Sex/gender differences as determinants of quality, and benefits, of science knowledge

Information for researchers

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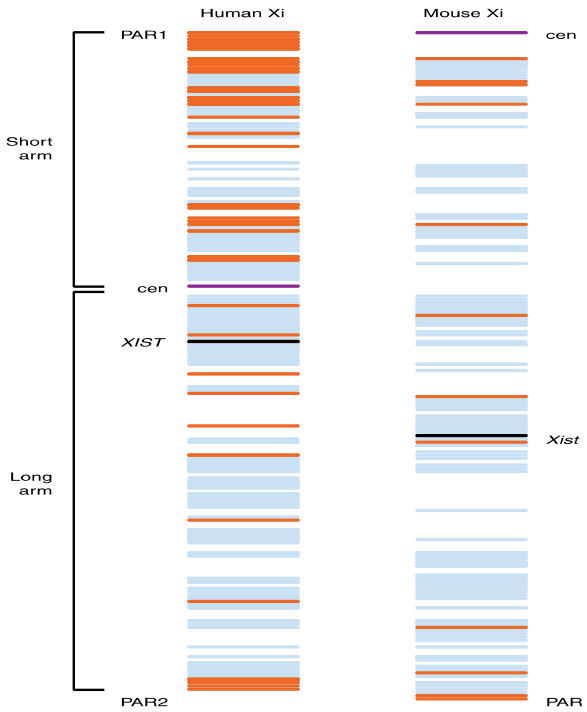
Background

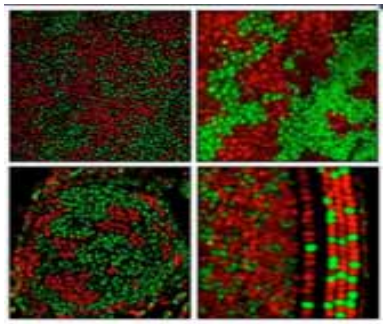
- Sex/gender differences arise from biology/sex (e.g. genetic composition), and/or psychosocial and cultural influences/gender (e.g. normative gender roles), and/or exposure to (harmful) physical environment (e.g. natural or synthetic toxic chemicals, famine). We can't change our biology, though the environment can (e.g. gene mutations). Most of the time we can/could change the effects of the sociocultural conditioning (i.e. gender stereotypes), and of environment (e.g. avoid unnecessary exposure to radiation)
- There has been resistance among scientists in accepting that sex/gender differences influence research results. Many prefer to believe that 'science is gender neutral'. But evidence shows this neutrality is an illusion that hides male gender bias.
- Many past studies have relied on the use of males as research subjects, or have included more males than females in experiments. This means that male has becomes the 'norm', and that science has more evidence for men than for women, which means that research outcomes can be often worse for women. Sometimes, the reverse is true, e.g. breast cancer.
- Researchers have also often failed to analyse data and to report results disaggregated by sex. This limits their usefulness in meta analysis and systematic review studies
- Any gender bias in science knowledge will be transferred into technological innovation products (e.g. poorer safety for women) and design of intervention measures to tackle societal challenges (e.g. vaccination strategies). For this reason, it is important to conduct gender analysis as part of the research process.

Why and how males and females are different

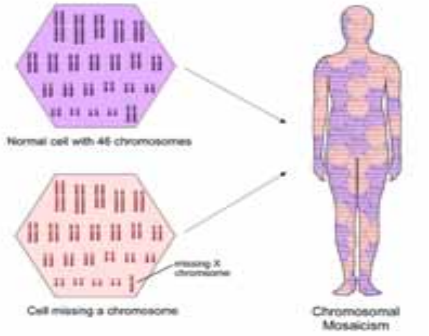
The fundamental sources of sex differences are sex chromosomes, their genes, how they are expressed and interact with genes located on other chromosomes. i.e. differences are not just about developmental and hormonal conditions



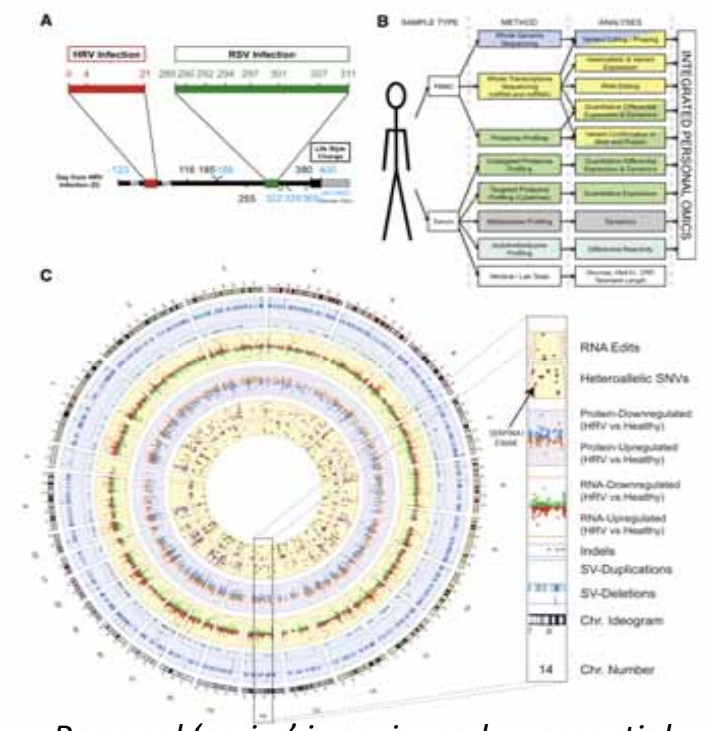
X inactivation in female mice and women: almost complete in mice; ~15 - 25% left active in human females. This means that women have more X active genes than men, which may explain why they suffer more autoimmune diseases for example. It also means that the mice model may not be fully representative of what happens in women (Berletch, J.B)



X inactivation is not random, this means cells in the same organ in a woman may function differently. This makes women much more interesting than men as research subjects



Since women have XX they may be protected from mutations on an X, if it affects only one of the two Xs

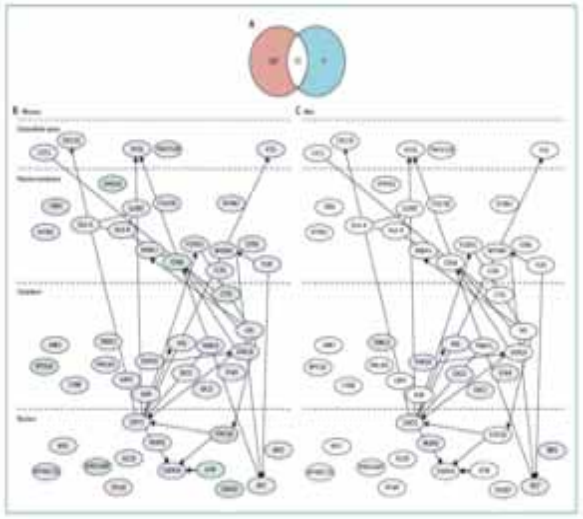


Personal 'omics' is envisaged as essential to personalised medicine. It was thought that sex chromosome were not involved in the expression of genes on the other chromosomes. New studies show, however, presence of shared activity during transcription and interdependency between many genes located on the sex and on other chromosomes, i.e. the expression of hundreds of autosomal genes is sensitive to sex chromosome complement

Thoughts to keep in mind

- The fact that 15%-25% of genes on the second X chromosome in women are not silenced has been suggested as a possible explanation for sex differences in health, e.g. autoimmune diseases.
- Vast majority of epidemiological and clinical trials conducted over the past 30 years have reported results only in one sex/gender or underreported role of sex differences
- Studies that underrepresent females, or those that ignore sexual dimorphism at basic biological level can lead to worse outcomes for women, e.g. of the 10 prescription drugs withdrawn from the market in the USA during 1997-2000, 8 were more dangerous for women (which has several important socioeconomic consequences)

Understanding sex and gender differences and interactions can help achieve cross cutting benefits, e.g. from biochemistry of immune response to sex/gender sensitive vaccines and vaccination strategies

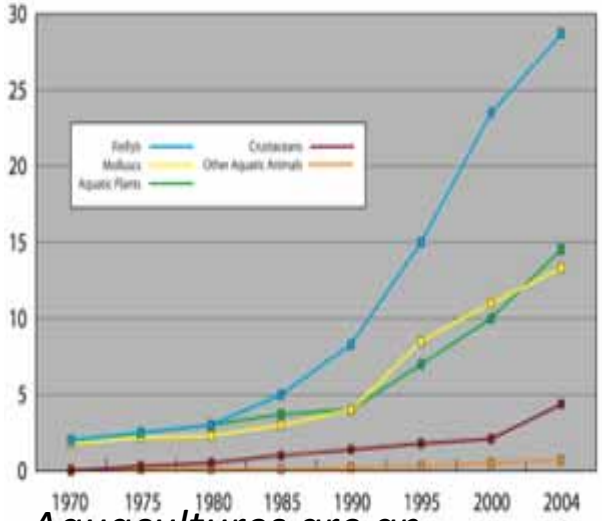


Women mount much stronger immune response to viral vaccinations than men do. They need less vaccine then men. Pregnancy is also a critical influence in vaccine efficacy that needs further study. This requires change in vaccine design and in public health vaccination programmes

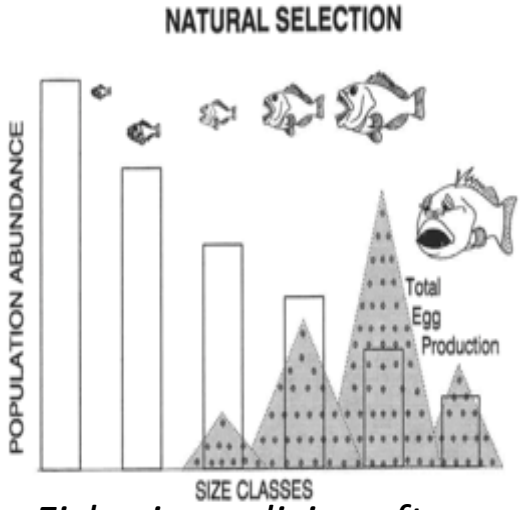
Protecting the cared for and the careers from infectious disease transmission in epidemics. During the Ebola virus epidemic women suffered more than men because they were exposed to more virus than the men, this related to their caring role at home, as health workers in hospitals, and in their role in community as responsible for taking care of the dead.

Human Papilloma Virus vaccinations benefit boys and girls. In many countries the vaccination is only given to girls to protect them from cervical cancer but the virus causes many other cancers that affect boys too, so in some countries it is given to both girls and boys. Despite an effective vaccine being licensed in 2006, it was approved for girls in China and endorsed for boys in the USA only in July 2016..

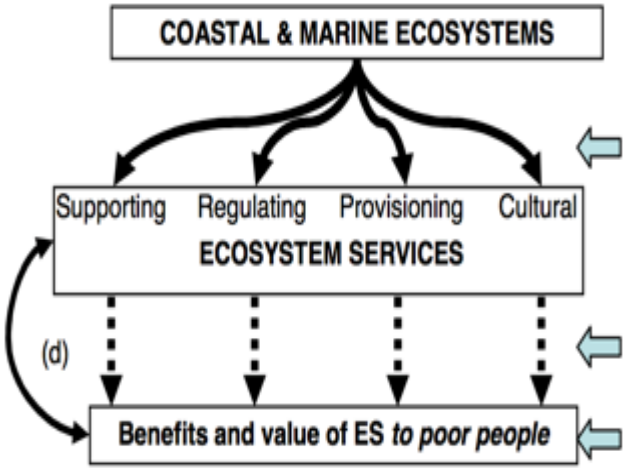
Understanding sex/gender differences may also apply to any species that reproduces sexually, with cross cutting benefits for protecting natural ecosystems and improving methods of food production



Aquacultures are an important source of food. Consumption of fish has key nutritional benefits. In some fish species males grow faster (Tilapia) in others it is the females (Turbot). Effective managing and controlling reproduction and sexual maturation of fish in fisheries is important, but currently often involves the use of hormones.

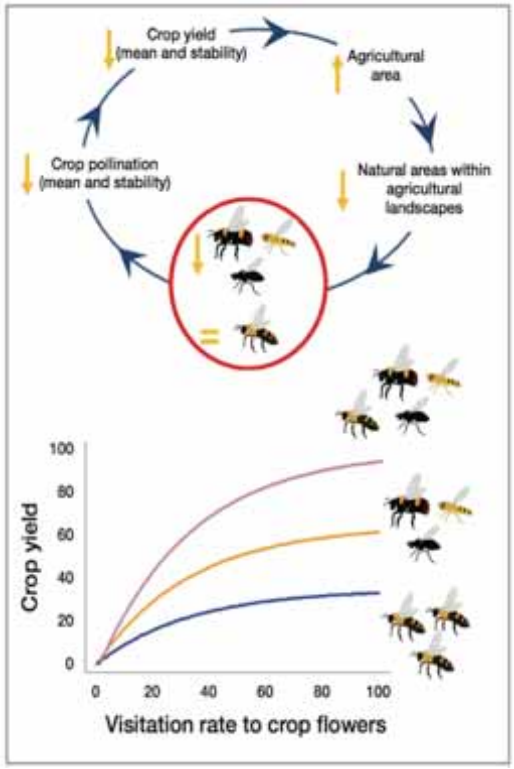


Fisheries policies often advise to take out 'old' fish and leave the young behind in the sea. But recent study shows that old female fish produce lots of high quality eggs. This is important for effective management of fish stocks, and necessary for protecting marine biodiversity



Natural marine ecosystems provide a range of services, in which women may play an important role e.g. processing of fish, or harvesting sea weed. Intensive farming of prawns has been shown to destroy mangroves and with it the ecosystem. Male prawns can grow 60% bigger than females. Gene silencing has been used to produce just males. Such ways of increasing productivity could help protect marine environment by enabling less water systems to be used for farming.

Understanding sex/gender issues in plant reproduction and their influence on resilience and yields of crops can improve food security, and protect biodiversity

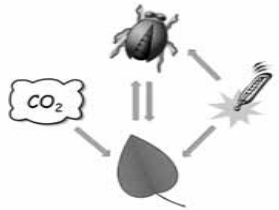


Pollinators improve yields and quality of plant food – knowing how plants attract pollinators can improve these effects – beekeeping as source of income for women farmers, e.g. bees tend to visit male flowers in the morning and female flowers in the evening

Sex determination in flowering food plants has to wait until the plant flowers. In the multi-use kokum tree the distinction between male and female plants can not be done until it flowers at 10-12 years.

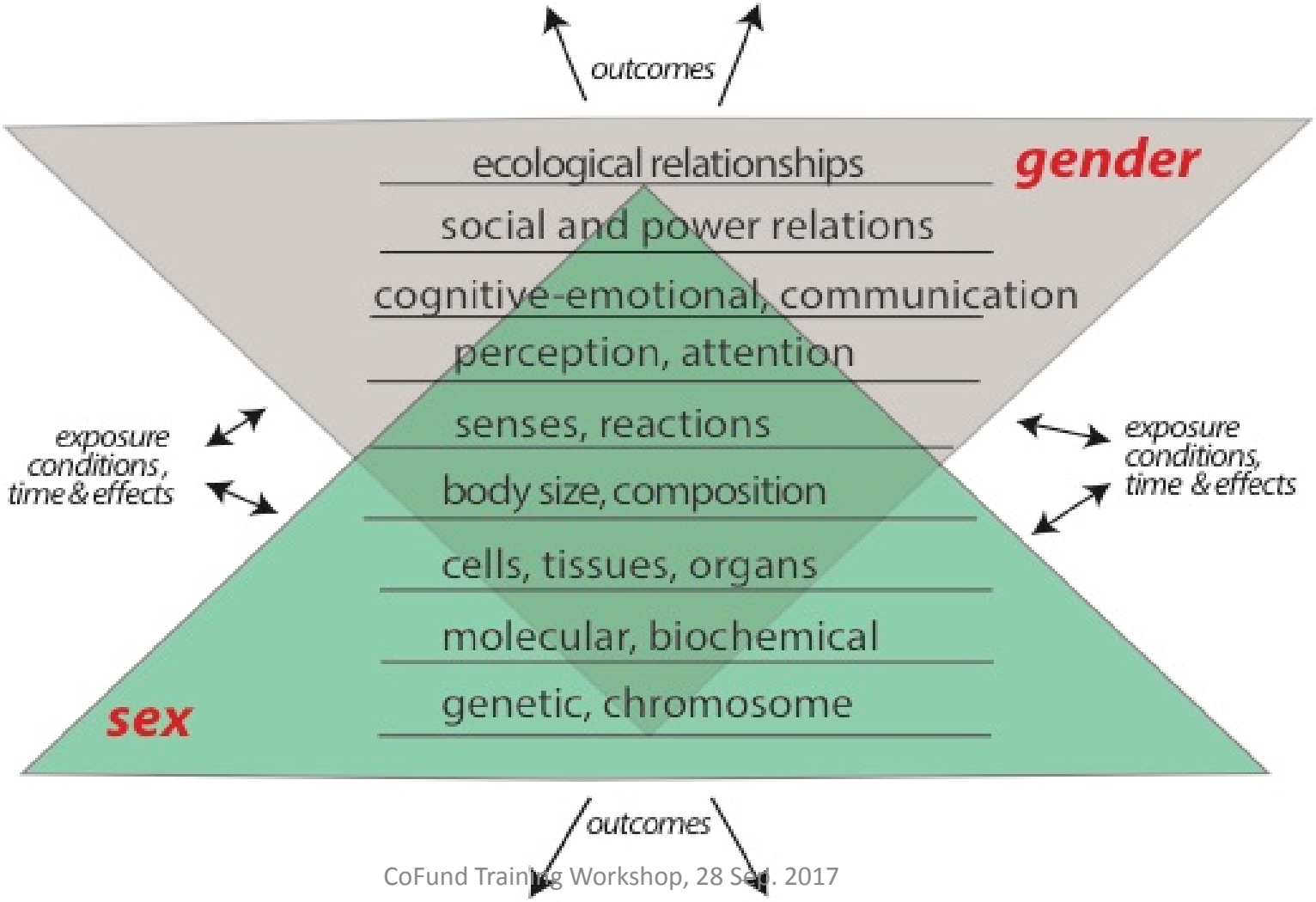
Understanding pathogen resistance of male and female flowers help maintain healthy crops.

Hybrid maize gives higher yields and is produced by crossing two different parental lines. This is done by de-tasseling the female parent to ensure that it would outcross with the pollen provided by a different plant. A bioengineering solution avoided this step but resulted in a plant that was more prone to viruses



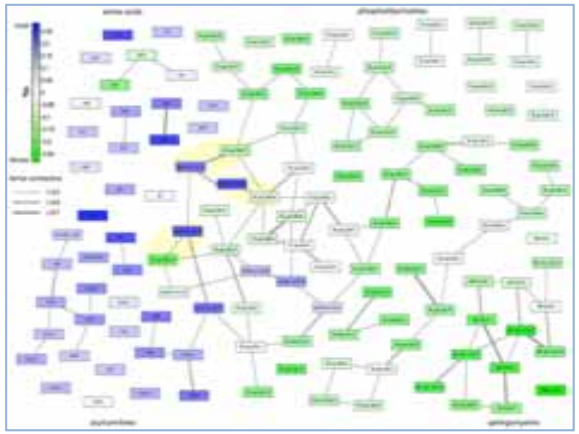
Climate change increases CO2 levels, which impacts on the metabolism of plants and insects and their interactions including reproduction

Summary: sex and gender differences can operate at different levels, influence results independently, or in interaction with each other, and with the environment

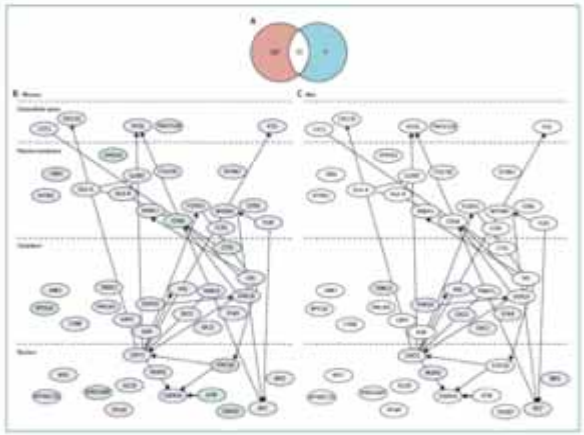


Some examples of the evidence showing sex/gender differences

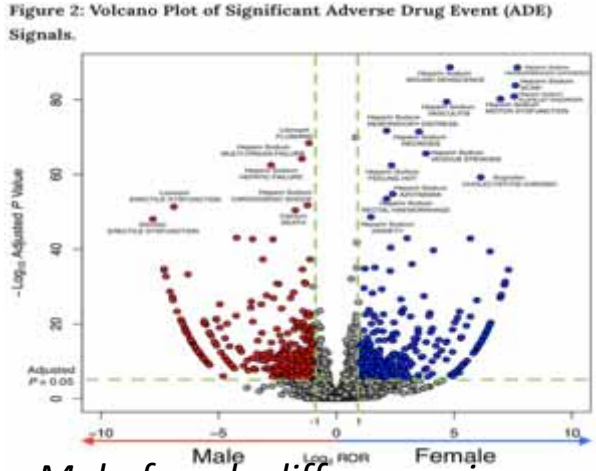
Example 1: some sex differences in women and men at biochemical level



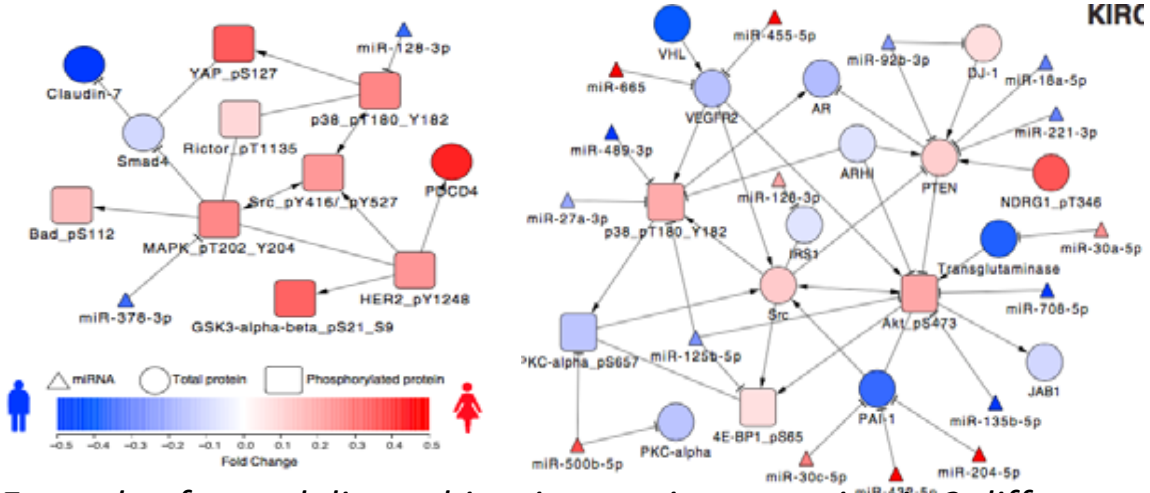
Metabolic profiles of women and men are different important for biomarkers (K. Mittlestrass)



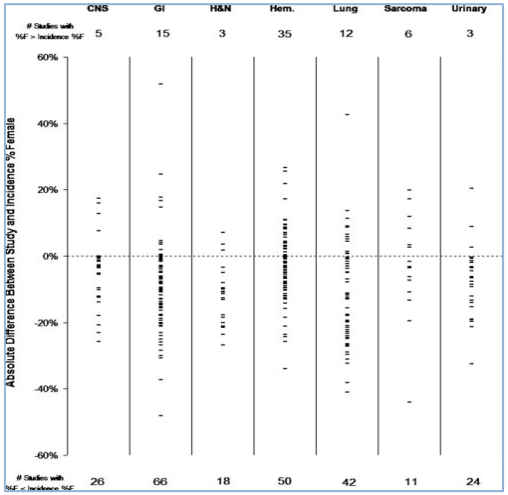
Immune response to vaccines differs between women and men: women mount much stronger response so need less vaccine (S.Klein)



Male-female differences in adverse effects of drug treatments are found in half of common treatments (Yue, Y.)

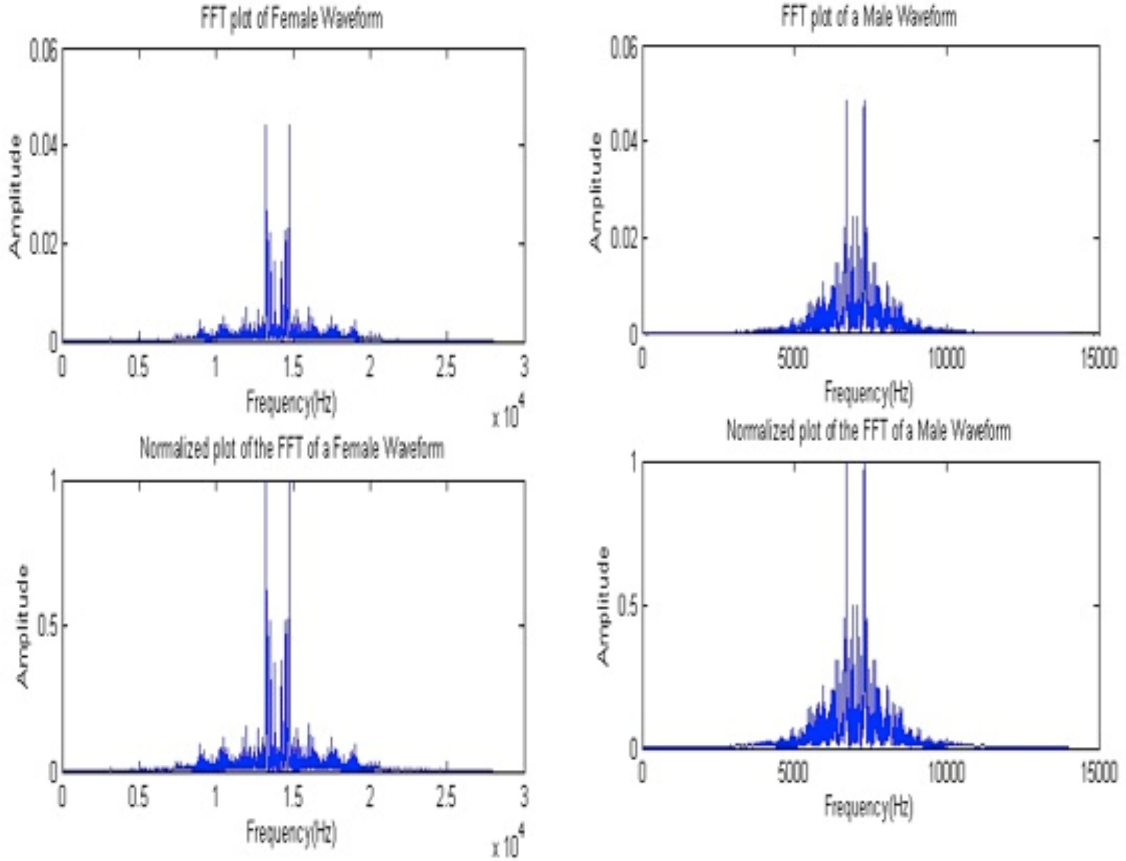


*Example of sexual dimorphism in protein expression in 2 different cancer types, **also found in other cancers** (Pellegrini, P.)*

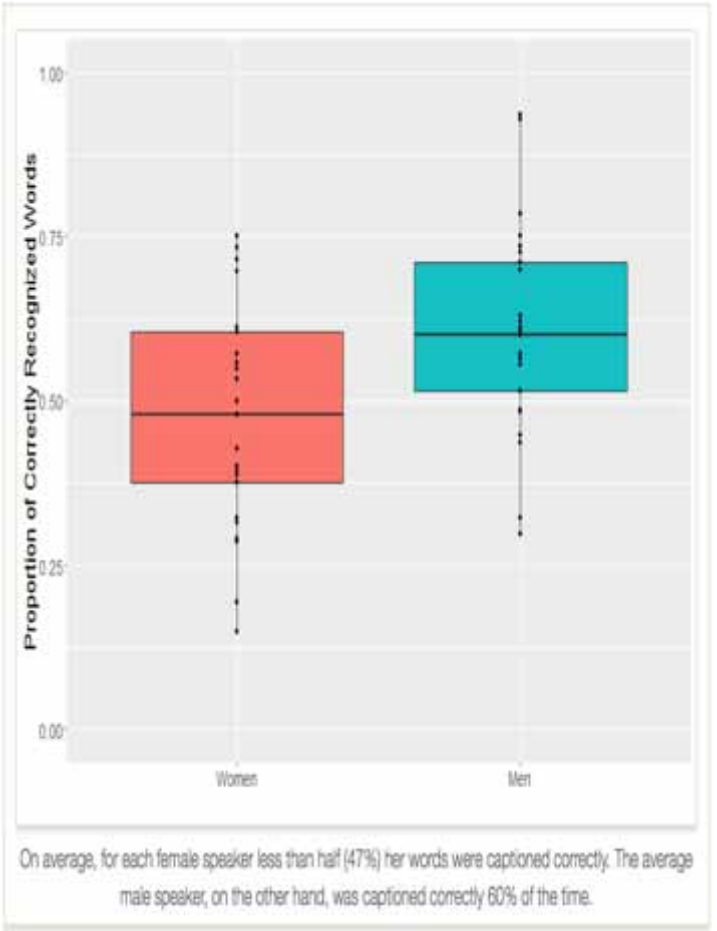


Cancer studies: more male than female subjects in 70% of cases (Jagsi,R)

Example 2: sex differences in voice/speech characteristics of women and men at <u>biophysical level</u>



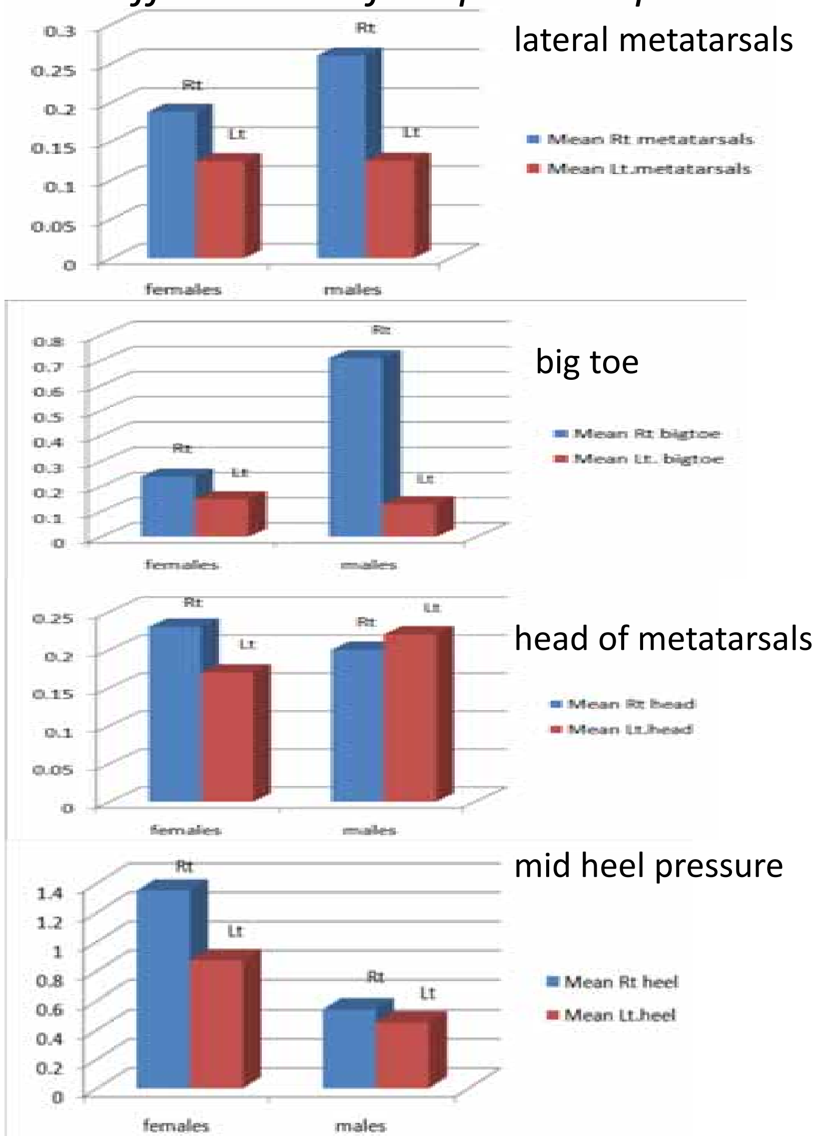
Men and women have different voice frequency and tone. In medical applications of automatic speech recognition reports generated with ASR are associated with higher error rates than reports generated with conventional dictation transcription. Data showed that breast imaging reports generated with ASR are 8 times as likely as reports generated with convention- al dictation transcription to contain major errors. (Basma, S)

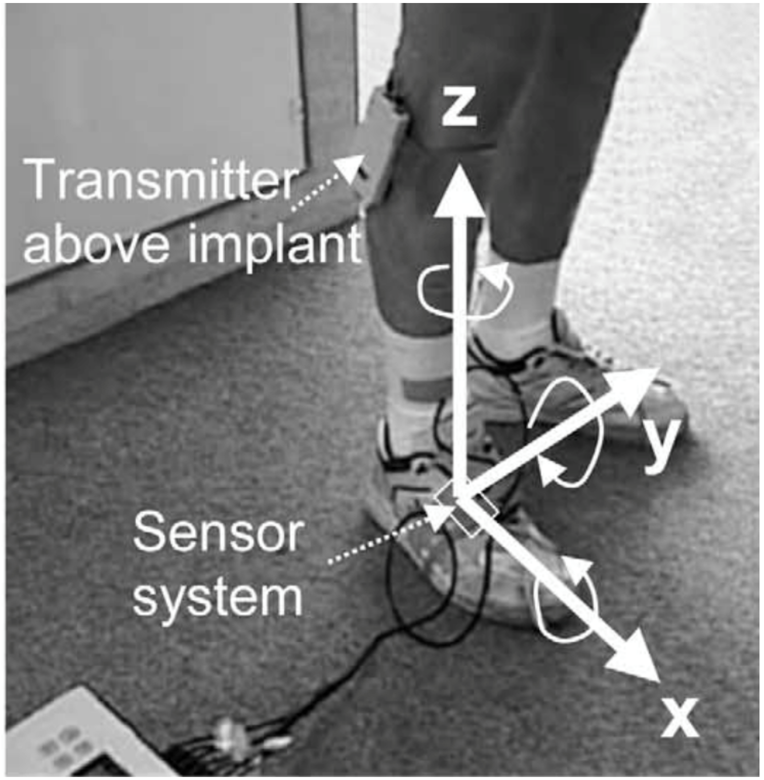


Voice recognition with Google

Example 3: sex differences in biomechanical response of muscles to mechanical forces

Sex differences in foot pressure points





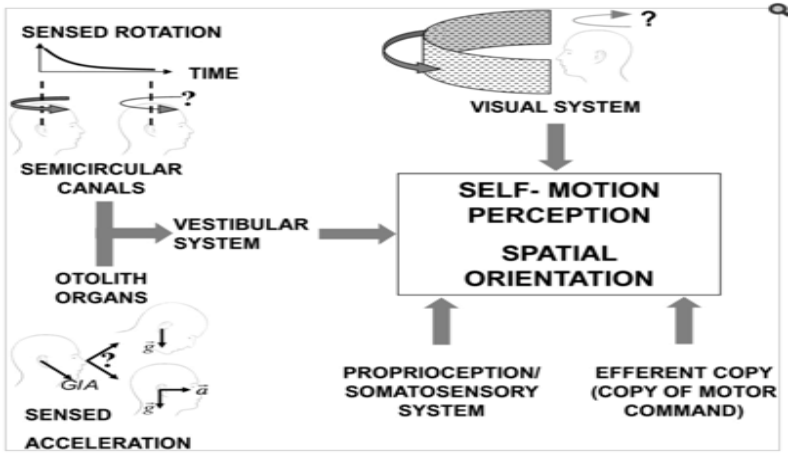
3D inertial sensors for automated balancing systems could help stroke patients. (Stroke occurs more often in women than in men).

https://www.xsens.com/images/stories/PDF/Xsens_MedicalEngineering_Physics_2003.pdf

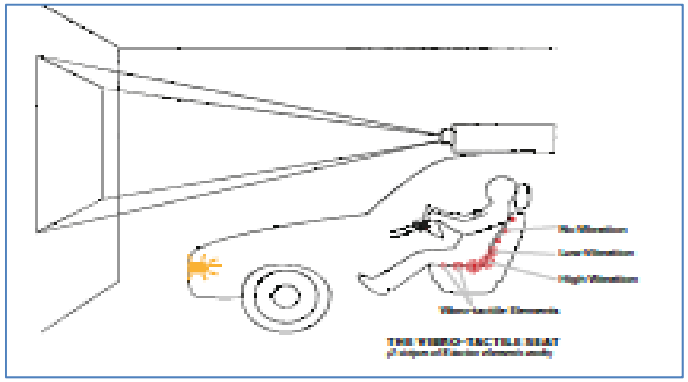
American Journal of Biomedical Engineering 2014, 4(1): 1-9 DOI: 10.5923/j.ajbe.20140401.01

Example 4: sex differences between women and men at perceptual and sensory level

Women are more susceptible to motion sickness than men when using VR. They are generally better than men in picking up visual cues



A model of perception, cognition and behaviour when interacting with VR



Men are faster in responding to perceptual cues but women are better in recognising cues

Male-female differences in the amount of force that will be required to perform a task when wearing a glove: women will need to make extra effort with the same glove

Example 5: sex/gender differences between women and men at cognitive level

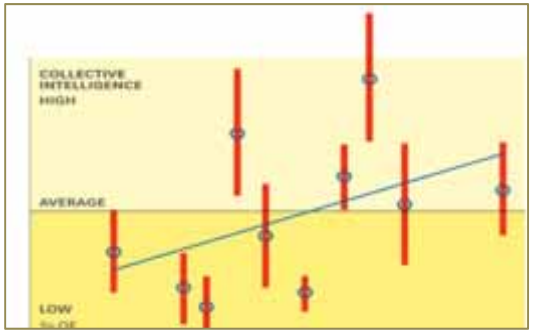
Dunbar, 2013. No difference in neuronal response: context determines differences.

No difference when experiments go according to plan but when things go unexpectedly wrong there are ***differences in the problem solving*** *strategies preferred by women and men.*

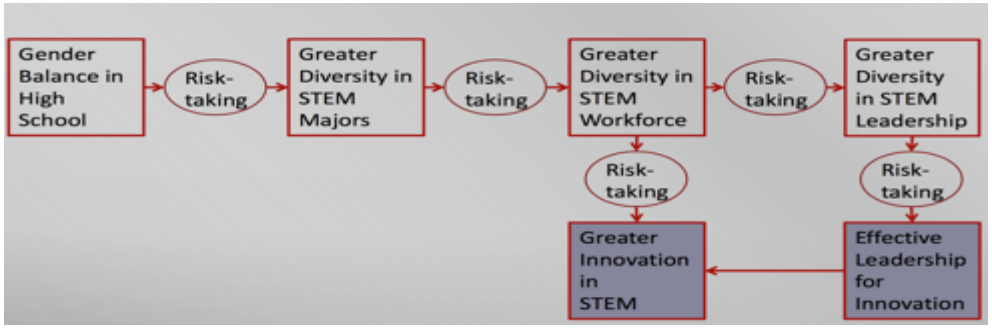
	Unknown	Method	Mistake	New Hyp
Women	38%	38%	10%	14%
Men	73%	22%	5%	0%

	Replicate	Analyze	New Method	Abandon	Continue
Women	15%	40%	26%	19%	0%
Men	0%	27%	50%	14%	9%

Williams Woolley, 2010. Gender balance in teams improves the team's ***collective intelligence.*** *Study of 192 teams showed that teams with more women tended to perform above average score and those with more men below it.*



Jeppesen, 2009. A study of 1200 solvers showed that female solvers – known to be in the "outer circle" of the scientific establishment - performed significantly better than men in developing ***successful solutions****.*



Byrnes et al, 1999. ***Males take more risks*** *even when it is clear that it is a bad idea to take a risk. The same analysis shows the* ***opposite is true for women*** *and girls. This means that women experience success less than they should. Risk taking is a learned behaviour, so women's behaviour can be changed.*

Thoughts to keep in mind

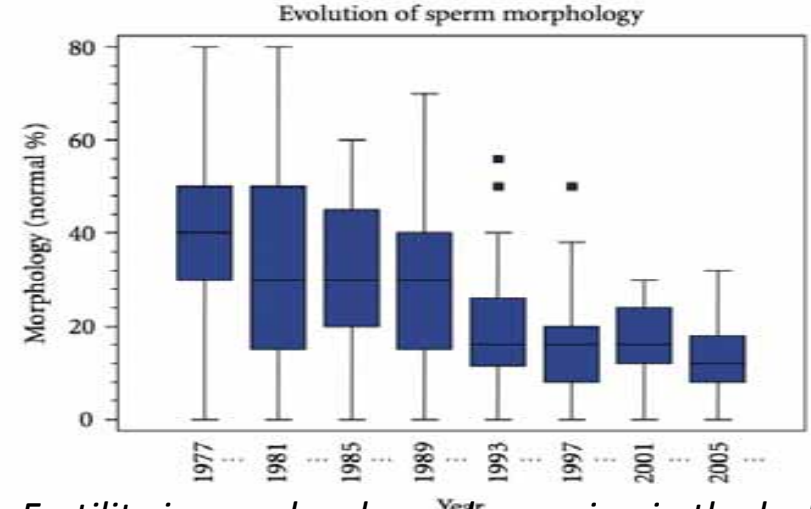
- It matters ‘who is in the lab’. Gender balance improves communication, idea creation, ensures better analysis of results, and recognitions of (all) user(s) needs
- It is not abut whether women or men are intellectually more superior in any area but about recognising that they have different problem solving styles, attitudes to risk, and bring different experiences to understand the problem
- Wikipedia lists around 150 cognitive biases, therefore diversity helps dilute the effects of cognitive bias on decisions (e.g. homophily – preferring to associate with those who are like ourselves, or confirmation bias)
- Gender balance in a team helps overcome gender stereotypes, and any inequalities based on societal normative gender stereotypes, and gender socializations

Example 6: sex/gender differences between women and men in response to (adverse) physical environment

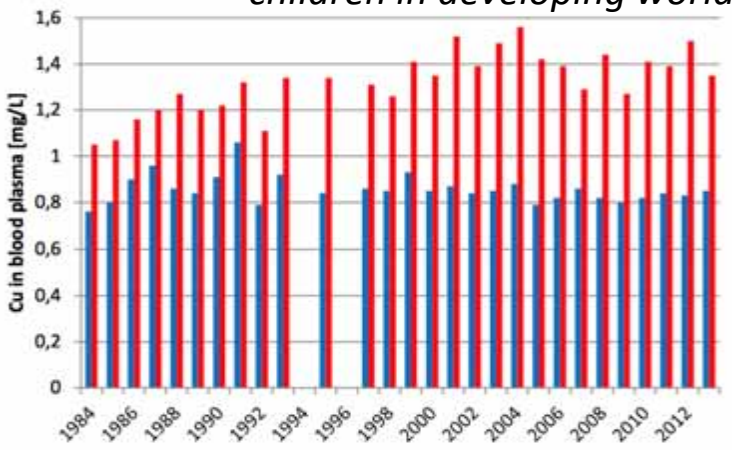
Endocrine disruptors, lead, mercury, and arsenic affect development of boys and girls differently (Butter, 2006)

Altered sex ratio after exposure to dioxin (Mocarelli, 1991.

Indoor pollution from primitive stoves is a big health risk for women and children in developing world



Fertility in men has been decreasing in the last decades (in developed countries). One proposed reason: quality of sperm may be affected by exposure to pollutants (e.g. dioxin) (De Coster, 2012)



Women have higher levels of copper in blood than men (linked to contraceptives?) Women are also more exposed to household cleaning chemical and suffer chemical allergies more (Kolossa, 2015).

Thoughts to keep in mind

- Historically, studies of toxicity depended on the use of male animals
- Most environmental standards are based on animal data only. These data are extrapolated to humans, with a safety factor of 100 to allow for differences between humans and test animals and for differences within the human population at large.
- Men and women are affected differently by micro-pollutants, and women are often the stronger sex. Micro-pollutants are primarily a threat to fertility, foetuses and small children.
- Approximately 500 chemicals that have been tested on rats by a federal agency (NTP) in the USA, resulted in 69 per cent more tumours among the male rats than among the female rats.
- Environment can impact on basic biological functioning, but also depends on gender, e.g. the effects of pollutants experienced by working women in the very early stages of pregnancy may result in a child's learning difficulties, which later may be wrongly attributed to social conditions, such as poverty.

Example 7: sex/gender differences between women and men in the effects of exposure to harmful environment

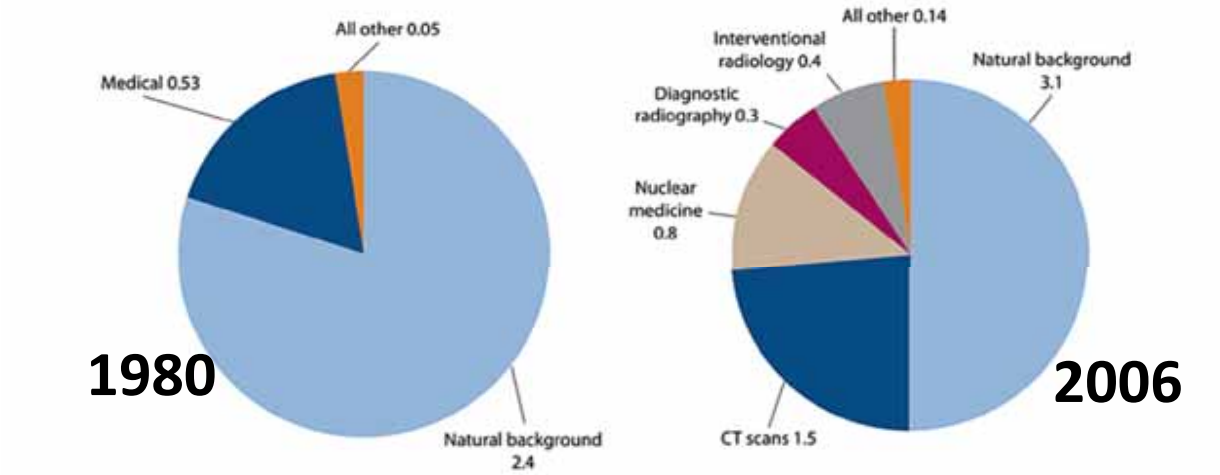
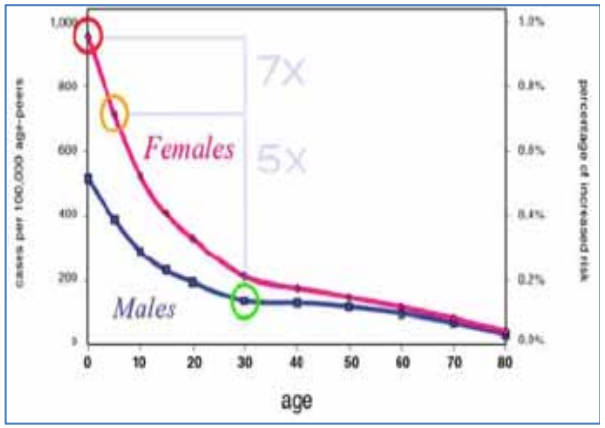
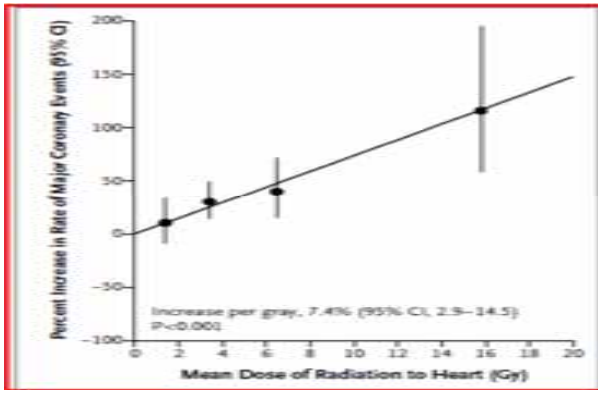


Figure 2. Average annual effective dose/person received in 1980 (left panel) and 2006 (right panel) in the United States. The large increase in the use of ionizing radiation for medical purposes, in the period 1980-2006, contributed to a total increase from 3.0 mSv in 1980 to 6.2 mSv in 2006. Similar trends are observed in other industrialized countries (51).



The incidence of cancers in women after irradiation is higher than in men

Safer mammograms using radio antenna and technology applied in land mine detection

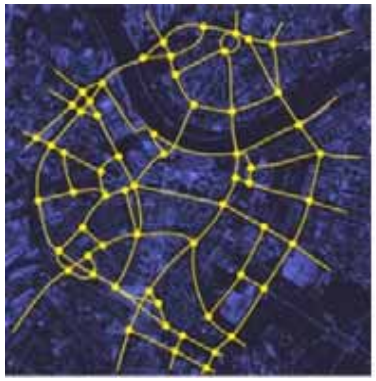


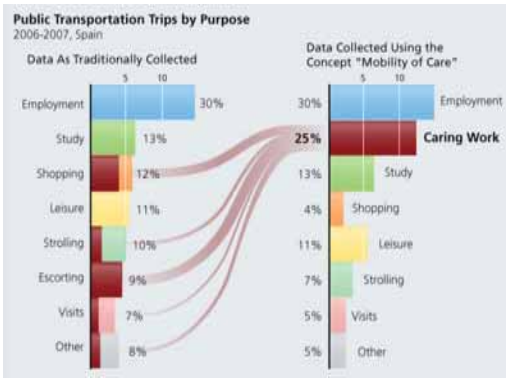
Major coronary events increase with received radiation dose. The shown data are for women.

Thoughts to keep in mind

- **Female bodies are up to ten times more harmed by radiation exposure** (depending on age of exposure) than the Reference Man used by global radiation regulators
- **93% of doctors underestimate the actual ionizing radiation dose patients** are exposed to during diagnostic procedures
- A Computer Tomography brain scan (for diagnosis of acute stroke) is equivalent to a year's natural background radiation. **A mammogram delivers radiation dose equal to ½ a year of background radiation**.

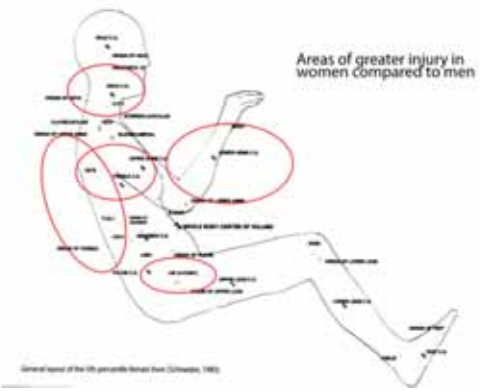
Example 8: sex/gender differences in biomechanical and social behaviour, and response to environment





Men used to drive and women did not. Roads were designed for men, to get fast from home to work.

But transport should support different mobility needs. Women tend to make more stops when using a car.



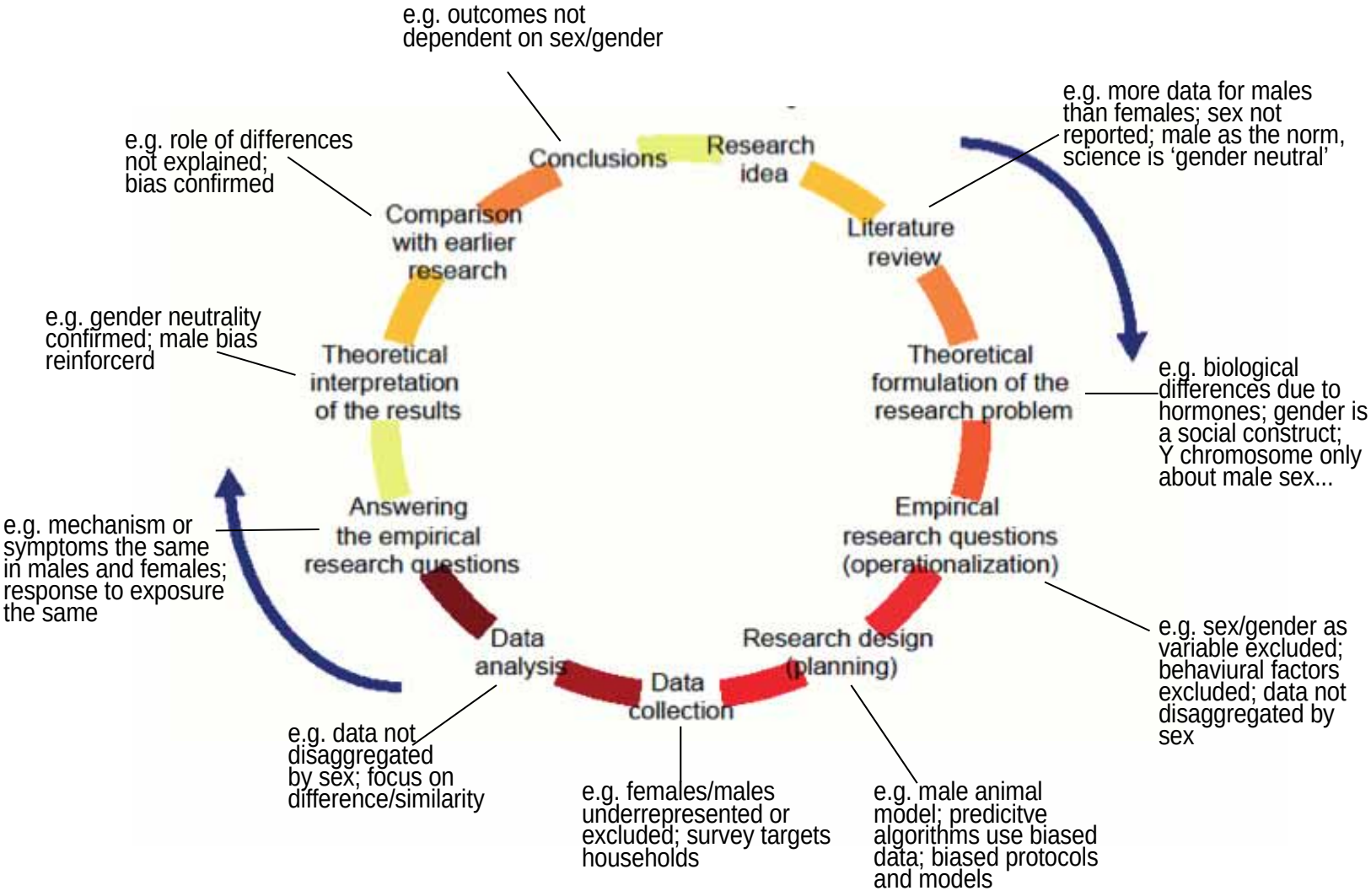
Women have 47% higher risk of injury than men in a car crash (Dipan 2011). Bio-fidelity between female injuries in real and laboratory crashes is poor. Biomechanical response models do not account for morphological differences between women's and men's bodies (Parenteau 2013).

Thoughts to keep in mind

- Transport is assumed to be gender neutral but gender differences become evident when transport is viewed in terms of enabling the mobility of people for different purposes and needs, and by different modes—rather than in terms of mere investment in hard infrastructure, which assumes ‘equal benefit’ for all social groups
- Review of the ECE regulations shows that the average sized woman, and thus half the adult population, is not represented in regulations assessing the protection of adult vehicle occupants (Linder 2016).
- Even though cars are not tested for women, in the EU women pay the same car insurance as men (a recent change in legislation after a challenge to the previous one on the grounds of unequal access to services).
- Crash injuries have repercussions for the sufferer but also for their families (impact will be harsher if it is a mother).

Making improvements: focus on the research process

Gender issues can affect research quality at each step of the research process



Example of gender bias in Literature Review (Search terms for climate change and human health scoping review)

Which of these terms has a sex/gender component?

Table 2 Search terms for 'climate change and health' scoping review

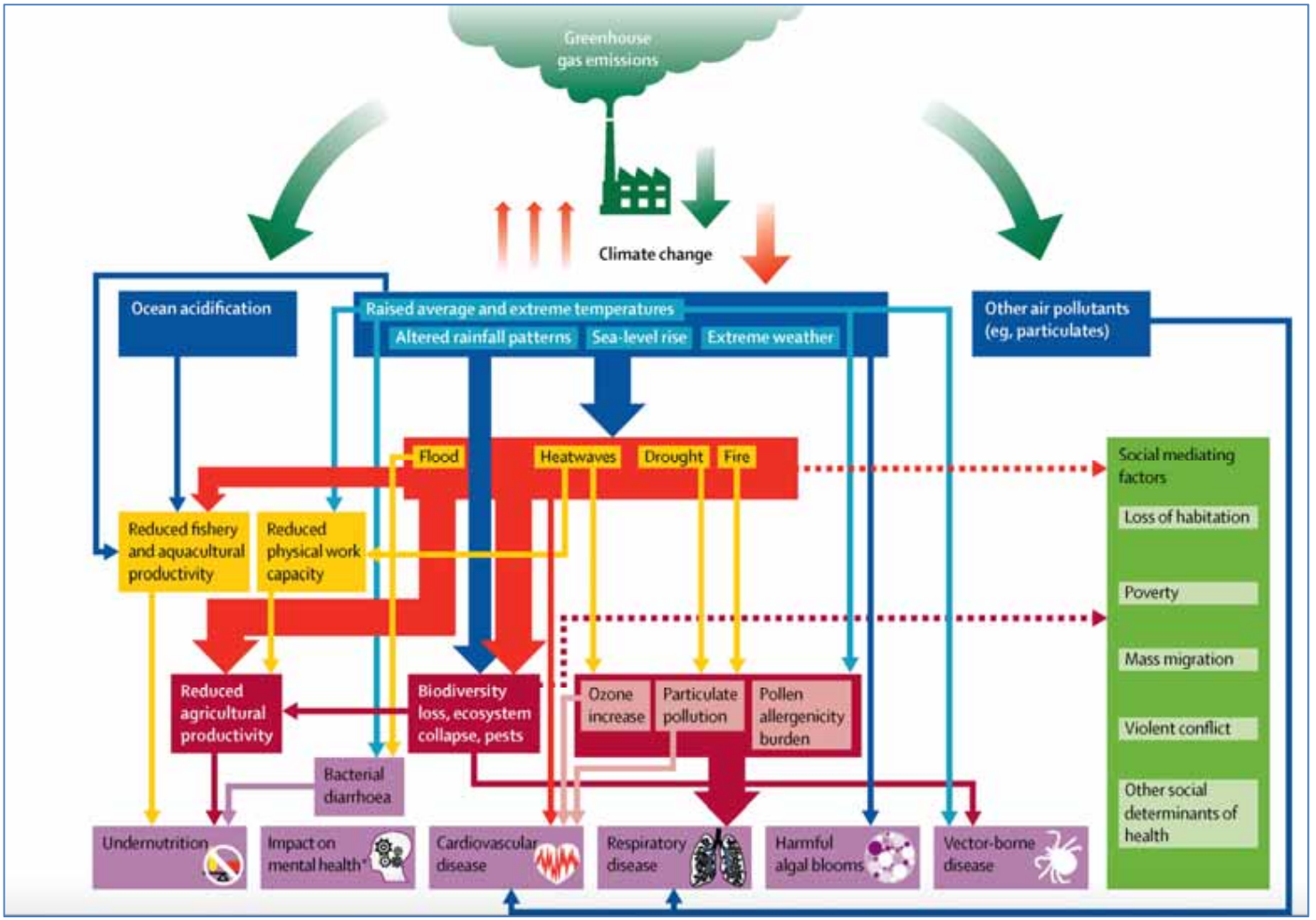
Climate change-related terms	Health-related terms	Date of publication
Climate change	Health	1990–2015
Global warming	Disease	
Climate variability	▶ Non-communicable	
Greenhouse effect	▶ NCD	
GHGE	▶ Communicable	
	Epidemiology	
	Lifestyle	
	Co-benefits	
	Mortality	
	Morbidity	
	Nutrition	
	Malnutrition	
	Dehydration	
	Migration	
	Mental disorders	

GHGE, greenhouse gas emissions; NCD, non-communicable disease.

Herlihy N, Bar-Hen A, Verner G, et al. Climate change and human health: what are the research trends? A scoping review protocol. BMJ Open 2016;6: e012022. doi:10.1136/bmjopen-2016-012022

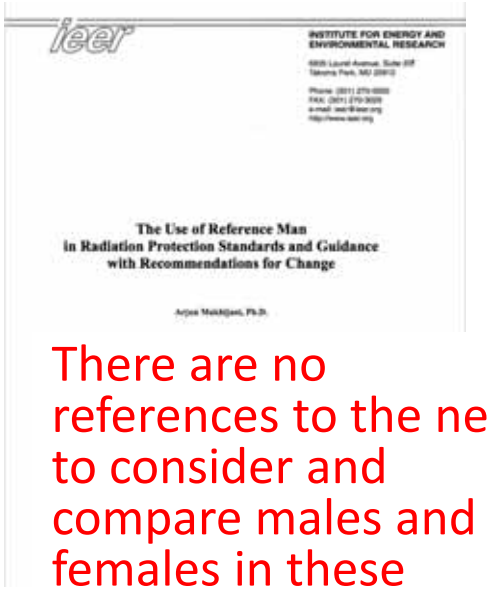
Example of gender bias in Theoretical Formulation of Research Problem (The LANCET Countdown model of how climate change impacts on health

Where would you expect sex or gender differences to matter?



***Lancet* 2017; 389: 1151–64**
http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(16)32124-9/fulltext

Example of gender bias in Research Design in (these) research protocols and standards



There are no references to the need to consider and compare males and females in these examples

Example of gender bias in Research Design: sampling methods

Review of sex bias in research on mammals in 10 biological fields showed male bias in 8 disciplines. Single-sex studies of male animals outnumber those of females by 5.5 to 1 (Beery, K. and Zucker, I.)

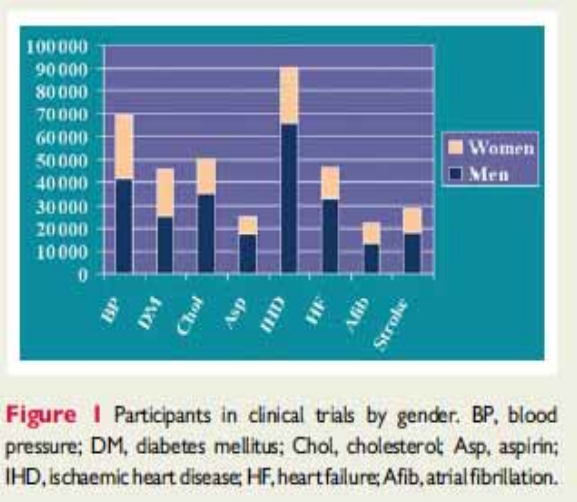
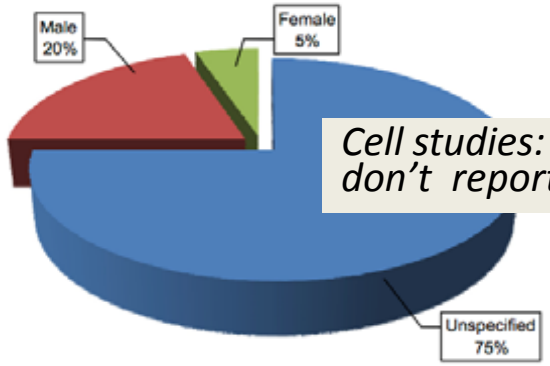
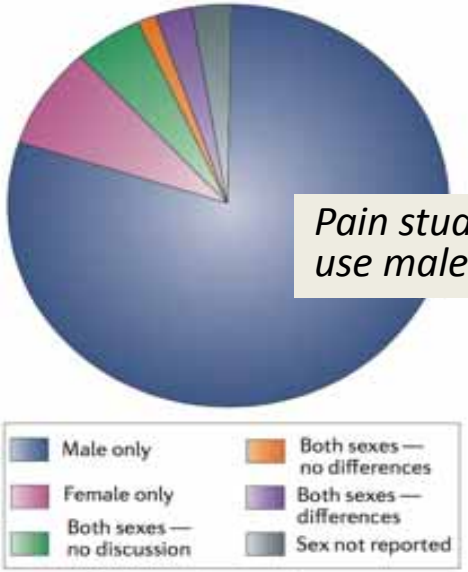


Figure 1 Participants in clinical trials by gender. BP, blood pressure; DM, diabetes mellitus; Chol, cholesterol; Asp, aspirin; IHD, ischaemic heart disease; HF, heart failure; Afib, atrial fibrillation.

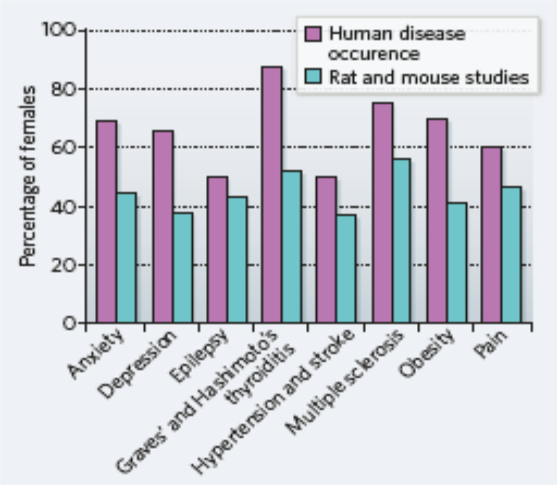


Cell studies: >70% don't report cell sex

Fig. 1. Distribution of studies by sex, published in *AJP-Cell Physiology* in 2013. Shown is the percentage of articles describing the sex of cells derived from male subjects, female subjects, or unreported (n = 100 articles randomly selected from *AJP-Cell Physiology* manuscripts published in 2013).



Pain studies:79 % use male animals



Gender gap. The percentage of women in the total population presenting with a disease (purple; see ref. 1) outstrips the percentage of females in rat and mouse models of that disease (green; data from Web of Science). Only

Example of gender bias in Empirical Research Questions

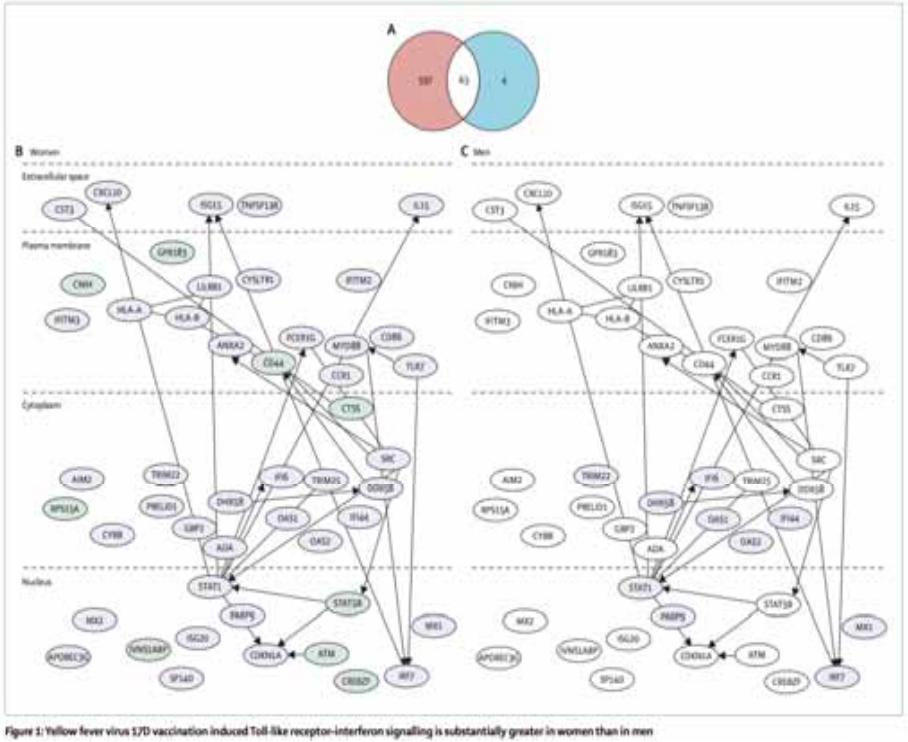
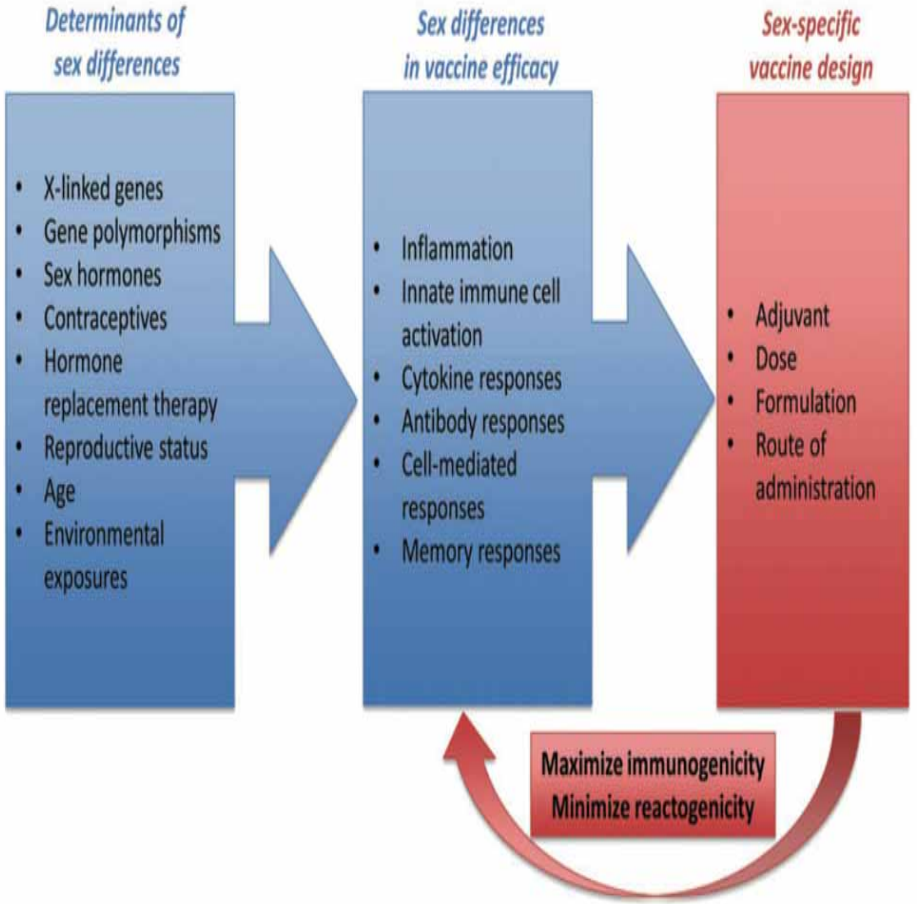
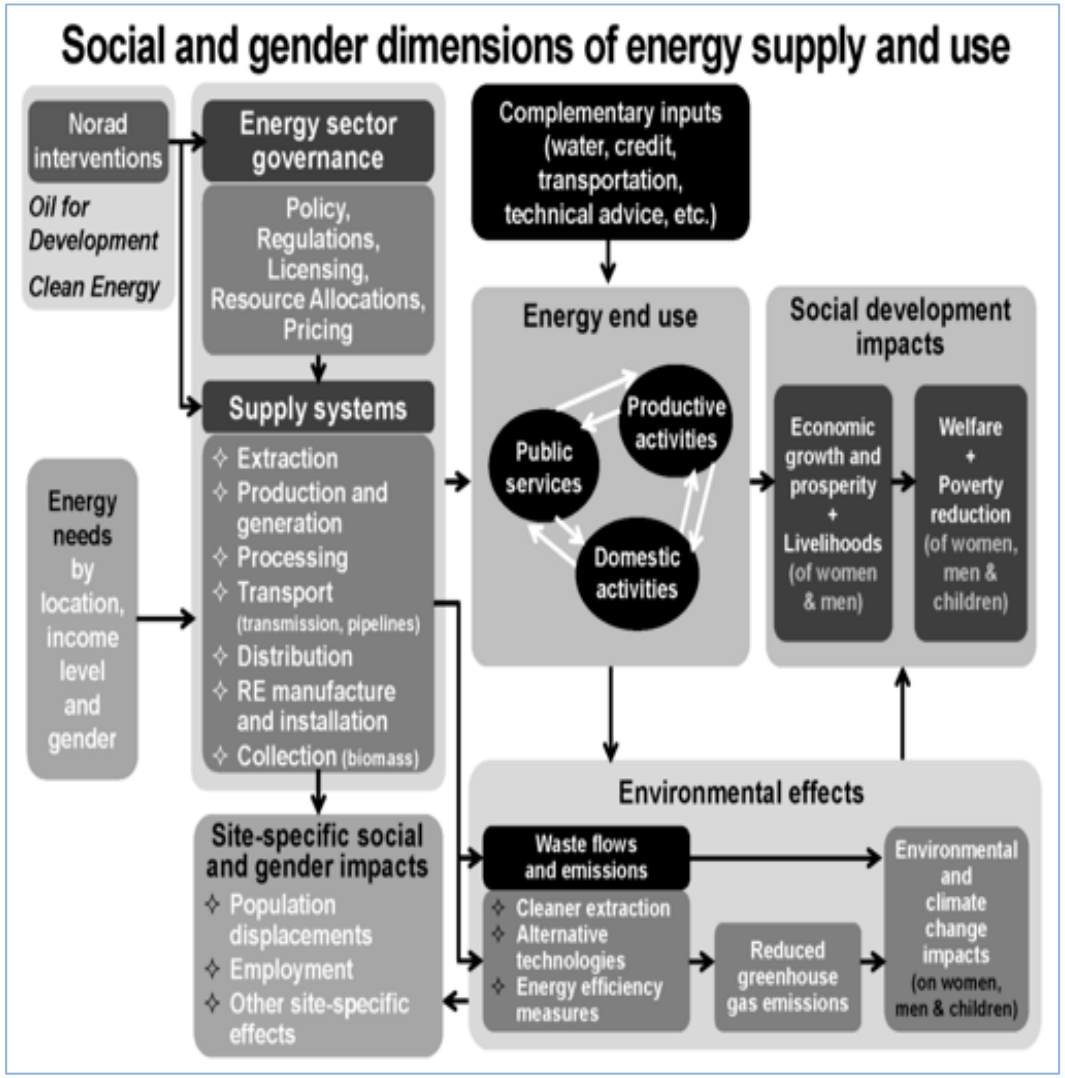


Figure 1: Yellow fever virus 17D vaccination induced Toll-like receptor-interferon signalling is substantially greater in women than in men



Klein S. & Pekosh, A. 2014. "Vaccines should be matched to an individual's biological sex, which could involve systematically tailoring diverse types of FDA-approved influenza vaccines separately for males and females. One goal for vaccines designed to protect against influenza and even other infectious diseases should be to increase the correlates of protection in males and reduce adverse reactions in females in an effort to increase acceptance and vaccine-induced protection in both sexes."

Example of gender bias in Data Collection



Women needs and views are missing in energy planning and use:

- in the governance of energy sector
- in discussions concerning energy needs or energy supply
- in evaluation of site-specific impacts (e.g. population displacement)
- in energy end-use (e.g. domestic) or social development (e.g. better livelihood and poverty reduction)
- and in environmental effects of waste flows and emissions as part of energy production

Example of gender bias in Data Analysis (The Lancet Countdown - 31 indicators to track progress on health and climate change)

1: Health impacts of climate hazards

1.1 Exposure to temperature change
1.2 Exposure to heatwaves
1.3 Changes in labour productivity
1.4 Exposure to flood
1.5 Exposure to drought
1.6 Changes in the incidence and geographical range of climate-sensitive infectious diseases across sentinel sites
1.7 Food security and undernutrition

2: Health resilience and adaptation

2.1 Integration of health into national adaptation plans
2.2 Climate services for health
2.3 Adaptation of finance for health

3: Health co-benefits of climate change mitigation

3.1 Coal phase-out
3.2 Growth in renewable energy
3.3 Access to clean energy
3.4 Energy access for health facilities
3.5 Exposure to ambient air pollution
3.6 Deployment of low-emission vehicles and access to public transport
3.7 Active travel infrastructure and uptake
3.8 Greenhouse gas emissions from the food system and healthy diets
3.9 Greenhouse gas emissions of health-care systems

4: Economics and finance

4.1 Change in annual investment in renewable energy
4.2 Change in annual investment in energy efficiency
4.3 Low-carbon technology patent generation and innovation
4.4 Valuing the health co-benefits of climate change mitigation
4.5 Direct and indirect fossil fuel subsidies
4.6 Coverage and strength of carbon pricing
4.7 Equity of the low-carbon transition

5: Political and broader engagement

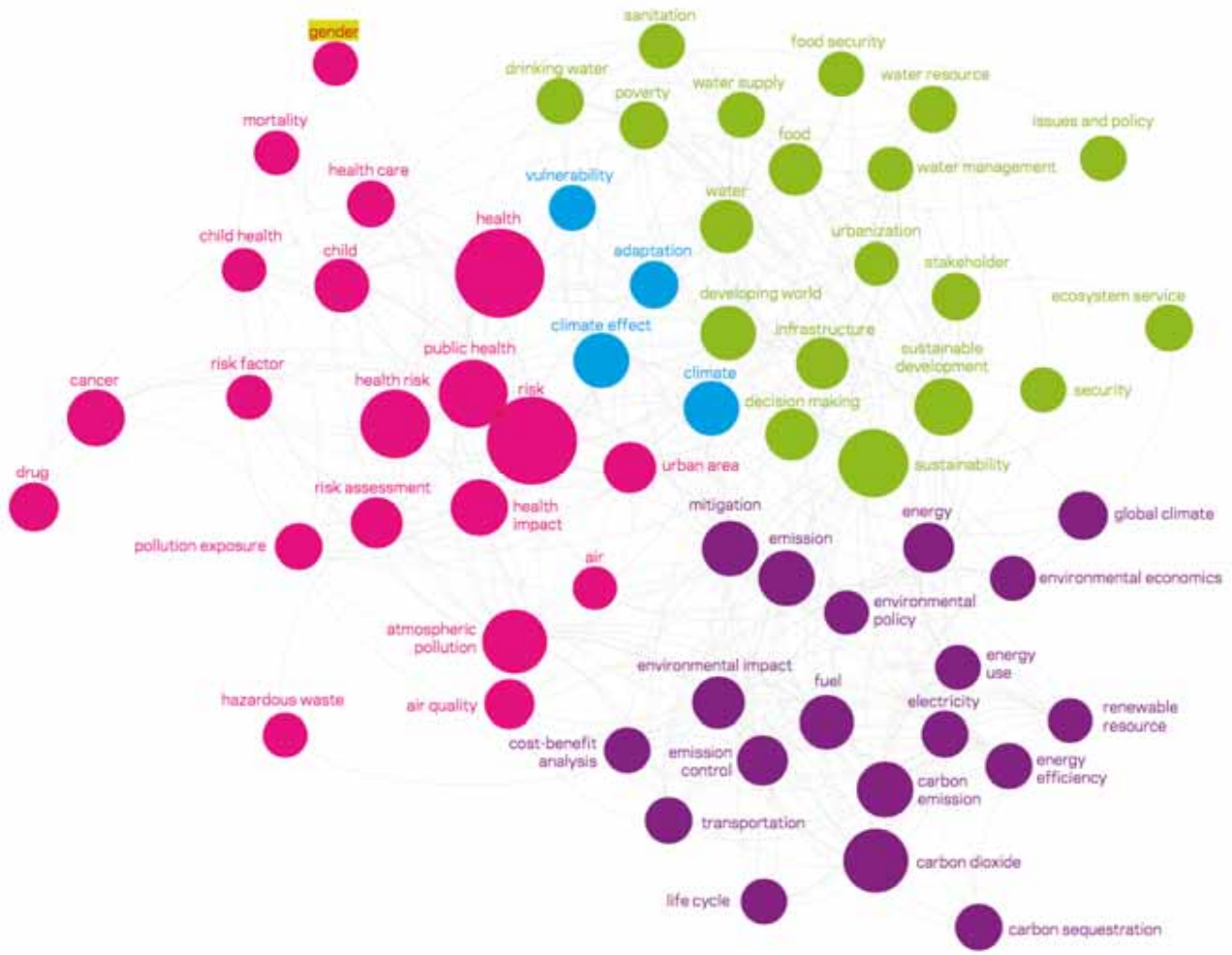
5.1 Public engagement with health and climate change
5.2 Academic publications on health and climate change
5.3 Inclusion of health and climate change within medical and public health curricula
5.4 Health and climate change in high-level statements of the UNFCCC and UNGA
5.5 Implementation and estimated health benefits of the nationally determined contributions (NDCs)

Which indicators should be sex/gender sensitive?

Lancet 2017; 389: 1151–64
http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(16)32124-9/fulltext

Example of gender bias in Comparison with Earlier Research (Elsevier's bibliometric analysis of literature on sustainability science)

350 search terms were used but only 6 were for "gender": "gender gap", "gender inequality", "gender wage gap", "gender identity", "gender disparity" and "transgender" IS THIS SUFFICIENT?



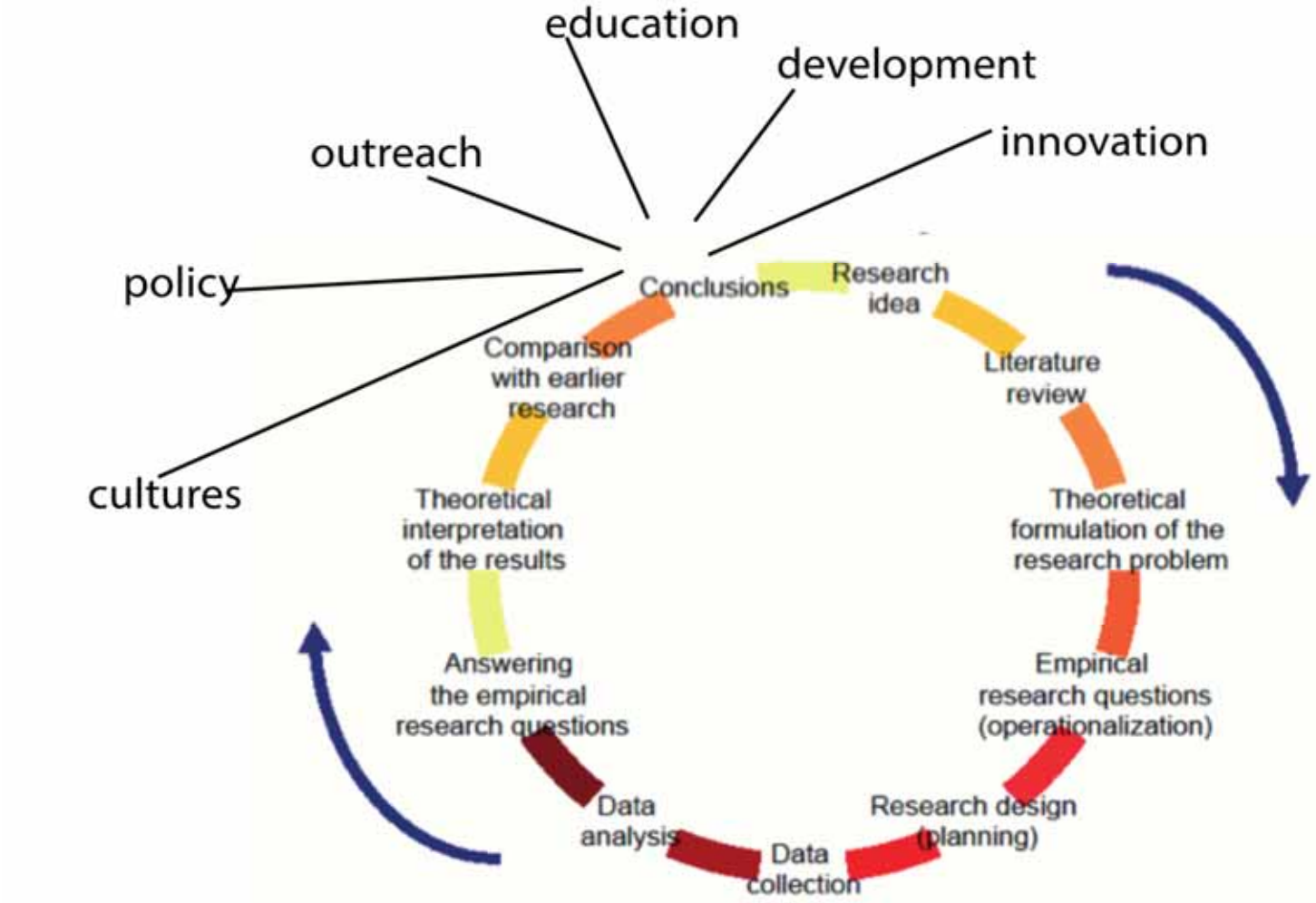
Example of gender bias in Conclusions (keywords for mapping SDGs-related research)

SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9	SDG 10	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 16	SDG 17
Africa	Agricultural Orientation index	Access to clean water and sa	Access to education	Basic living standards	Accessible water	Affordable energy	Aid for trade	Access to the internet	Affordable housing	Adaptable	Capitalism	Average global temperature	Artisanal fishery	Afforestation	Abuse	Capacity building
Basic services	Agricultural productivity	Affordable medicines	Basic education	Dignity	Affordable drinking water	Alternative energy	Banking	Affordable access	Age	Adaptation	Cars	Carbon	Biodiversity	Agriculture	Accountability	Civil society partnerships
Class	Agriculture	AIDS	Basic literacy	Disadvantaged	Aquifer	Animal waste	Child labour	Affordable credit	Ageism	Affordable housing	Circular economy	Carbon dioxide	Carbon dioxide	Animals	Accountable institutions	Communication technologies
Developing countries	Consume	Air contamination	Basic literacy skills	Discrimination	Cities	Battery	Child soldiers	Clean technologies	Business	Air pollution	Commercial enterprises	Changing weather patterns	Coastal biodiversity	Arable land	Arbitrary detention	Debt sustainability
Disadvantaged	Crop diversity	Air pollution	Cultural diversity	Employment	Clean water	Carbon	Creativity and innovation	Cooperation	Children	Air quality	Consumer levels	Climate	Coastal ecosystems	Bees	Arms	Development assistance
Economic resources	Crops	Alcohol abuse	Disability	Empower girls	Contaminated	Charcoal	Culture	Data banks	Culture	Cities	Consumerism	Climate action	Coastal habitats	Biodiversity	Arms trafficking	Disaggregated data
End poverty	Doha Development Round / (	Antenatal care	Disability and education	Empowerment	Defecation	Clean energy	Decent work	Economic development	Developing countries	Climate change	Consumption	Climate adaptation	Coastal parks	Biodiversity loss	Birth registration	Doha Development Agenda
Environment	End hunger	Antiretroviral	Early childhood	Empowerment of women / ar	Desalination	Clean energy technology	Decent work for all	Electrical power	Developing states	Community	Deep decarbonisation	Climate and gender	Coastal resources	Conservation	Bribery	Entrepreneurship
Equality	Environment	Antiretroviral therapy	Early childhood development	Equal access	Diarrhoeal diseases	Clean fuel technology	Development oriented policy	Energy	Development assistance	Cultural heritage	Ecological	Climate and infectious diseas	Coastlines	Deforestation	Combat terrorism	Environmentally sound techn
Extreme poverty	Food	Biomedical	Education	Equal opportunities	Drought	Clean fuels	Economic growth	Enterprises	Disabilities	Decentralisation	Efficient use of resources	Climate and politics	Conserve	Desertification	Conflict resolution	Foreign direct investments
Financial inclusion	Food gap	Bodily autonomy	Education for sustainability	Equality	Dumping	Cleaner fossil fuel technology	Economic productivity	Environmentally sound techn	Discrimination	Development planning	Energy	Climate change	Conserve oceans	Drought	Conflicts	Fostering innovation
Income	Food production	Child deaths	Education in developing	Exploitation	Ecosystem protection	Climate goal	Economy	Financial services	Discriminatory	Disaster management	Energy consumption	Climate change management	Coral bleaching	Drylands	Corruption	Free trade
Income equality	Food reserves	Contraceptive use	Enrolment	Female genital mutilation	Ecosystem restoration	Coal	Enterprises	ICT infrastructure	Economy	Disaster risk reduction	Energy efficiency	Climate change planning	Coral reef	Ecosystem	Discrimination	Fundamental principles of off
Microfinance	Food Security	Death rate	Equal access	Feminism	Equitable sanitation	Electricity	Entrepreneurship	Industrial diversification	Education	Disaster Strategy	Energy use	Climate change policy	Ecosystem management	Ecosystem restoration	Education	Global partnership
Non discrimination	Genetic diversity	Dental	Equal education	Forced marriage	Floods	Electricity infrastructure	Equal pay	Industrialisation	Empower	Disasters	Food	Climate early warning	Fish species	Ecosystems	Enforced disappearance	Global partnership for sustain
Poor	Genetic diversity of seeds	Disability and family support	Equitable education	Gender	Fresh water	Emissions	Finance	Information and communicat	Equal opportunity	Fine particulate matter	Food losses	Climate hazards	Fish stocks	Extinct	Equal access	Global stability
Poor and vulnerable	Genetics	Disability and inclusion	Gender disparities in educatio	Gender discrimination	Hydropower	Energy	Financial services	Infrastructure	Equality	Green spaces	Food supply	Climate impact	Fish stocks AND FISHERIES MA	Extinct species	Equity	International aid
Poverty	Hunger	Disability and politics of local	Gender disparity	Gender equality/parity	Hygiene	Energy efficiency	Forced labour	Innovation	Equity	Heritage	Food waste	Climate mitigation	Fisheries	Extinction	Exploitation	International cooperation
Poverty eradication	Hungry people	Diseases	Gender equality	Governance and gender	Improving water	Energy infrastructure	GDP growth	Internet access	Ethnicity	Housing	Food fuel subsidies	Climate refugees	Fishers	Forest	Flow of arms	International population and
Poverty line	Improved nutrition	Family planning	Gender equity	Human rights	Inadequate water	Energy research	Global resource efficiency	Irrigation	Financial assistance	Human settlements	Future proof	Climate related hazards	Fishing	Forest management	Freedom	International support
Quality of Life	Innovations and health	Health	Gender sensitive	Human trafficking	Inadequate water supply	Energy technology	Global trade	Knowledge in education for a	Foreign aid	Impact of cities	Global food waste	Climate resilience	Fishing practices	Forests	Geography of poverty	International support for dev
Resources	Legumes	Health in resource constraine	Global citizenship	Humanitarian	Infrastructure	Fossil fuel	Gross domestic product grow	Mobile networks in developir	Foreign investment	Inadequate housing	Greenhouse gasses	CO2 capture	Global warming	Genetic resources	Governance	Knowledge sharing
Social protection systems / sc	Maize	Health worker density	Global education	Marginalised	Irrigation	Green economy	Human trafficking	National Security	Global financial markets	Informal settlements	Harvest losses	CO2 conversion	Illegal fishing	Illegal wildlife products	Hate crime	Multi-stakeholder partnership
Sustainable	Malnourished	Healthy	Inclusion and education	Parity	Lakes	Greenhouse gas	Inclusive economic growth	Network infrastructure	Health	Infrastructure	Life cycle	COP 21	Kelp	Illicit trafficking	Human rights	Poverty eradication
Third World	Malnutrition	Healthy lives	Inclusive	Pay	Latrines	Greenhouse gas emissions	Innovation	Phone service	Homelessness	Land	Market distortions	COP 22	Law of the Sea	Indigenous	Human trafficking	Public private partnerships
Vulnerable	Nutrition	Hepatitis	Innovation	Reproductive rights	Open defecation	Hydroelectric	Insurance	Public policy	Homelessness	Land consumption	Materialism	Ecosystems	Marine	Indigenous populations	Illegal arms	Science cooperation agreeme
Wealth distribution	Nutritional needs	HIV	International cooperation	Sexual and reproductive healt	Pollution	Low carbon	Job creation	Quality of life	Homophobia	Local materials	Materials goods	Emissions	Marine areas	Invasive alien species	Illicit financial flows	Technology cooperation agre
	Nutritious	Improving mortality	Learning opportunities	Sexual exploitation	Recycled water	Modern electricity	Jobs	Regional infrastructure	Human rights	Natural disasters	Monitoring sustainable devel	Extreme weather	Marine biodiversity	Land conservation	Inclusion	Technology transfer
	Poverty	Increasing life expectancy	Lifelong learning	Sexual violence	Reuse	Modern energy	Labour market	Research	Inclusion	Natural heritage	Natural resources	Extreme weather events	Marine ecosystems	Land degradation	Inclusive institutions	Weighted tariff average
	Produce	Indigenous	Literacy	Social inclusion	River basins	Reliable energy	Labour rights	Resilient infrastructure	Income growth	Obsolescence	Obsolescence	Global mean temperature	Marine fisheries	Land loss	Inclusive societies/society	Women entrepreneurs
	Productivity	Infected	Literacy skills	Trafficking	Rivers	Renewable	Micro finance	Resource use efficiency	Income inequality	Over crowding	Overconsumption	Global temperature	Marine Parks	Land use and sustainability	Institutions	World Trade Organisation
	Quality of life	International health policy	Numeracy	Universal health coverage	Safe drinking water	Renewable energy	Migrant workers	Roads	Indigenous	Pollution	Production	Global warming	Marine pollution	Manage forests	Internally displaced	
	Resilient agriculture	International health regulatio	Preprimary education	Violence	Sanitation	Renewable power	Modern slavery	Sanitation	Inequalities	Population	Recycle	Greenhouse gas	Marine resources	Managed forests	Judiciary	
	Rural infrastructure	Malaria	Primary education	Violence against girls	Sanitation and hygiene	Solar	Poverty eradication	Scientific research	Inequality	Population growth	Recycling	Greenhouse gas emissions	Oceans	Micro organisms	Justice	
	Small scale food producers	Maternal mortality	Qualified teachers	Violence against women	Sanitation management	Solar energy	Poverty line	Society	Migrant remittance	Public spaces	Reduce waste generation	Greenhouse gases	Ocean acidification	Permaculture	Justice for all	
	Stunted growth	Measles	Refugees and learning	Women	Sewerage	Solar power	Productive employment	Sustainable industrialisation	Migration	Public transport	Reduction	Ice loss	Ocean temperature	Plants	Legal identity	
	Stunting	Medical	Scholarships	Women in work	Sustainable water manageme	Sustainable energy	Productivity	Sustainable infrastructure	Population growth	Resilient	Renewable	Low carbon economy	Oceanography	Poaching	National Security	
	Sufficient food	Mental health	School	Women's rights	Sustainable withdrawals	Sustainable energy services	Public policy	Technological capabilities	Poverty	Resilient buildings	Resource efficiency	Natural disasters	Oceans	Poverty	Non-violence	
	Sustainable	Mortality	School enrolment	Workplace equality	Third world	Sustainable power	Quality jobs	Technology	Public policy	Resource efficiency	Responsible production chain	Natural systems	Overfishing	Protected fauna	Organised crime	
	Sustainable agriculture	Mortality rate	Secondary education		Toilets	Vehicles	Quality of life	Trade	Quality of life	Resource needs	Retail	Ocean warming	Productive oceans	Protected flora	Paris principles	
	Sustainable food production	Narcotic drug abuse	Teacher training		Untreated wastewater	Wave	Resource efficiency	Transborder infrastructure	Race	Risk reduction strategy	Retail industry	Paris Agreement	Protected areas	Protected species	Peace	
	Trade diversity	Neonatal mortality	Universal education		Urban	Wind	Safe work	Transport	Racism	Road safety	Reuse	Pollution	Sea grasses	Reforestation	Peaceful societies	
	Trade restrictions	Polio	Vocational training		Waste	Wind power	Secure work	Value chains	Reduce inequalities	Safe cities	Sustainable	Renewable	Seas	Soil	Physical abuse	
	Under nourished / Undernou	Premature mortality	Vulnerable		Wastewater	Wind turbine	Slavery	Value chains and markets	Religion	Slums	Sustainable consumption	Sea level rise / Rising sea / Ri	Sustainable ecosystems	Soil degradation	Police	
	Wasting	Preventable death	Women's rights		Wastewater treatment	Wood	Social policies	Water infrastructure	Rural	Smart cities	Sustainable management	Temperature	Unregulated fishing	Species	Prevent violence	
	World's hungry	Reducing malaria			Water		Society	Water resources	Sea	Solid waste	Sustainable practices	Warming	Water resources and policy	Strategic plan for biodiversity	Psychological abuse	
		Reducing mortality			Water access		Stable employment		Season	Suburban	Sustainable production			Terrestrial ecosystems	Public policy	
		Refugees and health services			Water disasters		Stable jobs		Social protection	Sustainable	Sustainable public procurement			Threatened species	Quality of life	
		Reproductive health			Water ecosystems		Sustainable consumption		Society	Sustainable building/s	Sustainable resource use			Tree	Representative decision-making	
		Road traffic accidents			Water efficiency		Sustainable economic growth		Vulnerable nations	Sustainable cities/city	Sustainable supply chain			Tree species	Rule of law	
		Sexual and reproductive health-care			Water harvesting		Sustainable production		World trade	Sustainable communities	Sustainable tourism			Wetlands	Security threats	
		Sexual health			Water quality		Sustainable tourism			Sustainable urbanisation	Vehicles				Sexual abuse	
		Soil contamination			Water resources management		Trade			Town planning	Waste				Sexual violence	
		Soil pollution			Water scarcity		Unemployment			Transport	Wasteful consumption				Stolen assets	
		Tobacco control			Water supply		Well-paid jobs			Transport systems	Water				Tax evasion	
		Treatment of substance abuse			Water related ecosystems		Women migrants			Urban	Water pollution				Theft	
		Tuberculosis			Water-use efficiency		Work			Urban development	Water supply				Torture	
		Universal health					Work opportunities			Urban planning					Trafficking	
		Universal health coverage					World trade			Urban sustainability					Transparency	
		Vaccines					Youth employment			Urbanisation					Un sentenced detainees	
		Vaccines in developing countries					Youth unemployment			Waste					Unstable societies	
		Violence								Waste generation					Victims of violence	
		WASH								Waste management					Violence	
		Water, Sanitation and Hygene for All								Water					Violence against women and children	
		Water borne disease								Water related disasters					Violence rates	
		wellbeing/well being/well-being													Weapon seizures	
		World Health Organisation														

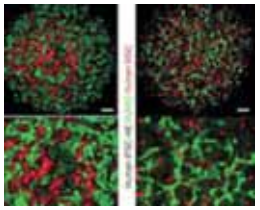
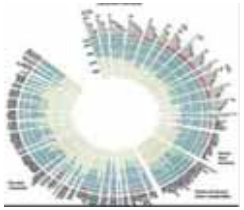
http://ap-unsdsn.org/webinar-mapping-university-contributions-to-the-sdgs/

Understanding gender bias in science knowledge making is essential for excellence, which should also mean better efficacy of applications, and more impactful use of science knowledge

Gender bias in knowledge will also impact on how gender is considered outside of research



Gender bias in science knowledge can lead to bias in technological innovation producing different risks and benefits for women and men

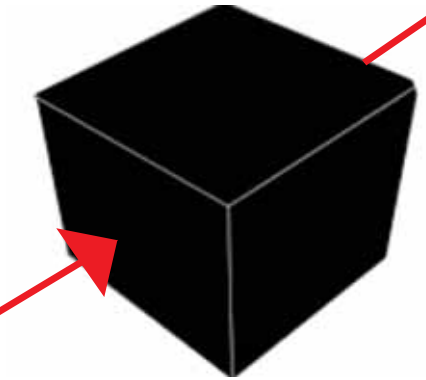



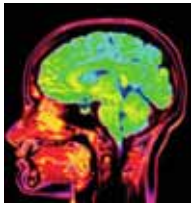












outcomes (products with poorer efficacy or safety for women,and/or men)

knowledge (and any gender bias 'hidden' in data, models, protocols, standards)

The vision of the 4th Industrial Revolution: will the future be gender blind (and poor blind)

Who makes decisions

When will the future arrive?

800 technology executives and experts from the information and communications technology sector were surveyed as part of our *Technology Tipping Points and Societal Impact* report

WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

Technology tipping points expected to occur by 2025	Percentage of respondents
10% of people wearing clothes connected to the internet	91.2
The first robotic pharmacist in the US	6.5
The first 3D-printed car in production	.1
5% of consumer products printed in 3D	1
90% of the population with regular access to the internet	
Driverless cars equalling 10% of all cars on US roads	78.2
The first transplant of a 3D-printed liver	76.4
Over 50% of internet traffic to homes for appliances and devices	69.9
The first city with more than 50,000 people and no traffic lights	63.7
The first AI machine on a corporate board of directors	45.2

Which of these products is likely to work less well for women?

Source: World Economic Forum, Technology Tipping Points and Societal Impact report, 2015

Sustainability in Horizon 2020: programme framed by seven societal challenges

- Health, demographic change and wellbeing (SC1)
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the bio-economy (SC2)
- Secure, clean and efficient energy (SC3)
- Smart, green and integrated transport (SC4)
- Climate action, environment, resource efficiency and raw materials (SC5)
- Europe in a changing world - inclusive, innovative and reflective societies (SC6)
- Secure societies - protecting freedom and security of Europe and its citizens (SC7)

Seven Expert Advisory Groups decide on SCs research priorities. Advice on gender is improving, especially in SC1, SC4, SC6, but is still poor in SC2, SC3, SC5 and SC7

Sustainability is about societal and environmental challenges, which are **not** gender neutral

Dirty water kills more women than AIDS and breast cancer

0.7-1.0 million girls under 5 annually die from diarrheal diseases

Women have 47% higher risk of injury in a car crash

Natural disasters impact on women up to 4 times more strongly than on men

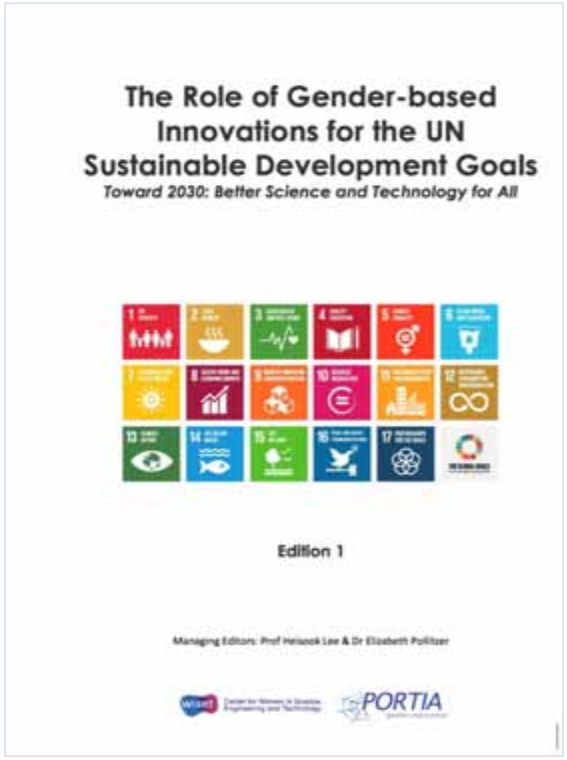
75% of new diseases emerge from animals: women can be at greater health risk

Women are at greater health risk from internal pollutions due to bad cooking stoves

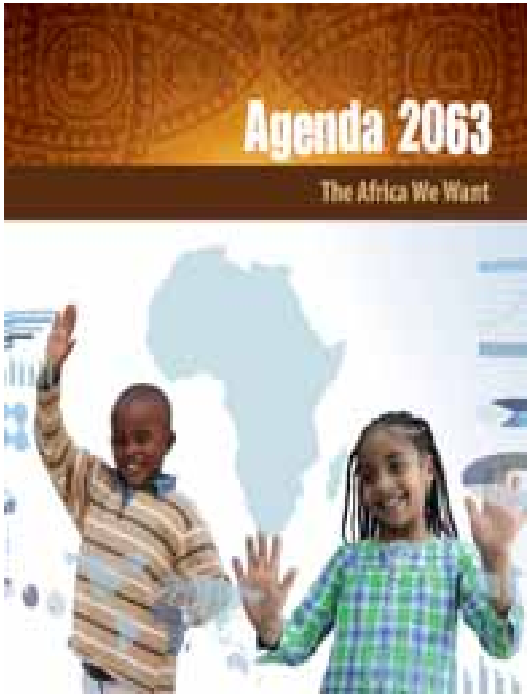
Women have better knowledge of plants and uses of natural resources than men

Women and girls spend more time gathering fuel than men and boys

Interventions to tackle societal challenges that draw on biased knowledge will also be biased (i.e. fail women, again). **There is an overwhelming lack of gender indicators**



Currently, of the 150 SDG indicators, only a handful are for gender, and all are about empowerment. In 2016, 27 international experts produced a report to show that gender issues are relevant to achieving targets of all 17 SDGs, not just SDG5



- 69 aspirations: 16 mentions of “gender”: gender x 2; + (dis)parity x 4; + equality x 7; + violence x 2’ + discrimination x 1

Conclusions and Thank you

- Science is not gender neutral
- Science has more evidence for men than for women
- There is widespread gender bias in science knowledge, and resistance to adopt gender analysis in research process
- Societal and environmental challenges are not gender neutral
- Gender issues influence quality of research, innovation and development outcomes
- Intervention measures based on biased knowledge will fail women
- Gender issues can stimulate new research questions and open up new opportunities for research application

Background research, and more, can be found at

www.gender-summit.com
www.portiaweb.org
www.genderportal.eu
www.genderinscience.org

Gender Summits®

PORTIA
gender and science