HEALTH IN ENVIRONMENTAL ASSESSMENT

Guidance on how to improve assessment of impacts on human health in a Danish context

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The guidance in brief – Executive summary

For many years, it has been a legal requirement to integrate human health in environmental assessments of plans, programs, and projects. In a Danish context, very little guidance is made, and this guidance seeks to guide current practice towards a better assessment of health impacts.

The guidance outline ley phases of the assessment of health impacts: Identification of the population at risk, identification of potential health outcomes of interest, definition of significance levels of health outcomes, and quantification of impacts.

The guidance includes references to recent literature and enlists a range of available software tools to support quantification of effects.

It highlights the need to consider all relevant determinants of health and go beyond assessment of environmental determinants related impacts by adding the wider social determinants. It is acknowledged that a population can be at risk due to other factors such as social determinants, human biology, and physiology, etc. Those factors influence the overall health impacts through interaction with environmental determinants, highlighting the importance of considering cumulative and synergic effects on human health.

The guidance is based on reviews of Danish environmental assessment documents, data, and experiences from the recent IAIA/EUPHA guidance document on human health[1]. It is furthermore based on dialogues and testing within the DREAMS project. The guidance is publicly available to all interested readers.

[1] https://eupha.org/repository/sections/HIA/Human%20Health%20Ensuring%20Protection%20Main%20and%20Appendices.pdf

Introduction

Symbiotic relationship between human health and the environment is increasingly apparent. The decisions we make regarding land use, infrastructure development, and resource management can have profound consequences on the well-being of individuals and communities. Recognizing the intricate interplay between environmental factors and human health, environmental assessments (EA) of plans, programs, and projects is a critical tool to ensure that our actions align with the preservation and enhancement of human health.

This guidance document aims to provide a framework for assessing human health within the context of EA. By doing so, it seeks to empower practitioners, policymakers, and stakeholders to make informed decisions that safeguard public health, promote sustainability, and mitigate potential risks associated with various plans and projects.

One of the key shortcomings of current Danish EA practice is the population at risk. Current practice rarely describes the population's health status in a way that allows an assessment of impacts. The guidance document therefore provides advice on how to identify and describe the population at risk.

Another shortcoming is the identification of potential health outcomes of interest. A broad spectrum of environmental determinants, e.g., noise and air quality, can influence health outcomes. Current EA practice often only considers a few health outcomes, and there are concerns as how to identify the appropriate outcomes. The guidance document provides and overview of outcomes of interest and advice in that regards.

Significance determination is often a tricky part of the EA process, and this is also the case of health impacts. A few health outcomes are related to regulatory limit values, but besides from these, there are little support on significance of health impacts. The guidance therefore provide advice in this regard.

Finally, the guidance provides advice on quantification of impacts as quantification involves potential benefits.

This guidance document is developed within DREAMS project[2], which aims to promote progress on Sustainable Development Goals (SDGs) by digitally transforming the way society accesses and communicates information about environmental impacts of projects and plans to enable the best decisions towards green transition in a transparent and inclusive democratic process. As part of the DREAMS project, health impacts have also been linked to SDGs[3].

As the DREAMS project has its outset in Danish and European conditions, the guidance document has point of departure in the current Danish practice on environmental assessment of plans and projects. It is, however, likely of interest to a broader audience.

[2] https://dreamsproject.dk/
[3] https://www.ssph-journal.org/articles/10.3389/ijph.2022.1604420/full

Definitions and approach

The globally used definition of health as presented by WHO Constitution: “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”[4] is applied within this document. This is a definition which is rather hard to translate to impact assessment terminology. Another perspective is to define health as “a balance among emotional, physical and social environment”. This definition involves the three core determinant groups (mental, physical, and social environment) and considers the balance among them avoiding highlighting only negative changes caused by a plan or a project. As a classical example, a new investment project improves social conditions through employment and income but at the same time creates environmental pollution. Environmental assessment then evaluates all determinants and the balance among them.

Environmental assessment is understood as the European Directives on environmental assessment of programmes and plans (Directive 2001/42/EC) and projects (Directive 2011/92/EU). Both directives prescribe description and assessment of direct and indirect significant effects of human health of projects, programmes and plans prior to adoption or consent. The requirements have been implemented differently across member states.

The approach to assessing health impact is based on the focus on causalities as outlined in the DREAMS project. This approach is in principle reflecting the impact pathway analysis method[5] with exception that instead of monetary costs, we aim to define the health outcome. It is furthermore in line with the full chain methodology developed in the RAPID project for assessment or policy related risks[6].

The approaches start with a project or plan which is modifying the determinants of health leading to change of distribution of risk factors. As consequence of such change, changes in specific health outcomes are expected. To identify the health outcome the process should therefore start by a definition of the risk factor, which in case of developmental projects or plans is often an environmental agent (air pollutant, chemical substance in environment, physical agent such as light, vibration, etc.). The second step is comparison of levels of environmental agent to existing limit values. If limit values are expected to be exceeded, or they do not exist a population at risk is identified and described. Due to existence of non-threshold effects in case of many pollutants (e.g., noise, air pollution, radiation) and an overall aim to decrease pollution to lowest possible and feasible level, the limit value-based approach is recommended to overrule when possible, using qualitative considerations or quantification. Health effects relevant to risk factors are described, and when available quantification of health impacts is performed using available tools or methods (e.g., risk assessment), see figure 1.

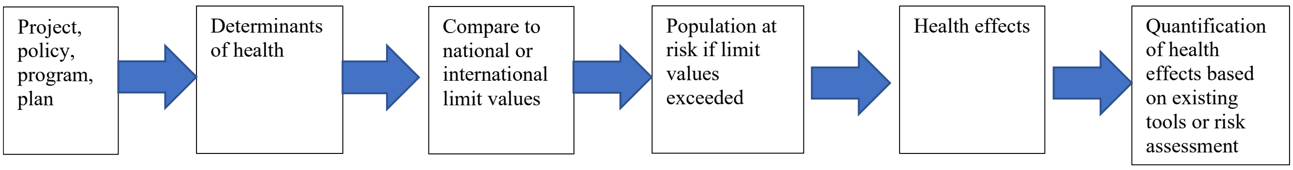


Figure 1 Impact pathway as applied in this guidance document.

A specific issue to consider with each step is time. A number of plans and development projects span over substantial time frame (from planning through construction, operation and potential decommissioning) resulting in a need to be careful about the time frames, when considering population at risk and all other steps.

[4] https://www.who.int/about/governance/constitution

[5] https://www.oecd-ilibrary.org/environment/human-acceleration-of-the-nitrogen-cycle/examples-of-impact-pathway-analysis-and-its-translation-into-policy-making_9789264307438-6-en

[6] https://www.academicbooks.dk/da/content/assessment-population-health-risks-policies-0

Population at risk

It is legislative requirement in environmental assessment to describe relevant aspects of the current state of the environment and an outline of the likely evolution thereof without implementation of the plan or the project as well as the aspects of the population and human health likely to be significantly affected by the proposed plan or project. This is here described as population at risk.

The population at risk is defined as the population that is exposed to the occurrence of a vital event[7]. People can be at risk also due to their socio-economic, genetical, physiological status, yet in case of environmental impact assessment this definition means the population living in vicinity of the new developmental project or plan. The term “affected population” is also used for this population.

How to determine the population at risk?
In case of a well-defined area (project site) it is usually the population living around the site within a pre-defined circle (this circle could differ depending on scale and type of the project as well as the risk factors present). In case of line constructions such as railways, highways, etc., it is usually a population living along the route within a certain distance (could be different from hundreds of meters to couple of kilometers). Such defined population is expected to be directly impacted by new construction (including pre-construction, operation, and decommissioning phases if relevant).

[7] https://stats.oecd.org/glossary/detail.asp?ID=2081

How to describe the population at risk?
To describe the population at risk standard demographic variables and indicators are used such as age and sex structure. In addition, measures such as socio-economic status, income level, employment characteristics, education level, vulnerability, susceptibility, and ethnicity can be applied to allow for stratification of impacts by specific sub-populations and addressing equity issues within impact assessment.

Vulnerability refers to populations at higher risk due to environmental factors. Examples of vulnerability factors include poverty, poor sanitation and stress associated with mental health diseases. If area specific data does not exist on required characteristics (often the case for social and behavioural risk factors) the method of age standardization can be applied to make area estimates based on data available on higher area level (region, country). General information about methods is available here: https://en.wikipedia.org/wiki/Age_adjustment .

Susceptibility refers to intrinsic biological factors (e.g., pregnant women) that can increase the health risk of an individual at a given exposure level. Examples of susceptibility factors include genetic factors, elderly and children and prior or existing disease. Sensitive groups refer to populations with both susceptibility and vulnerability factors. As an example, the number of pregnant women in a population at risk can be calculated using the "geographic pregnancy calculator tool of Center of Disease Control of USA", see:
https://www.cdc.gov/reproductivehealth/emergency/docs/Geographic-Calculator-for-Pregnant-Women_508.xlsx

Understanding population vulnerability is important to ensure that vulnerable population groups are considered in the EA process. This enables environmental hazards to be prevented where possible, or, if not possible, their impact can be minimized. Identifying vulnerability also enables resources to be directed more effectively to those who have the greatest need.

Where to find good examples of reports?
The following two references provide examples how was the population described in case of a:

- Localized regeneration project in Wales https://phwwhocc.co.uk/whiasu/wp-content/uploads/sites/3/2021/05/BayLife_HIA_2012_Final_Report.pdf, see specifically pages 2-3
- Highway construction HIA example, Sweden available at: https://www.yumpu.com/en/document/read/20818586/health-impact-assessment-of-a-road-traffic-project-552-kb, see page 11
- A recent report presenting case studies of human health addressed in SEA or EIA from Europe available at https://apps.who.int/iris/handle/10665/353810

Identification of health outcomes

Relevant health outcomes can be identified by using table 2 in appendix 1, which provide an overview of relations between environmental determinants and health outcomes.

How to use the table on health outcomes?
The generic relations in the table, following the impact pathway analysis process, may be used in early meetings to inspire the screening and scoping of environmental assessments. The references to literature may furthermore inform the description and assessment of human health effects.

The table is based on generic relations, and the relevance of the suggested health outcomes must be critically considered for each specific plan or project. A specific plan or project may lead to multiple health outcomes, and the table guides the user in likely relevant directions that would then have to be explored by a competent person.

How to describe specific health outcomes?
Having the environmental agent identified (the risk factor) visit one of environmental risk library databases, e.g., "ProQuest Environmental Science Index", and search for publications including health effects of the identified environmental agent. Focus on review papers as they can give relatively quick orientation. When reviewing the identified papers, select the most important health effects described. This will produce a list of relevant health outcomes for the assessed project. If available, summary reports of national authorities (environmental, health, etc.) or international authorities (World Health Organization) can be used as well.
Second option to identify the health outcomes is to consult the citizens in target area; they are likely to express their health concerns in general and in relation to a proposed plan or project.

Where to find good examples of reports?
A good example of this health outcome identification process is described in a report on health impact assessment on proposal to substitute chopped tires for some of the coal as fuel in cement kiln in Rugby, Wales, UK. The full text of the report is available here:
Rugby cement kiln case as example
https://www.sciencedirect.com/science/article/pii/S0195925503001756

Did you know?
A third, parallel way to identify the health outcomes is a consultation process with public health experts. Key public health institutions to ask for support in Denmark are:

- The National Board of Health – department for disease prevention and equity at https://www.sst.dk/da/om-os/organisation/sundhedsfaglige-enheder/forebyggelse-og-ulighed
- Universities operating a master program in public health, environmental health, or health promotion:
  - Copenhagen University at https://ifsv.ku.dk/
  - Aarhus University at https://ph.au.dk/
  - Aalborg University at https://vbn.aau.dk/da/organisations/faggruppen-for-folkesundhed-og-epidemiologi
  - Syddansk Universitet at https://www.sdu.dk/da/om_sdu/institutter_centre/ist_sundhedstjenesteforsk or https://www.sdu.dk/da/sif
  - Roskilde University at https://ruc.dk/en/research-centre/research-centre-health-promotion
- Health departments of Association of Danish Regions at https://www.regioner.dk/sundhed/sundhedsinnovation-og-forskning
- Health department of KL at https://www.kl.dk/kommunale-opgaver/sundhed-og-aeldre/
- Municipal health departments

Cumulative and synergic health outcomes
Ill health is unfortunately rather rarely caused by a single determinant or risk factor. A cardiovascular disease can be linked to noise, air pollution, poor diet, bad lifestyle habits, low socio-economic status (education, income) and stressful life among others. The disease therefore is a result of a cumulative effect of many stressors, determinants of health.

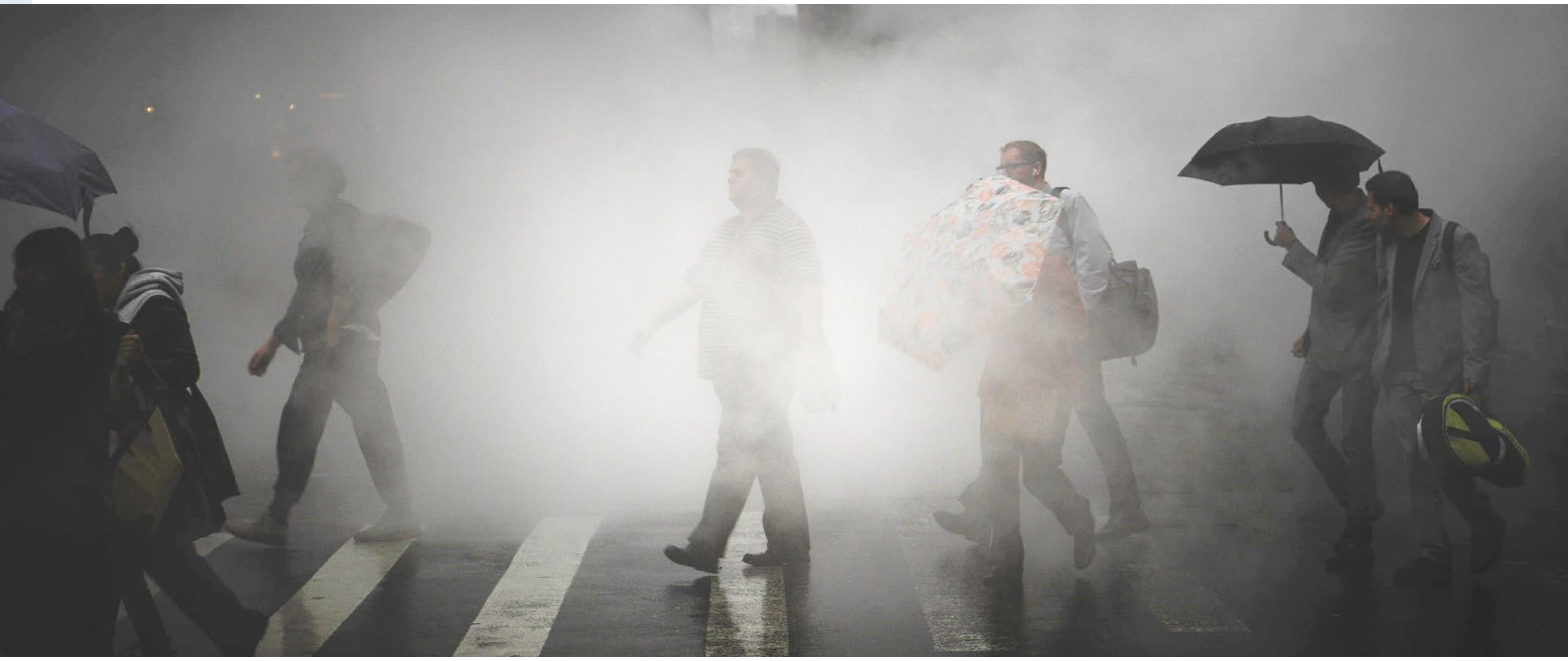
If an assessment is based on comparison with limit values (if available), and none of limit values is exceeded, the case can be treated as a single risk-outcome case and no further quantification of impact might be necessary. However, caution is necessary as the aim of assessment is to minimize potential risks, and limit values are not always reflecting the scientific limits (as discussed above).

In a case, where some of the risk factors is expected to exceed limit values, and the relation of stressors as well as the strength of association is described in literature, the population attributable fraction of the risk factor can be calculated. In such case, it is highly recommended to contact one of above-mentioned public health institutions and consult the assessment with them.

Another complex issue within assessment of impacts on health is the synergic effect of many health issues. For instance, if a construction is going to elevate noise levels as well as to reduce green areas and thus physical activity possibilities, this might result in synergic effect of sleep disturbance, annoyance and increasing obesity. This may then result in a larger increase of diabetes, as it would be not expected in case of individual hazards only.

A solution to manage the issues of cumulative and synergic effects seems to be in introduction of composite measures to assess the impact on health. The most often applied composite measure is the burden of disease measure expressed via disability adjusted life years (DALY). It consists of two measures, the years of life lost due to premature mortality (YLL) and years of life lived with disability (YLD). Until now there are few cases of application of DALYs to impact assessment[8,9].

Software to calculate DALYs, YLLs and YLDs is available at http://daly.cbra.be/. It can be recommended to contact public health experts for collaboration while using the burden of disease approach and the software.



[8] Rojas-Rueda D, de Nazelle A, Teixedo O, Nieuwenhuijsen MJ: Health Impact Asssessment of increasing public transport and cycling use in Barcelona: A morbidity and burden of disease approach, Prev. Med. (2013), http://dx.doi.org/10.1016/j.ypmed.2013.07.021
[9] Xiao J, Li X., Zhang Z.: DALY-based health risk assessment of construction noise in Beijing, China, Int. J. Environ. Res. Public Health (2016), 13, 1045; doi:10.3390/ijerph13111045

Establishing significance of the health outcome

When all potential health outcomes are identified, it might turn out to be a long list. The next step is to determine the establish significance of the outcomes.

How to determine significance?
The following criteria are most frequently used to assess significance of an outcome. They are widely aligned with the criteria given by the EU directives on environmental assessment of plans and projects:

- Severity of the outcomes – how severe is the health outcome? The scale is from mild symptoms of a disease to acute fatality. More serious health outcomes are more likely to be significant.
- Size of population at risk – how big is the population at risk? Are we thinking about few people or a whole city, or region, etc.
- Frequency of the outcomes – how often is the outcome presented? Is the health outcome a single event which after short treatment disappears, or it is a recurrent event?
- Reversibility of the outcome/ability to treat the disease – what is our ability to reverse the outcome? Can we fully treat the disease caused by risk factor or it is going to develop to a chronic, lifelong condition?
- Distribution of the outcome in population – is the impact equally distributed across population or some sub-populations are more hit as others?

More extensive explanation of significance from a health perspective is found in the IAIA/EUPHA guidance on human health[10], page 19.

To express significance risk matrix approach is often used combining the above-mentioned categories. A risk matrix is in principle a table which could look like the following table 1.

LIKELIHOOD	**SEVERITY OF HEALTH OUTCOME**					
	No effect	Minor effect	Short hospitalization	Long term hospitalization	Major disability	Death
Very likely						
Likely						
Possible						
Unlikely						
Rare						

Table 1 Risk significance matrix

[10] https://eupha.org/repository/sections/HIA/Human%20Health%20Ensuring%20Protection%20Main%20and%20Appendices.pdf

Where to find good examples of reports?
A good example of matrix approach, though assessing impact of a preventive health intervention is described in a recent paper by Lemmens, S.M.P., Lopes van Balen, V.A., Röselaers, Y.C.M. *et al.* The risk matrix approach: a helpful tool weighing probability and impact when deciding on preventive and diagnostic interventions. *BMC Health Serv Res* 22, 218 (2022). https://doi.org/10.1186/s12913-022-07484-7.

Another good example directly to health impact assessment is described in paper by McCallum LC, Ollson CA and Stefanovic IL (2016) Prioritizing Health: A Systematic Approach to Scoping Determinants in Health Impact Assessment. *Front. Public Health* 4:170. doi: 10.3389/fpubh.2016.00170 available at https://www.frontiersin.org/articles/10.3389/fpubh.2016.00170/full#F5. Figure 5 in that paper describes how to make priorities among many health outcomes.

Further information on determining significance of health outcomes:

- A summary paper evaluating different risk matrixes is published by Elmonstri and is available here https://www.atlantis-press.com/journals/jracr/11718.
- A new guidance report from UK on establishing significance is available to download at IEMA website of https://web.iema.net/iemanet-ay0iq/pages/egwrxmxfee2vyqanoilk4g.html?PageId=5eab6510c565ed119561000d3a294ae2.

Appendix II. provides a possible way of identification of significant health outcomes using the Global Burden of Disease data.

Quantification of impact/data

Although health impact assessment or health assessment within environmental assessment often uses qualitative approach when analyzing potential health effects of policies and projects, use of quantitative methods can improve the information to decision makers, public and other stakeholders by estimating the magnitude of potential positive or negative effects of the policy or project.

Impact assessment often uses comparison with established limit values as a method of assessing whether there are health impacts expected or not, setting the limit value as a kind of threshold. There is however one risk related to this approach, and it is the issue of existence of different limit values. As an example, there are differences between noise limit values between Denmark and WHO[11] and different limit values for some air pollution substances between EC legislation and WHO recommendations. The reason for these differences is often due to differences between pure health science approaches (WHO) or overall societal priority approaches (EC or individual countries). A solution to avoid this problem is quantification of impacts based on existing dose-response relationships of risk factors and health outcomes.

Epidemiological methods and published epidemiological studies provide a great pool of knowledge upon relation of risk factors and health outcomes. They mostly provide a baseline for quantitative calculations of the impact. Use of epidemiological methods and interpretation of findings requires public health expertise, and assessors are always recommended to consult public health authorities.

In several cases, epidemiological knowledge has already been transformed into publicly available software tools to quantify specific health impacts. A likely non-exhaustive list of such tools and calculators is provided here:

- Dynamo HIA (National Institute for Public Health and the Environment, 2022) addressing behavioral risk factors available at https://www.dynamo-hia.eu/
- Contaminated Land Exposure Assessment (CLEA) tool (Environmental Agency, 2015) available at https://www.gov.uk/government/publications/contaminated-land-exposure-assessment-clea-tool
- AirQ+ (WHO Regional Office for Europe. 2020) available at https://www.who.int/europe/tools-and-toolkits/airq---software-tool-for-health-risk-assessment-of-air-pollution
- CaRBonH calculation tool available at https://apps.who.int/iris/handle/10665/346551
- Health equity assessment tool HEAT available at https://whoequity.shinyapps.io/heat/
- iSThAT: the Integrated Sustainable Transport and Health Assessment Tool available at https://www.who.int/europe/tools-and-toolkits/isthat--the-integrated-sustainable-transport-and-health-assessment-tool; under testing and expected to be available in 2023
- GreenUr: the Green Urban spaces and health tool available at https://www.who.int/europe/tools-and-toolkits/greenur--the-green-urban-spaces-and-health-tool; under testing and expected to be available in 2023
- Although not a standard calculator or tool, but calculation of noise related effects is well-described in Dutch report available at https://www.rivm.nl/bibliotheek/rapporten/2018-0121.pdf , especially chapter 3
- A noise impact assessment tool is available at https://www.datakustik.com/products/cadnaa/cadnaa

Databases with information about risk calculation methods relevant to health in EIA are available at different sources:

[11] https://ing.dk/artikel/danskere-maa-leve-med-hoej-flystoej-ny-graensevaerdi-langt-whos-anbefalede-260028

- Global burden of disease database and study especially the risk part of it available at https://vizhub.healthdata.org/gbd-compare/ (Institute of health metrics and evaluation of University of Washington, 2022)
- Toxicology oriented database and guidance ToxTutor (University of California, Davis, 2021) available at https://www.toxmsdt.com/0-toxtutor-home.html
- PubChem – a database with information about chemicals (National Center for Biotechnology Information, 2022) https://pubchem.ncbi.nlm.nih.gov/
- IARC Monographs on the Identification of Carcinogenic Hazards to Humans (IARC, 2022) available at https://publications.iarc.fr/Book-And-Report-Series/Iarc-Monographs-On-The-Identification-Of-Carcinogenic-Hazards-To-Humans

Despite of growing number of software tools and databases to enhance quantification of human health impacts of policies and projects, there are cases when quantification needs to be considered "by hand" as software' is not available. Therefore, in following we provide a list of human health risk assessment methodology guidelines and tools:

- WHO Human Health Risk Assessment Toolkit: Chemical Hazards (IPCS, 2010) available at https://www.who.int/publications/i/item/9789241548076
- Chapter 5: Health Risk Assessment (EEA, 2020) available at https://www.eea.europa.eu/publications/GH-07-97-595-EN-C2/chapter5h.html
- Human Health Risk Assessment (USEPA, 2022) available at https://www.epa.gov/risk/human-health-risk-assessment
- Health Risk Assessment (NSW Health, 2022) available at https://www.health.nsw.gov.au/emergency_preparedness/planning/Pages/health-risk-assessment.aspx

Appendix I: Health outcomes related to determinants.

Table 2: Impact pathway within the assessment process.

Project	Determinants of health		DK Limit values	Population at risk	Health effects	Quantification tools*
	Main group	Sub-category				
	Environmental determinants	Noise	If exceeded continue to population at risk description and quantification	Total number, age, sex, education, income, etc.	1. Annoyance 2. Sleep disturbance 3. Cognitive impairment 4. Hearing impairment – ICD 11 code AB5Z 5. Tinnitus – ICD 11 code MC41 6. Hypertension – ICD 11 code BA 00 7. Stroke – ICD 11 code 8B11 8. Cardiovascular disease -ICD 11 code – BE2Z 9. Immune effects Source of information: https://www.euro.who.int/__data/assets/pdf_file/0008/383921/noise-guidelines-eng.pdf https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1637786/pdf/envhper00310-0128.pdf https://www.eea.europa.eu/publications/health-risks-caused-by-environmental	https://www.datakustik.com/products/cadnaa/cadnaa

		Air pollution degassing, particles, PM10, PM2,5, Sulphur, NOx, carbon monoxide			1. Lower respiratory infection, ICD 11 code – 1C12 2. COPD (KOL), ICD 11 code – CA22 3. Cardiovascular disease ICD 11 code – BE2Z 4. Stroke, ICD 11 code 8B11 5. Trachea, bronchus and lung cancer, ICD 11 code 2C25 6. Impaired brain development among children – ICD 11 code 6D71 7. Daily mortality Source of information: https://vizhub.healthdata.org/gbd-compare/ https://www.euro.who.int/__data/assets/pdf_file/0006/298482/Health-risk-assessment-air-pollution-General-principles-en.pdf	https://www.who.int/europe/tools-and-toolkits/airq---software-tool-for-health-risk-assessment-of-air-pollution
		Shadow cast			1. Annoyance 2. Stress 3. Sleep disturbance 4. Un-specified acute health effects 5. Un-specified chronic health effects Source of information: Hubner G, Pohl J, Hoen B, Firestone J, Rand J, Elliott D, Haac R: Monitoring annoyance and stress effects of wind turbines on nearby residents: A comparison of U.S. and European samples, Environment International 132 (2019) 105090	

		Vibration			1. Headaches 2. Motion sickness 3. Sleep and visual disturbances 4. Stomach problems 5. Chronic back pain (occupational mostly), ICD 11 code ME84.2 6. Other heterogenous effects	Good information source including a risk assessment tool is available here: https://www.healthyworkinglives.scot/workplace-guidance/health-risks/vibration/Pages/common-hazards-and-controls.aspx
		Contaminated soil			To identify the health effects the specific pollutant must be identified. Source of information: Steffan JJ, Brevik EC, Burgess LC, Cerdà A. The effect of soil on human health: an overview. *Eur J Soil Sci*. 2018;69(1):159-171. doi:10.1111/ejss.12451	
		Radiation, radioactive material, radon, low-frequency radiation, electromagnetic radiation.			1. Tracheal, bronchus and lung cancer – ICD 11 code 2C25 Source of information: https://vizhub.healthdata.org/gbd-compare/ Source of information including calculation of impact: Elvin S. Cheng, Sam Egger, Suzanne Hughes, Marianne Weber, Julia Steinberg, Bayzidur Rahman, Heather Worth, Alberto Ruano-Ravina, Patrick Rawstorne, Xue Qin Yu European Respiratory Review 2021 30: 200230; DOI: 10.1183/16000617.0230-2020	

		Fire, explosion, toxic exposure, accidents, etc.			In this case it is impossible to make a final list of health effects as they need to be related to specific event. Therefore, I enlist the most likely effects, but not in order of importance or time sequence: • Mesothelioma (type of cancer) ICD 11 code 2C26.0 • Tracheal, bronchus and lung cancer ICD 11 code 2C25 • Back pain ICD 11 code ME84.2, • Larynx cancer, ICD 11 code 2C23 • Road injuries, ICD 11 code PA0Z • Asthma, ICD 11 code CA23 • COPD, ICD 11 code CA22 • Falls, ICD 11 code PA6Z • Ovarian cancer, ICD 11 code 2C73 Source of information: https://vizhub.healthdata.org/gbd-compare/	
		Visual impact			Health outcomes are mostly related to better recovery and stress management and cannot be set into time sequence or priority order: • Mental health issues • Stress management • Fast rehabilitation of physical illness • Overall well-being Source of information: M.D. Velarde, G. Fry, M. Tveit, Health effects of viewing landscapes – Landscape types in environmental psychology, Urban Forestry & Urban Greening, Volume 6, Issue 4, 2007, Pages 199-212, ISSN 1618-8667. https://doi.org/10.1016/j.ufug.2007.07.001.	

		Light impacts (visual)			1. Sleep, mood, and circadian rhythm disruption (leading in extreme cases to cardiovascular diseases or breast cancer – unlikely on population level!) 2. Thermal and chemical effects leading to skin cancer and other types of melanomas. 3. Eye diseases like cataracts ICD 11 code9E1Z Source of information: https://ec.europa.eu/health/scientific_committees/opinions_layman/artificial-light/en/index.htm	
		Flooding, bad indoor climate, perception of safety.			1. Diarrhoeal diseases ICD 11 code ME05.1 2. Stress 3. Mental health 4. PTSD – ICD 11 code 6B40 5. Respiratory, skin and eye infections 6. Injuries 7. Drowning Source of information: https://www.euro.who.int/__data/assets/pdf_file/0020/189020/e96853.pdf	
		Odor impact, ammonia, odorants			• Eye, nose, throat irritation • Headache • Nausea • Diarrhea ICD 11 code ME05.1 • Shortness of breath • Mood alterations Source of information: Schiffman SS, Williams CM. Science of odor as a potential health issue. J Environ Qual. 2005 Jan-Feb;34(1):129-38. PMID: 15647542.	

		Drinking water quality, pesticides, nitrate.			The specific pollutant must be defined to add the relevant health effect and risk calculation process: • Diarrhea ICD 11 code ME05.1 • Gastrointestinal diseases ICD 11 code DE2Z • Cancer Source of information: https://vizhub.healthdata.org/gbd-compare/ Source of general guidance: https://www.who.int/publications/i/item/9789241549950 Source to assess the impact: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3948022/pdf/ehp.1206229.pdf	
		Quality of bathing water, toxic algae.			• Gastrointestinal diseases • Diarrhea ICD 11 code ME05.1 • Respiratory infections • Skin diseases Source of information: Gary S. Russo, Sorina E. Eftim, Alexandra E. Goldstone, Alfred P. Dufour, Sharon P. Nappier, Timothy J. Wade, Evaluating health risks associated with exposure to ambient surface waters during recreational activities: A systematic review and meta-analysis, Water Research, Volume 176, 2020, 115729, ISSN 0043-1354, https://doi.org/10.1016/j.watres.2020.115729.	

		Public transport, barrier effect.			1. All-cause mortality 2. Cardiovascular disease 3. Diabetes Source of information: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0069912	
		Possibilities for physical activity, access, paths.			Range of health outcomes depending on specific situation; in most cases positive impacts are reported as consequence of improved physical activity possibilities. It is impossible to make an order of significance: • psychiatric diseases (depression, anxiety, stress, schizophrenia), • neurological diseases (dementia, Parkinson's disease, multiple sclerosis), • metabolic diseases (obesity, hyperlipidemia, metabolic syndrome, polycystic ovarian syndrome, type 2 diabetes, type 1 diabetes), • cardiovascular diseases (hypertension, coronary heart disease, heart failure, cerebral apoplexy, and claudication intermittent), • pulmonary diseases (chronic obstructive pulmonary disease, asthma, cystic fibrosis), • musculo-skeletal disorders (osteoarthritis, osteoporosis, back pain, rheumatoid arthritis), • cancer Source of information: https://doi.org/10.1111/sms.12581 https://apps.who.int/iris/bitstream/handle/10665/345335/WHO-EURO-2021-3409-43168-60449-eng.pdf	

		Recreation, access to green areas, parks, etc.			Range of health outcomes depending on specific situation, very similar to access to physical activity in previous row https://apps.who.int/iris/bitstream/handle/10665/345335/WHO-EURO-2021-3409-43168-60449-eng.pdf	

*To include cumulative and synergistic effect composite measures can be used such as DALY (YLL, YLD) or QALY

Appendix II: Establishing significant health outcomes based on Global Burden of Disease study

Significance of diseases with respect to years lived with disability according to Global Burden of Disease study (https://vizhub.healthdata.org/gbd-compare/)
Data were analyzed on 03/07/2023 and only diseases linked to environmental or occupational risk factors were considered. Data for Denmark, year 2019 were used.

Significance means percentual share on total YLDs lost by the disease and the % attributable fractions means the percent of disease caused by the environmental risk factors. The attributable fraction is always for all environmental risk factors together, not individually. It can be presented individually as well but only for limited number of risk factors.

With injuries and mechanical forces, the risk factor part is left open, as it can be very different, though mostly related to transport accidents. Those causes of disability can be relevant during construction phases of projects.

Unfortunately, the age group below 70 could not be split up. It also includes age group below 20. The reason is unknown, but it might not be a major problem, as those diseases relevant for below 20 are also in below 70 age group.

Please note, that there might be small changes in tables after each GBD data update, and data needs to be updated. The next update is expected end of 2023 or early 2024.

Males

Age group <20

Disease	Significance as % of YLD	% attributable fraction to environmental risks	Risk factors
Back pain	7.54	9.58	Vibration
Asthma	4.66	2.9	Air pollution particulate matter
Hearing loss	0.78	4	Noise
Diarrheal diseases	2.68	5.48	Microbial water pollution
Falls	4.21	7.82	
Exposure to other mechanical forces	1.09	8.88	
Unintentional injuries	0.94	6.67	
Lower respiratory infections	0.075	5.1	Air pollution
Poisoning	0.17	6.13	
Pulmonary aspiration	0.057	5.52	
Motorcyclist road injuries	0.057	11.61	

Age group <70

Disease	Significance as % of YLD	% attributable fraction to environmental risks	Risk factors
Back pain	13.11	22.75	Vibration
Falls	4.67	19.32	
Diabetes type 2	2.76	8.63	Air pollution particulate matter
Hearing loss	2.23	15.25	Noise
COPD	2.1	16.81	Air pollution particulate matter
Other exposure to mechanical forces	1.83	19.82	
Asthma	1.65	12.57	Air pollution particulate matter
Unintentional injuries	0.98	19.38	
Diarrheal diseases	0.67	5.43	
Stroke	0.59	9.53	Air pollution particulate matter, noise
Fire, heat and hot substances	0.42	19.96	
Ischemic heart disease	0.38	9.07	Air pollution particulate matter, noise
Cyclist road injuries	0.32	19.54	
Motor vehicle and road injuries	0.29	20.02	
Motorcyclist road injuries	0.19	19.83	
Pedestrian road injuries	0.12	19.93	
Lung cancer	0.11	38.2	Air pollution particulate matter, radon
Poisoning	0.086	18.28	
Larynx cancer	0.034	11.3	Occupational chemical hazards

Age group >70

Disease	Significance as % of YLD	% Attributable fraction to environmental risks	Risk factors
Back pain	9.64	4.7	Vibration
COPD	8.24	16.48	Air pollution particulate matter
Hearing loss	6.66	4.94	Noise
Diabetes type 2	5.72	8.16	Air pollution particulate matter,
Falls	5.13	0.71	
Stroke	2.88	6.6	Air pollution particulate matter, noise
Atrial fibrillation	2.82	0.81	Lead exposure
Ischemic heart disease	1.77	6.4	Air pollution particulate matter, noise
Other mechanical exposures	1.36	0.93	
Unintentional injuries	0.69	0.89	
Lung cancer	0,38	57.28	Air pollution particulate matter, radon
Fire, heat and hot substances	0.27	0.94	
Motor vehicle road injuries	0.23	0.94	
Larynx cancer	0,063	24.31	Occupational chemical hazards
Mesothelioma	0.035	99.6	Asbestos – likely occupational

Females

Age group <20

Disease	Significance as % of YLD	% attributable fraction to environmental risks	Risk factors
Back pain	7.16	9.12	Vibration
Asthma	3.22	2.91	Air pollution particulate matter
Hearing loss	0.46	3.93	Noise
Diarrheal diseases	1.94	5.49	
Falls	2.88	1.92	
Exposure to other mechanical forces	0.41	1.93	
Unintentional injuries	0.79	1.59	
Lower respiratory infections	0.054	5.12	Air pollution
Intellectual disability	0.087	11.09	Lead

Age group <70

Disease	Significance as % of YLD	% attributable fraction to environmental risks	Risk factors
Back pain	12.06	18	Vibration
Falls	3.18	6.56	
Diabetes Type 2	1.91	8.58	Air pollution particulate matter
COPD	1.8	11.79	Air pollution particulate matter
Asthma	1.69	9.08	Air pollution particulate matter
Hearing loss	1.27	12.31	Noise
Unintentional injuries	0.6	6.85	
Stroke	0.56	9.63	Air pollution particulate matter, noise
Diarrheal diseases	0.47	5.43	
Other exposure to mechanical forces	0.43	6.9	
Fire, heat and hot substances	0.27	7.12	
Motor vehicle and road injuries	0.18	7.2	
Cyclist road injuries	0.13	6.89	
Lung cancer	0.084	18.83	Air pollution particulate matter, radon

Age group >70

Disease	Significance as % of YLD	% Attributable fraction to environmental risks	Risk factors
Back pain	10.97	1.69	Vibration
COPD	8.22	11.03	Air pollution particulate matter
Falls	7.84	0.035	
Hearing loss	5.24	2.96	Noise
Diabetes type 2	4.41	8.68	Air pollution particulate matter,
Stroke	2.47	6.22	Air pollution particulate matter, noise
Atrial fibrillation	1.64	0.8	Lead exposure
Ischemic heart disease	1.02	6.12	Air pollution particulate matter, noise
Unintentional injuries	0.54	0.056	
Lung cancer	0,24	21.79	Air pollution particulate matter, radon
Other mechanical exposures	0.42	0.059	
Fire, heat, and hot substances	0.21	0.063	
Motor vehicle road injuries	0.16	0.064	
Ovarian cancer	0.1	8.93	Hazardous chemical mostly in occupational setting