with accidents, the issues of moral and legal responsibilities, and decision-making when there is uncertainty.

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Steering Autonomous Vehicle Policy: The Role of Public Health
Report. Richland J et al. Steering Autonomous Vehicle Policy: The Role of Public Health. Altarum Institute 2016. https://altarum.org/our-work/autonomous-vehicles-and-public-health.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12130
This report from the Altarum Institute examines policy issues related to the use of autonomous vehicles and how they will affect public health. It identifies research topics that can inform decision-making in public health, through interviews with a wide range of stakeholders, including public health professionals, industry representatives, researchers, and federal transport officials. Through an extensive literature review, this report explores potential public health harms and benefits to discuss the impact of autonomous vehicles on traffic safety, environmental emissions, land use, urban design, stress, mobility, and health equity.

Global Status Report on Road Safety 2015
Report. Global Status Report on Road Safety 2015. World Health Organization 2015. http://www.who.int/violence_injury_prevention/road_safety_status/2015/en.
GHELI repository link: http://repository.gheli.harvard.edu/repository/10991
This report from the World Health Organization provides a snapshot of the road safety situation globally, highlighting both progress and challenges. Reflecting information from 180 countries, the report indicates that worldwide the total number of road traffic deaths has plateaued at 1.25 million per year, with the highest road traffic fatality rates in low-income countries. While there has been progress toward improving road safety legislation and in making vehicles safer, the pace of change is too slow. Urgent action is needed to achieve the ambitious target for road safety reflected in the newly adopted 2030 Agenda for Sustainable Development, with its goal to reduce by half the global number of deaths and injuries from road traffic crashes by 2020. The report is accompanied by a brief summary, and sections are also available to access individually.

FACT SHEETS AND COUNTRY PROFILES

Autonomous Vehicles and Public Health
Fact Sheet. Autonomous Vehicles and Public Health. Altarum Institute 2018. https://altarum.org/our-work/autonomous-vehicles-and-public-health.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12133
This fact sheet from the Altarum Institute describes how transformational technological changes—such as self-driving cars, or autonomous vehicles (AVs)—can be accompanied by unintended consequences. AVs hold the potential to dramatically affect public health through increased vehicle safety, reduced environmental impact, improved land use and urban design, decreased stress related to traffic and congestion, and greater health equity. However, the factsheet also anticipates potential negative effects of AVs and suggests that the public health community be engaged as an influential voice in decision-making processes related to these emerging technologies.

Global Road Safety 2015: Country Profiles
Country Profiles. Global Status Report on Road Safety 2015: Country Profiles. World Health Organization 2015. http://www.who.int/violence_injury_prevention/road_safety_status/2015/country_profiles/country_profiles/en.
GHELI repository link: http://repository.gheli.harvard.edu/repository/11227
This web portal, offered by the World Health Organization (WHO), provides the country profiles accompanying *The Global Status Report on Road Safety 2015*. This report provides a snapshot of the road safety situation globally, highlighting both progress and challenges. Urgent action is needed to achieve the ambitious target for road safety reflected in the newly adopted 2030 Agenda for Sustainable Development: halving the global number of deaths and injuries from road traffic crashes by 2020. The report reflects information from 180 countries, documenting 1.25 million road traffic deaths per year, with the highest road traffic fatality rates in low-income countries. The companion country profiles are provided as a single set and as individual downloadable documents.

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NEWS AND BLOGS

The Government Is Pushing for Self-Driving Cars — but the Public May Not Be Ready for Them
News and Blogs. Barkenbus J. The Government Is Pushing for Self-Driving Cars — but the Public May Not Be Ready for Them. Business Insider 2018; Jan 6. http://www.businessinsider.com/the-public-may-not-be-ready-for-the-push-for-self-driving-cars-2018-1.
Every day about 100 people die in car crashes on U.S. roads. This death toll is a major reason why both Congress and the Trump administration are backing automotive efforts to develop and deploy self-driving cars as quickly as possible. However, the public does not share the same level of concern about road traffic fatalities, and many Americans are distrustful of or reluctant to adopt autonomous vehicles (AVs) that would radically alter their driving patterns. The author suggests that by taking an incremental approach to autonomous driving technologies, industry and government decision-makers may be able to avoid consumer backlash that could set back progress toward public health gains associated with AVs.

Self-Driving Cars 'Game Changing' for FBI… & ISIS
News and Blogs. Black J. Self Driving Cars 'Game Changing' for FBI… & ISIS. The Cipher Brief 2018; Jan 3. https://www.thecipherbrief.com/article/exclusive/international/self-driving-cars-game-changing-fbi-isis.
This news article explores the national security implications of self-driving cars. Although self-driving cars have the potential to reduce traffic fatalities, such vehicles could also be misused by terrorist groups for violent purposes. Concerns include using driverless cars for car bomb attacks, or hackers hijacking the vehicle navigation systems. On the other hand, driverless cars could revolutionize how law enforcement tackles terrorism—whether it is better tailing of suspects or coordinating vehicle responses. The article also reviews current legislation on the table to make all vehicles less vulnerable to hacking.

Self-Driving Uber Kills Arizona Woman in First Fatal Crash Involving Pedestrian
News and Blogs. Levin S, Wong JC. Self-Driving Uber Kills Arizona Woman in First Fatal Crash Involving Pedestrian. The Guardian 2018; Mar 19. https://www.theguardian.com/technology/2018/mar/19/uber-self-driving-car-kills-woman-arizona-tempe.
This article in *The Guardian* describes the context of the first fatal crash in the U.S. involving a self-driving vehicle and a pedestrian. According to Arizona police review of the crash footage, the car did not seem to slow down as it approached the pedestrian. The autonomous Uber car is part of the larger fleet that the company has been testing in different states; Uber had briefly suspended its cars in Arizona after another crash involving its vehicles. The experts interviewed in the article emphasize the need for better regulatory oversight of autonomous vehicle testing and involving the public sector in what has been a primarily private sector operation.

Public Health and the Ethics of Self-Driving Cars: Developing a Framework
News and Blogs. Batchelder S. Public Health and the Ethics of Self-Driving Cars: Developing a Framework. Healthify 2017; Aug 2. https://www.healthify.us/healthify-insights/public-health-and-the-ethics-of-self-driving-cars-developing-a-framework.
Motor vehicle fatalities and injuries pose an ongoing problem for the U.S. public health and health care systems. Motor vehicles are responsible for more than 30,000 deaths each year in the United States, and self-driving cars, or autonomous vehicles (AVs) have the potential to change this. This article advocates for including public health input in decision-making around the ethical issues in AV algorithm design, as well as input from communities that will be most impacted by self-driving cars.

Self-Driving Cars Could Make Moral Decisions like Humans with a Simple Algorithm
News and Blogs. Conroy G. Self-Driving Cars Could Make Moral Decisions like Humans with a Simple Algorithm. Science Alert 2017; Jul 6. https://www.sciencealert.com/self-driving-cars-may-soon-be-making-moral-decisions-like-humans.
This article discusses the findings of a research team that demonstrated that self-driving vehicles are capable of making ethical decisions on the road, just like human drivers. By studying human behavior in virtual reality-based trials, the team was able to capture this moral decision-making in the form of an algorithm, disproving the widely held assumption that modelling complex ethical choices was out of reach.

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Intel Proposes System to Make Self-Driving Cars Blameless
News and Blogs. King I. Intel Proposes System to Make Self-Driving Cars Blameless. Bloomberg News 2017; Oct 17. https://www.bloomberg.com/news/articles/2017-10-18/intel-proposes-system-to-make-self-driving-cars-blameless.
This article highlights Intel Corp's set of standards that the chip company believes will bring clarity to questions of liability and blame in driverless car accidents. This is part of an effort to develop an appropriate framework to address a potentially chaotic world where self-driving and human-driven vehicles coexist on the same roads. Intel leveraged accident information from the U.S. National Highway Traffic Safety Administration to develop mathematical models that create a measureable "safe state" for driverless cars.

Robot Cars and Fake Ethical Dilemmas
News and Blogs. Lin P. Robot Cars and Fake Ethical Dilemmas. Forbes 2017; Apr 3. https://www.forbes.com/sites/patricklin/2017/04/03/robot-cars-and-fake-ethical-dilemmas.
Many individuals believe that the questions the driverless car industry is testing—like whose life would the car algorithm save?—are fake ethical dilemmas. This opinion piece in *Forbes* first explores the rationale behind this point of view, before illustrating why ethical thought experiments can be useful, despite being overly simplistic—or perhaps precisely because of that.

Faster Rollout of Self-Driving Cars Would Save Lives
News and Blogs. Plungis J. Faster Rollout of Self-Driving Cars Would Save Lives, Study Says. Consumer Reports 2017; Nov 7. https://www.consumerreports.org/autonomous-driving/faster-rollout-self-driving-cars-would-save-lives.
This *Consumer Reports* article reviews a new study by the RAND Corporation indicating that slowing the introduction of self-driving cars will lead to thousands of preventable highway fatalities. That study compared three scenarios: Adopting self-driving cars when they are 10 percent better than human drivers, waiting until they are 75 percent better, and waiting until they are 90 percent better. The authors argue that introducing self-driving cars quickly, even when they are only a little better than human drivers, will save thousands of lives over the next 15 years.

Most Americans Don't Think Self-Driving Cars Are Safe
News and Blogs. Plungis J. Most Americans Don't Think Self-Driving Cars Are Safe. Consumer Reports 2017; Mar 7. https://www.consumerreports.org/autonomous-driving/americans-dont-think-self-driving-cars-safe.
While automakers are excited about the potential of driverless cars, most Americans believe that the self-driving cars are not safe, according a recent AAA survey. In particular, U.S. drivers don't believe that the underlying technologies work consistently enough to replace human drivers, and that advances in such technologies come at the cost of their own control of the vehicle. According to the survey, U.S. baby boomers were most likely to express fear of self-driving cars compared to millennials and Generation Xers.

Self-Driving Cars: Driving Into the Future
News and Blogs. Plungis J. Self-Driving Cars: Driving Into the Future. Consumer Reports 2017; Feb 28. https://www.consumerreports.org/autonomous-driving/self-driving-cars-driving-into-the-future.
Self-driving cars promise no crashes: To test this assumption, research teams across the country are putting car algorithms through a battery of tests. While most experts in the space agree that self-driving cars are 85 to 90 percent of the way to perfect, thorny issues still remain—perfecting sensors that allow cars to "see" in all weather conditions, addressing whether car companies designing the software will accept liability for any flaws, and untangling ethical decisions of whether the car occupant or pedestrian is saved first. The biggest technical hurdles that still remain include sensor technology, mapping, and software.

Autonomous Cars and Mathematical Traffic Models Could Improve Driving Fluidity
News and Blogs. Cheng M. Autonomous Cars and Mathematical Traffic Models Could Improve Driving Fluidity. FutureCar 2016; Nov 15. http://www.futurecar.com/article-425-1.html.
This article describes how self-driving cars can improve traffic flow by applying specific mathematical models that reduce road congestion and bottlenecks in traffic. One useful model is called the "queuing model," which is used to estimate waiting times and length of lines. Queuing models leverage principles such as First-in-First-Out (FIFO), Last-in-

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First-Out (LIFO), and Priority, while more complex traffic scenarios may require a grid model, which groups cars in grids with specific rules and criteria.

Whose Life Should Your Car Save
News and Blogs. Shariff A et al. Whose Life Should Your Car Save? The New York Times 2016; Nov 6. https://www.nytimes.com/2016/11/06/opinion/sunday/whose-life-should-your-car-save.html.
This opinion piece in *The New York Times* makes a case for the importance of understanding the psychological barriers facing trust in autonomous vehicles—specifically, how vehicle algorithms make decisions in unavoidable traffic accidents.

How Maths and Driverless Cars Could Spell the End of Traffic Jams
News and Blogs. Wilson L. How Maths and Driverless Cars Could Spell the End of Traffic Jams. The Conversation 2016; Aug 30. http://theconversation.com/how-maths-and-driverless-cars-could-spell-the-end-of-traffic-jams-63462.
This article in *The Conversation* argues that integrating driverless cars into mathematical traffic models will be essential to improving traffic jams. In addition to outlining current mathematical models for mapping movement and traffic density, the author describes how the predictability of driverless cars may actually make the mathematician's job in developing such models much easier, but that differing traffic-controlling software among manufacturers may make the effort to relieve long commutes more challenging.

Driverless Cars Are Colliding with the Creepy Trolley Problem
News and Blogs. Achenbach J. Driverless Cars Are Colliding with the Creepy Trolley Problem. The Washington Post 2015; Dec 29. https://www.washingtonpost.com/news/innovations/wp/2015/12/29/will-self-driving-cars-ever-solve-the-famous-and-creepy-trolley-problem.
In the ethical thought experiment known as the "trolley problem," a trolley is hurtling towards five people on a track. An observer can throw the switch to divert the trolley to a different track where only one person is standing. Should the observer throw the switch and reduce the death toll from five to one life? This *Washington Post* piece illustrates how the self-driving car industry must wrestle with this question while designing car algorithms, in addition to designing for the eccentricities of human drivers in other vehicles. Proponents of self-driving cars say that driverless car technology will help evade the "trolley problem" altogether, and still save more lives in the long run.

Self-Driving Cars Could Save 300,000 Lives per Decade in America
News and Blogs. Lafrance A. Self-Driving Cars Could Save 300,000 Lives Per Decade In America. The Atlantic 2015; Sep 29. https://www.theatlantic.com/technology/archive/2015/09/self-driving-cars-could-save-300000-lives-per-decade-in-america/407956.
This article in *The Atlantic* argues that if driverless cars successfully reduce the majority of fatal traffic accidents as promised, it will be a major public health achievement. According to estimates, driverless cars could reduce traffic fatalities by up to 90 percent—on par with the number of lives vaccines save each year. The article discusses potential obstacles during the transition to self-driving cars, as well as the underlying ethics of how the cars' algorithms are designed.

America's Unfair Rules of the Road: How Our Transportation System Discriminates against the Most Vulnerable
News and Blogs. Ramey C. America's Unfair Rules of the Road: How Our Transportation System Discriminates against the Most Vulnerable. Slate 2015; Feb 27. http://www.slate.com/articles/news_and_politics/politics/2015/02/america_s_transportation_system_discriminates_against_minorities_and_poor.html.
This *Slate* article highlights the ways in which the U.S. transportation system—how it was built and how it expands—disproportionately affects the health of America's vulnerable populations. For example, pollutants and other emissions from long-haul trucks hurt the health of neighborhoods closest to high-volume transit areas. In another example, most transportation planning processes lock out the communities most affected by the decisions, leading to ill-planned bus routes, environmental costs, and changed neighborhoods. Examining recent complaints by the Federal Highway Administration and Federal Transit Authority, the article also shows how new public transportation projects often serve those who own cars, at the expense of those who don't: historically, communities of color.

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ORGANIZATIONS AND TOPIC PORTALS

Automated Vehicles for Safety
Topic Portal. Automated Vehicles for Safety. National Highway Traffic Safety Administration. United States Department of Transportation. https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12140
This topic portal from the National Highway Traffic Safety Administration highlights current federal guidance and resources focused on Automated Driving Systems (ADS), which have the potential to reduce road crash fatalities and injuries. The portal provides a timeline of safety innovation in the U.S., explains types of automation levels, articulates the benefits of automation, answers frequently asked questions about ADS vehicles, and offers other relevant resources.

Google's Autonomous Vehicle
Topic Portal. Google's Autonomous Vehicle. http://googlesautonomousvehicle.weebly.com.
This portal provides an overview of Google's autonomous vehicle program, including information about technology and costs, current laws and policies, potential failures and liability, ethics, future policy and implications, and additional reading.

National Highway Traffic Safety Administration
Organization. National Highway Traffic Safety Administration. United States Department of Transportation. https://www.nhtsa.gov.
The National Highway Traffic Safety Administration (NHTSA) aims to save lives, prevent injuries, and reduce economic costs associated with road traffic accidents. As a federal agency, NHTSA regulates the safety of motor vehicles and related equipment through four arms: education, research, safety standards, and enforcement activity.

United States Department of Transportation
Organization. United States Department of Transportation. https://www.transportation.gov.
The United States Department of Transportation (DOT), established in 1966, oversees the American transportation system to ensure that it is fast, safe, efficient, accessible, and convenient. Areas of focus and oversight include automobiles, aviation, bicycles and pedestrians, public transit, pipelines, railroads, research, trucking, waterways, roadways, and bridges.

DATA PUBLICATIONS AND PORTALS

NHTSA Databases and Software
Data Portal. Databases and Software. National Highway Traffic Safety Administration. United States Department of Transportation. https://www.nhtsa.gov/research-data/databases-and-software.
This data portal from the National Highway Traffic Safety Administration (NHTSA) offers links to the NHTSA's several databases related to vehicle safety and testing. NHTSA's two research offices—the Office of Vehicle Safety Research and the Office of Behavioral Safety—study behavior and attitudes towards highway safety, with the goal of reducing injuries and fatalities. The Vehicle Crash Test Database host data on compliance crash testing and the New Car Assessment Program (NCAP). The Biomechanics Test Database hosts data for developing anthropomorphic test devices and injury criteria. These databases are critical in providing evidence-based research in motor vehicle safety and development.

Moral Machine
Data Interactive. Moral Machine. Scalable Cooperation, MIT Media Lab, Massachusetts Institute of Technology. http://moralmachine.mit.edu.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12142
This data interactive, developed at the Massachusetts Institute of Technology, presents scenarios depicting moral dilemmas and lets the user pick the outcome they believe to be more acceptable. Users can see how their responses

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compare to others and design their own moral dilemma scenarios. This platform is creating a crowd-sourced picture of human opinions about machine decision-making in morally challenging scenarios, and provides a platform to facilitate discussion around machine ethics and moral consequences.

Autonomous Vehicle Safety Scenario Explorer
Data Interactive. Autonomous Vehicle Safety Scenario Explorer. RAND Corporation 2017. https://www.rand.org/pubs/tools/TL279/tool.html.
This data interactive from the RAND Corporation explores how current choices in autonomous vehicle (AV) technology will affect the future of road safety. It allows users to create future scenarios and estimates the fatalities that would result from these choices compared with a future without AV technology. This interactive tool is helpful in helping policy-makers, the transportation industry, and the public to think about the long-term implications of AVs in road safety.

Initiative on Cities and Autonomous Vehicles
Data Interactive. Initiative on Cities and Autonomous Vehicles. Bloomberg Aspen Initiative on Cities and Autonomous Vehicles. Bloomberg.org Group 2017. https://avsincities.bloomberg.org.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12136
This data interactive, launched by the Bloomberg Aspen Initiative on Cities and Autonomous Vehicles, explores how cities around the world are preparing for and piloting autonomous vehicle (AV) initiatives. An interactive map allows cities to learn from one another about how to transition to AVs as technology advances. Data include information about policy and planning priorities, partners, pilot initiatives, lessons learned, and more.

Motorists' Preferences for Different Levels of Vehicle Automation
Data Publication. Schoettle B, Sivak M. Motorists' Preferences for Different Levels of Vehicle Automation. Sustainable Worldwide Transportation – The University of Michigan 2016.
http://www.umich.edu/~umtriswt/PDF/SWT-2016-8.pdf.
This data publication examines survey data from licensed U.S. drivers on public opinion, human factors, and safety of autonomous vehicles. Results found that completely self-driving vehicles were least preferred, with a high concern for safety reported, and that survey respondents still wanted to have the option of manually controlling autonomous cars. This survey has been repeated over two years and has shown the same general pattern of results, suggesting that public opinion has not drastically changed.

Self-Driving Cars are Coming, and the Technology Promises to Save Lives
Data Interactive. Wang U. Self-Driving Cars are Coming, and the Technology Promises to Save Lives. The Guardian 2015.
https://www.theguardian.com/technology/2015/dec/17/self-driving-cars-safety-future-interactive.
This data interactive illustrates how increased autonomous vehicle usage and decreased manual vehicle use could lead to less car crashes. It depicts what an accident-free future might look like through the year 2050.

MULTIMEDIA AND TEACHING MATERIALS

The Three Laws of Robotics
Video. Isaac Asimov: The Three Laws of Robotics. https://www.youtube.com/watch?v=AWJJnQybZlk.
In this short video, Isaac Asimov discusses three laws to govern the behavior of robots, which he first articulated in a 1942 short story. These laws are relevant to the current social and ethical discussions around autonomous vehicles. His three rules are:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given to it by human beings, except where such orders would conflict with the first law.
3. A robot must protect its own existence as long as such protection does not conflict with the first or second laws.

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Decision-Making for Autonomous Systems
Online Learning. Decision-Making for Autonomous Systems. ChalmersX, edX 2018. https://www.edx.org/course/decision-making-for-autonomous-systems.
This online learning course from ChalmersX teaches fundamental mathematical models for real-world problems, including decision-making surrounding autonomous vehicles (AVs). Advances in AV technology present ethical challenges with implications on both the individual and population levels. The course is taught by Samuel Jia Qing-Shan, associate professor at Chalmers University of Technology, a top engineering school that collaborates closely with the automotive industry.

Self-Driving Cars: Pros and Cons for the Public's Health
Online Learning. Self-Driving Cars: Pros and Cons for the Public's Health. The Forum. Harvard T.H. Chan School of Public Health 2018; May 4. https://theforum.sph.harvard.edu/events/self-driving-cars.
This webcast seminar from The Forum at the T.H. Chan School of Public Health examines the emergence of autonomous vehicle technology and its promise to revolutionize the automotive world, removing human error from driving, reshaping transport systems, and transforming the nation's roadway infrastructure. Expert panelists review current technology, long-term plans, and the risks and benefits of a driverless future, including the public health impacts on road traffic fatalities and vehicle-related air pollution. This Forum event is offered in partnership with NBC News Digital.

See also:

- Resource Pack: Driverless Cars and Public Health, Global Health Education and Learning Incubator at Harvard University

Case Study: Autonomous Cars
Lesson/Module. Case Study: Autonomous Cars. ICS 314: Software Engineering I. University of Hawai'i 2017. http://courses.ics.hawaii.edu/ReviewICS314/morea/ethics/experience-se-ethics-case-study-autonomous-cars.html.
This lesson, part of an ethics module in a software engineering course offered at the University of Hawai'i, examines the algorithms underlying autonomous cars, and the significant ethical dilemmas surrounding unavoidable accidents. The lesson offers discussion questions and links to relevant resources.

TED Collection: Driverless Cars
Videos. TED Collection: Driverless Cars. TED 2017. https://www.ted.com/topics/driverless+cars.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12135
This collection of 10 videos, curated by TED, examines some of the issues and challenges related to driverless cars. Speakers explore the ethics of autonomous vehicles, discuss the technology of artificial intelligence, and imagine a driverless future. Videos include:

- What AI is — and Isn't (Sebastian Thrun and Chris Anderson, 2017) – 24:21
- What Moral Decisions Should Driverless Cars Make? (Iyad Rahwan, 2017) – 13:35
- How AI Can Bring on a Second Industrial Revolution (Kevin Kelly, 2016) – 13:44
- What a Driverless World Could Look Like (Wanis Kabbaj, 2016) – 11:31
- Uber's Plan to Get More People into Fewer Cars (Travis Kalanick, 2016) – 9:18
- How a Driverless Car Sees the Road (Chris Urmson, 2015) – 15:29
- If Cars Could Talk, Accidents Might be Avoidable (Jennifer Healey, 2013) – 9:00
- The Future Race Car — 150mph, and No Driver (Chris Gerdes, 2012) – 10:47
- A Future Beyond Traffic Gridlock (Bill Ford, 2011) – 16:48
- Google's Driverless Car (Sebastian Thrun, 2011) – 4:14

The following descriptions are drawn from the *TED Collection: Driverless Cars* video pages:

Video (24:21). Thrun S, Anderson C. What AI Is – and Isn't. TED2017 2017. https://www.ted.com/talks/sebastian_thrun_and_chris_anderson_the_new_generation_of_computers_is_programming_itself.
Educator and entrepreneur Sebastian Thrun wants us to use AI to free humanity of repetitive work and unleash our creativity. In an inspiring, informative conversation with TED Curator Chris Anderson, Thrun discusses the progress of deep learning, why we shouldn't fear runaway AI and how society will be better off if dull, tedious work is done with the help of machines. "Only one percent of interesting things have been invented yet," Thrun says. "I believe all of us are insanely creative ... [AI] will empower us to turn creativity into action."

Video (13:35). Rahwan I. What Moral Decisions Should Driverless Cars Make? TEDx Cambridge 2016. https://www.ted.com/talks/iyad_rahwan_what_moral_decisions_should_driverless_cars_make.
Should your driverless car kill you if it means saving five pedestrians? In this primer on the social dilemmas of driverless cars, Iyad Rahwan explores how the technology will challenge our morality and explains his work collecting data from real people on the ethical trade-offs we're willing (and not willing) to make.

Video (13:44). Kelly K. How AI Can Bring on a Second Industrial Revolution. TEDSummit 2016. https://www.ted.com/talks/kevin_kelly_how_ai_can_bring_on_a_second_industrial_revolution.
"The actual path of a raindrop as it goes down the valley is unpredictable, but the general direction is inevitable," says digital visionary Kevin Kelly -- and technology is much the same, driven by patterns that are surprising but inevitable. Over the next 20 years, he says, our penchant for making things smarter and smarter will have a profound impact on nearly everything we do. Kelly explores three trends in AI we need to understand in order to embrace it and steer its development. "The most popular AI product 20 years from now that everyone uses has not been invented yet," Kelly says. "That means that you're not late."

Video (11:31). Kabbaj W. What a Driverless World Could Look Like. TED@UPS 2016. https://www.ted.com/talks/wanis_kabbaj_what_a_driverless_world_could_look_like.
What if traffic flowed through our streets as smoothly and efficiently as blood flows through our veins? Transportation geek Wanis Kabbaj thinks we can find inspiration in the genius of our biology to design the transit systems of the future. In this forward-thinking talk, preview exciting concepts like modular, detachable buses, flying taxis and networks of suspended magnetic pods that could help make the dream of a dynamic, driverless world into a reality.

Video (19:18). Kalanick T. Uber's Plan to Get More People into Fewer Cars. TED2016 2016. https://www.ted.com/talks/chris_urmson_how_a_driverless_car_sees_the_road.
Uber didn't start out with grand ambitions to cut congestion and pollution. But as the company took off, co-founder Travis Kalanick wondered if there was a way to get people using Uber along the same routes to share rides, reducing costs and carbon footprint along the way. The result: uberPOOL, the company's carpooling service, which in its first eight months took 7.9 million miles off the roads and 1,400 metric tons of carbon dioxide out of the air in Los Angeles. Now, Kalanick says carpooling could work for commuters in the suburbs, too. "With the technology in our pockets today, and a little smart regulation," he says, "we can turn every car into a shared car, and we can reclaim our cities starting today."

Video (15:29). Urmson C. How a Driverless Car Sees the Road. TED2015 2015. https://www.ted.com/talks/chris_urmson_how_a_driverless_car_sees_the_road.
Statistically, the least reliable part of the car is ... the driver. In 2015, Chris Urmson was head of Google's driverless car program, one of several efforts to remove humans from the driver's seat. He shares fascinating footage that shows how the car sees the road and makes autonomous decisions about what to do next.

Video (9:00). Healey J. If Cars Could Talk, Accidents Might Be Avoidable. TED@Intel 2013. https://www.ted.com/talks/jennifer_healey_if_cars_could_talk_accidents_might_be_avoidable.
When we drive, we get into a glass bubble, lock the doors and press the accelerator, relying on our eyes to guide us – even though we can only see the few cars ahead of and behind us. But what if cars could share data with each

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other about their position and velocity, and use predictive models to calculate the safest routes for everyone on the road? Jennifer Healey imagines a world without car accidents.

Video (10:47). Gerdes C. The Future Race Car—150mph, and No Driver. TEDxStanford 2012. https://www.ted.com/talks/chris_gerdes_the_future_race_car_150mph_and_no_driver.
Autonomous cars are coming – and they're going to drive better than you. Chris Gerdes reveals how he and his team are developing robotic race cars that can drive at 150 mph while avoiding every possible accident. And yet, in studying the brainwaves of professional racing drivers, Gerdes says he has gained a new appreciation for the instincts of professional drivers.

Video (16:48). Ford B. A Future Beyond Traffic Gridlock. TED2011 2011. https://www.ted.com/talks/bill_ford_a_future_beyond_traffic_gridlock.
Bill Ford is a car guy – his great-grandfather was Henry Ford, and he grew up inside the massive Ford Motor Co. So when he worries about cars' impact on the environment, and about our growing global gridlock problem, it's worth a listen. His vision for the future of mobility includes "smart roads," even smarter public transport and going green like never before.

Video (4:14). Thrun S. Google's Driverless Car. TED2011 2011. https://www.ted.com/talks/sebastian_thrun_google_s_driverless_car.
Sebastian Thrun helped build Google's amazing driverless car, powered by a very personal quest to save lives and reduce traffic accidents. Jawdropping video shows the DARPA Challenge-winning car motoring through busy city traffic with no one behind the wheel, and dramatic test drive footage from TED2011 demonstrates how fast the thing can really go.

4 Thought-Provoking Questions to Spark Conversation
Online Learning. Rawls NP. 4 Thought-Provoking Questions to Spark Conversation. TED 2017. https://ideas.ted.com/4-thought-provoking-questions-to-spark-conversation.
This online learning article from TED poses four ethical questions related to current technological innovations, with embedded TED Talks linked to each. The questions are intended to provoke discussion around the near future of technology and how it can affect society overall, and include:

1. If you could upload your brain to a computer, would you do it?
2. Should parents be able to edit their babies' genes?
3. Should a driverless car kill its passenger to save five strangers?
4. What morals should we program into intelligent machines?

What Moral Decisions Should Driverless Cars Make?
Video. Rahwan I. What Moral Decisions Should Driverless Cars Make? TEDx Cambridge 2016. https://www.ted.com/talks/iyad_rahwan_what_moral_decisions_should_driverless_cars_make.
GHELI repository link: http://repository.gheli.harvard.edu/repository/12134
This video from TEDx discusses the social and moral dilemmas posed by autonomous vehicle technology. It examines how technology can challenge our current morality, and showcases data to illustrate the ethical trade-offs that people are willing to make.

Hands Off the Wheel
Video. Whitaker B. Hands Off the Wheel. 60 Minutes. CBS Interactive 2015; Dec 6. https://www.cbsnews.com/news/self-driving-cars-google-mercedes-benz-60-minutes-bill-whitaker.
This episode of *60 Minutes*, featuring CBS correspondent Bill Whitaker, shows a self-driving car in action in Silicon Valley, and describes how driverless cars have developed.

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Driverless Car

Interactive Simulation. Driverless Car. CK-12 Foundation 2014.
https://interactives.ck12.org/simulations/physics/driverless-car/app/index.html.
This interactive simulation, designed for high-school physics students, illustrates how self-driving cars work and how they are able to get from point A to point B. Students learn how to add two vectors together by components in the context of a GPS-style city map, choosing the magnitude and angles of vectors within the simulation in order to explore the vertical and horizontal components of how a driverless car navigates.

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