January 2026

VALESOR
Valuation of environmental stressors

Policy Brief

Complexity issues in the valuation of health effects from environmental stressors

Key messages

- Links between different pollutants, health endpoints and time scales need to be accounted for in economic assessments of health costs and benefits
- The lacking harmonization in existing health cost assessments underscores the need for generally agreed cost classifications and methods reporting requirements
- Transferring unit health costs between countries and over time requires assumptions that need to be transparently communicated

Health effects from pollution can be expressed by different indicators. The VALESOR tool (https://valesor.eu/valesor/the-valesor-tool) with its modules for air pollutants and chemical substances quantifies specific health endpoints in terms of attributable cases (e.g., premature deaths, cases of bronchitis) and in terms of Quality Adjusted Life Years (QALY)[i]. Both metrics are valued in monetary terms (monetised) through multiplication of quantified health indicators with unit costs, either for a specific health endpoint or for a QALY. VALESOR investigates new cases (incidence) of health effects as this is the relevant metric for assessing policy effectiveness.[ii] Incidence assessments account for the lifetime cost of illness.

Monetisation of health effects can help decision making in situations where such effects need to be compared with other effects that are expressed in monetary terms. Examples are the choice between policy alternatives that reduce different health effects, cost-benefit analysis (CBA) comparing expected health benefits with the costs of policies to reduce the health risk, or the comparison of the health benefits with other benefits of investment options or policies. Monetisation can also be useful in setting tax levels or in the analysis of the overall burden of disease expressed in a common unit. Analyses of monetised health effects from air pollution are regularly used in policy assessments by national governments and the European Commission, environmental agencies, or non-governmental organisations.

Transparent information about what unit health costs comprise is crucial to be able to appreciate any risk of over- or underestimation of health damage or benefit, and to perform robust assessments so that policy makers can have confidence in decisions. Such risks may be due to complexities and uncertainties involved in the assessment.

Complexity factors of health effect evaluations

Over- or underestimates in health unit costs may arise from various complexities:

- The need to assess lifetime costs for incidence-based assessments,
- The multitude of relevant health cost components,
- The methodological choices in their assessment,
- The contribution of different pollutants to the same health effects, the occurrence of health effects in the short- and long-term, and links between different health effects,
- The lack of comparable unit health costs assessments for all countries, which requires transfer of cost values between countries and over time[2],
- The time component in health cost assessment and uncertainties involved in the parametrisation of future projections.

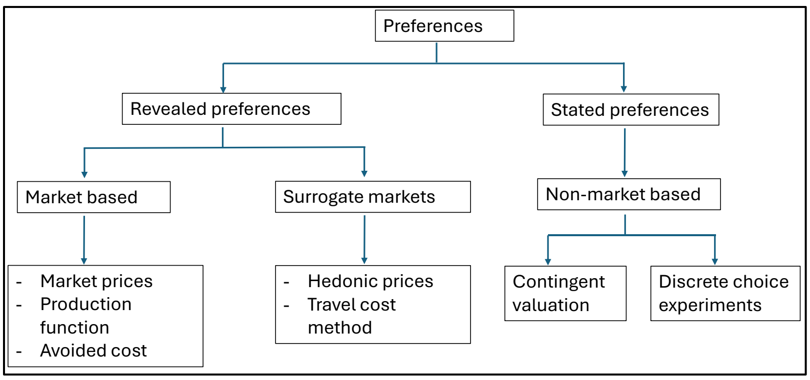

Figure 1: Valuation methods for market and non-market costs

VALESOR has studied these issues and provides recommendations on how to deal with them (see deliverable D4.2).

Health cost components covered by VALESOR

VALESOR recommends following a distinction into three main components of health damage costs and health benefits (avoided costs) as used for example in Hunt et al. (2016), OECD (2017) or Medina et al. (2025):

1. **Direct costs** refer to health care costs, such as costs for consultations, formal care, medication, medical exams, hospitalisation, emergency room visits, rehabilitation, home care, transportation ... They may be covered by health insurance or consist of out-of-pocket expenses by the patient and/or caretakers.
2. **Indirect costs** refer to productivity loss, which may relate to paid or unpaid work.
   a. Productivity losses in paid work include income losses to the patient and losses to the employer (e.g., lower productivity, absence from work, early retirement). Health insurance payments may partly or completely cover income losses to the patient.
   b. Productivity losses in unpaid care are the losses society experiences when people care for the patient without being paid (e.g., relatives taking time off from work or exchanging leisure time by unpaid care).
3. ***Disutility costs*** refer to the utility or welfare loss of the patient[iii] due to suffering, anxiety and loss of well-being caused by an episode of ill health.

Direct and indirect costs are often grouped together as Cost-of-Illness (COI). Direct and indirect costs of illness can be directly observed in monetary terms through market prices or estimated based on these (see the branch "revealed preferences" in Figure 1).
Disutility is a non-monetary measure; therefore, non-market valuation methods are required to express it in monetary units. In health cost assessment these are generally stated preference approaches (SP, right branch in Figure 1).
Disutility values are also assessed for mortality, in Europe mostly through SP.
Disutility can also be expressed in terms of QALYs or DALYs (see VALESOR deliverables D3.2 and D7.2).

Comparable unit health cost assessments for all countries are not readily available

Direct health costs may be identified from health registers, hospital records or health insurances. This requires detailed analysis to compile an average representative life-time cost per case of a given health endpoint that accounts for the evolution of the disease and its treatment over time. Expert input is required to identify possibly missing or underreported costs, or costs of co-morbidities that may be included or excluded, depending on the policy question. Productivity loss can be estimated based on surveys, cohort studies and statistics on illness leave and average wages.

VALESOR reviewed economic valuation studies of morbidity related to air and chemical pollution, systematically analysing literature from 2003 to 2023, covering 23 health effects known to be associated with air and chemical pollution (Kostopoulo et al., 2025; VALESOR deliverable D1.4). While the review provided valuable cost estimates it also revealed a significant variability in cost estimates, particularly within the same health endpoint. This variation is largely due to methodological differences between studies but also due to variation in the assumed severity of a given health endpoint. Differences in valuation techniques, included cost components, timeframes, study design, survey approach, population samples, and geographical context make comparisons challenging. Terminological inconsistencies add further ambiguity. The results call for greater transparency, harmonisation, and methodological consensus in the economic valuation of pollution-related morbidity. Developing standardised frameworks for cost estimation, reporting, and aggregation would substantially enhance the reliability and policy relevance of future assessments.

Stated preference methods to assess disutility use surveys asking a representative sample of the population about their willingness to pay (WTP) to attain a reduction in the risk of premature mortality or of developing a specific disease, typically for themselves. Using econometric analyses such surveys allow constructing a societal WTP of the disutility of a respective health endpoint.
To limit uncertainty and biases, such survey questionnaires must be precise and realistic in their instructions about the costs the respondents are to cover (for example not to include out-of-pocket expenses for an illness that should be covered under direct costs). The studies also must assess other reasons why respondents might under- or over-state their WTP and how important this might be.

VALESOR developed a health cost dataset for its tool

In establishing default unit costs per health endpoint, VALESOR has attempted to compile data that cover all relevant cost components (health care cost, productivity loss, disutility), that cover life-time costs and that are based on a representative sample of the population. The unit cost dataset included in the VALESOR tool distinguishes direct and indirect health costs and disutility.

VALESOR did not create COI estimates from health records but relied on existing scientific health cost valuation literature to identify COI. Instead of combining partial values from different studies, considered questionable because of the heterogeneity in the assessments, the VALESOR team considered it preferable to select a limited number of health cost studies that appeared to provide reasonably complete health costs for the health effects considered in the project and that transparently documented the methods used in compiling and processing the data (see VALESOR deliverable D3.5). These were in some instances multi-country studies directly providing health cost data for several countries in the geographical scope of VALESOR. These have the advantage of pointing to differences in the level and structure of costs between countries. Gap filling was applied to extend the data set to the whole UNECE[iv] region.

Disutility of morbidity and valuations of premature mortality were based both on relevant literature and on two original SP surveys carried out in several countries to assess disutility for a set of morbidity health endpoints (these are hereafter referred to as values of a statistical case, VSC), values for capturing the disutility of mortality (expressed in the Value of a Life Year Lost, VOLY, and the Value of a Statistical Life, VSL) and the value of a QALY (see VALESOR deliverables D3.1, D3.2 and D3.3) .The original SP surveys performed in the project put emphasis on being clear and precise to respondents what their trade-offs between health risks and willingness to pay to reduce those would be and that just disutility should be included in respondents' assessment.

All default values are calculated for 2020 and expressed in the same price year. Being based on a limited set of source studies, health costs were converted to all target countries and sub-UNECE regions, applying consumer price index (CPI) adjustments over time to account for inflation, and, where necessary, currency conversion between countries using purchasing power parity (PPP) adjusted exchange rates to account for the differences in purchasing power/living costs between countries.

Further conversion approaches are specific to health cost components. For direct health costs, health expenditure per capita was used to account for differences in the health systems between countries. Productivity losses were further adjusted between countries using GDP per capita ratios, to account for differences in wage levels, assuming that these are linked to the overall richness of a country. The disutility component was adjusted by GDP per capita PPP. The rationale here is that WTP estimates, used to value utility loss, are closely correlated with the level of income of the respondents in the SP surveys.

Variation in values between countries, e.g. with respect to wage rates (for productivity) or wealth (for disutility) should be recognised when carrying out analysis for a single country. However, when analysis concerns a common policy across multiple countries (e.g. across the EU, or across all UNECE Member States) VALESOR recommends using a value averaged across the countries that are covered by the analysis, as is common practice. Both types of values are part of the default data set.

The VALESOR tool contains a full set of default health cost data for the following morbidity health effects: acute lower respiratory infection in children, asthma in adults and in children, autism spectrum disorders, bladder cancer, breast cancer, colon-rectal cancer, COPD, dementia, diabetes, general cancer, Hodgkin lymphoma, hypertension, IHD events , lung cancer, prostate cancer and stroke. It also includes values for the two pervasively used mortality indicators VOLY and VSL as well as for the QALY indicator.

VALESOR accounts for interrelations between pollutants and health effects

Relations between pollutants and health effects can be complex and be of different kinds. The associated risk of double counting is more of an issue for work on air pollution than chemicals, given that the response functions for air pollutants are drawn from epidemiological research on exposure of the general public who are simultaneously exposed to a number of different air pollutants, and because the air pollution-health literature is richer, enabling quantification of a wide range of health impacts for a given pollutant.

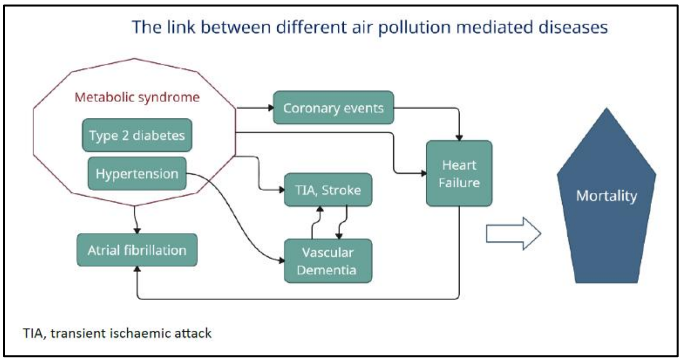

Figure 2: Interrelatedness of different health endpoints

Source: Forastiere et al., 2024

When epidemiological studies show that ***different pollutants are related to the same health effect*** and if the same population groups (age classes) are concerned, a simple addition of cases of the illness separately calculated for each air pollutant may overestimate the number of cases attributable to air pollution. Only accounting for the effects related to one pollutant would, on the other hand, underestimate the health burden. Epidemiological multi-pollutant modelling is required to assess the share of the cases attributable to each of the pollutants, and this is still in its beginning.

For all-cause mortality, part of which is both attributable to $PM_{2.5}$ and to NO_2, a recent publication (Chen et al., 2024) applying a two-pollutant model, allowed VALESOR experts to provide a method capable of calculating a combined relative risk function. It is implemented in the VALESOR air module and used by default when population exposure is reported for both pollutants. When using this function, the combined health effect result is lower than would be the sum of the attributable $PM_{2.5}$ and NO_2 cases calculated using the original response functions. However, the result is higher that the health damage attributed to each of the two pollutants. Available epidemiological evidence is not yet sufficient to calculate combined risk functions for other health endpoints relevant to the two pollutants. For these health endpoints users must not add up the monetised results.

Attention is also needed when dealing with acute health effects due to ***short-term (ST) pollution exposure and long-term (LT) effects*** from prolonged exposure. LT and ST mortality (for the same indicators) should not be aggregated, neither in the quantification of cases nor in the monetisation, as this would imply some double counting. Instead, they should be presented separately. It is generally not problematic to aggregate monetised results from LT mortality and from LT or ST morbidity. It is useful to quantify both LT and ST effects on morbidity, however in valuation attention needs to be paid to the risk of double counting (e.g. if a heart disease developed due to LT pollutant increases the risk of cardiac hospital admissions during ST pollution episodes and both are monetised). To avoid double counting between LT and ST effects, the VALESOR air module proposes a default selection including only long-term mortality when there is a risk of double counting. Short-term mortality can be selected at the same time – but only as user-made active choice.

Further issues relate to ***health effects being a subcategory of others***, in which case aggregation would imply an overestimate. For example, stroke and ischemic heart disease are subgroups of cardiovascular mortality, and COPD mortality a subgroup of respiratory mortality. In the VALESOR air module, lower-level health endpoints are indicated as "of which" relative to higher-level health endpoints and are not summed up into the total. For air pollutants and mortality, the preference is for using all-cause mortality estimates for monetised results because they are more comprehensive than the available cause-specific mortality response functions. Cause-specific mortality must not be added to all-cause mortality as this would result in double counting, and hence cause-specific mortality results should only be used to highlight the relative contributions of different diseases.

Finally, ***interconnections can exist between various diseases***, with some possibly acting as precursors to others. Figure 2 shows that diabetes and hypertension may lead for example to cardiovascular diseases, cerebrovascular events or stroke and eventually death. If not accounted for, such interconnections may lead to double counting, not in the quantification of health effects, but in their monetisation. This indicates that linking values to different health conditions requires an understanding of what those conditions are. This issue could not yet be accounted for in VALESOR other than by making users aware of the issue. The default cost-data for cost of illness in the VALESOR tool relies on selected studies that did not apply a pathway-based cost attribution. It is clearly one of the recommendations that future studies assessing unit costs for individual health endpoints consider these interdependencies and are transparent in the assumptions made and interdependencies accounted for in the valuation. Meanwhile, a pragmatic approach to dealing with the resulting uncertainty in monetised results is using sensitivity analysis. For the example of diabetes, to count as lower estimate only the damage of diabetes on the one hand, or of the health endpoints linked to it on the other hand (such as heart disease, stroke), and as higher estimate the sum combining all quantified effects.

VALESOR addresses the time component in health cost assessment

A time component is relevant in health cost assessment for various reasons that are outlined hereafter.
Assessing ***lifetime health costs*** per health endpoint requires the estimation of all future cost items throughout the duration of the illness and the calculation of a present value (PV) of these future cost streams. Present value is based on the concept that a sum of money in hand today is probably worth more than the same sum in the future because it can be invested and earn a return in the meantime. Calculating PVs works in the inverse way, by discounting future values. In the health cost assessment context, generally, a social discount rate (SDR) is applied, to calculate a current unit cost that can be compared to that of other health endpoints. Most countries, the EC and other institutions propose such a discount rate to be applied in the assessment of public policies or investments.

Discounting of future health costs (or benefits) is also recommended for chronic (LT) health effects that do not occur immediately after an increase in exposure but may take several years to emerge. This ***latency*** does not affect the quantification of health effects but their costs. It should hence ideally be accounted for in the unit cost estimated for such health endpoints. This requires knowledge of the exact lag structure (which part of the attributable cases would occur in which year following exposure? And over which time span?).
The default unit costs in the VALESOR tool do not account for latency. A first reason for this specifically for air pollution is that studies quantifying the lags between exposure to ambient air pollution and associated health endpoints are currently limited, thus there is high uncertainty surrounding knowledge in lag structures. More in general, accounting for latency also requires uncertain assumptions about how the unit health cost components will evolve over time and which discount rate to apply. Monte Carlo analyses carried out within VALESOR showed that under reasonable assumptions about growth and discount rates, the difference between an assessment accounting for latency and an assessment not doing so remains limited. Indeed, these different factors tend to cancel each other out to some degree (see VALESOR deliverable D4.2). Tool users wishing to account for latency can do so in postprocessing. An Excel table completing the VALESOR tool gives examples of discounting and calculation of present values.

Another consequence of lags is that even after an intervention has ended (e.g. equipment used for pollution control has come to the end of its life), the benefits of that intervention may continue to accrue for many years thereafter. This should be accounted for in health effect assessment to not introduce a bias in CBA and requires adapting the study period of a health impact assessment (HIA) to the time over which benefits occur.

When making health effect projections, time issues are also relevant because **health costs themselves may change over time**. The fact that prices may change due to inflation is dealt with when expressing prices in a specific price year, using a price index to make prices comparable over time. However, treatment methods may also become less costly over time when production becomes routine, for example due to economies of scale. Treatment methods may change, and this will both affect the costs of treatment but possibly also the effectiveness. A more sophisticated treatment may be more costly, but if it is more effective parts of the direct health costs may decline, and so may indirect health costs and disutility costs if symptoms become less severe. Finally, disutility costs, assessed through SP studies, are often thought to change over time with changes in GDP, as how much society is willing to pay to reduce a health risk also depends on income.
To avoid too many assumptions, the VALESOR tool takes a practical approach and uses a fixed unit cost per health endpoint that was established for 2020 and is expressed in $€_{2020}$ and which is applied in calculations for every year chosen by the user. Doing this assumes implicitly that while the unit health costs may change over time in nominal terms, they remain the same in real terms. If a user is not satisfied by this assumption, he or she may extrapolate the unit health costs over time. VALESOR recommends forecasting direct health costs by using the share of health expenditure per capita in GDP per capita in 2020 and extrapolate it using GDP per capita forecasts. For productivity losses and disutility cost it recommends using the GDP/capita in 2020 and forecast with GDP/capita projections. This is possible as the VALESOR tool provides damage or benefit estimates separately for the different components of health costs.

As a further simplification, and to keep the VALESOR tool flexible, it calculates only annual health burden (or benefits) that can be directly compared to annual (mitigation) costs, but no PVs. Calculating PVs for costs and benefits (or revenues) expressing them with their value at the start of a project or policy is recommended for CBA. This is so because policy measures often tend to involve important mitigation costs (investment) at the beginning of the project, in later years only operating and maintenance costs arise. Benefits, however, may occur over a long period. An unbiased assessment must take account of the current value of all future costs and benefits and adapt the time horizon of the study accordingly. A net present value (NPV) calculation, comparing costs and benefits with their value at the start of a project or policy would indicate whether the benefits exceed the costs or not.
PVs of the health costs estimated with the VALESOR tool can be calculated in postprocessing. VALESOR recommends using a SDR of 3% as supported by the EC (2021) when studies are for Europe or the whole UNECE, and a SDR of 5% for countries members of the cohesion fund (EU parliament, 2021). For national studies the choice of the SDR should rely on national recommendations. For studies reaching far into the future VALESOR recommends to additionally perform a sensitivity analysis using a SDR of 0%, consistent with intergenerational equity, as it values benefits and costs arising in the future equally to those arising in the base year.

Conclusions

- VALESOR guidance describes the complexity inherent in the valuation of health effects from environmental stressors and proposes easy to implement approaches for dealing with the complexity
- Default data and choices implemented into the VALESOR tool are developed to minimise the risk of over- and underestimation of health damage and health benefits
- Some simplifications in data and calculations are unavoidable and guidance and concrete calculation examples accompany the VALESOR tool to help users perform complementary calculations and sensitivity analyses in post processing steps
- Complexities in valuation, including the existence of alternative approaches, call for transparent documentation by users of the scope of the analysis, methods and data used and assumptions made. Uncertainties should also be documented
- VALESOR strongly invites its tool users to transparently communicate any divergence from default recommendations provided by VALESOR

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The VALESOR project aimed to make major contributions to the scientific- and policy communities, with efforts to accommodate economic values of environmental stressors more homogenously in policy making and planning. The environmental stressors of concern for VALESOR are chemical stressors including chemicals and pollutants transmitted via air, water, and soil vectors. The VALESOR project is supported by the EU's Horizon Europe Programme (Grant agreement ID: 101095430).

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[i] Quality-Adjusted Life Year is a generic measure of disease burden that includes both the quality, and the quantity of life lived. One QALY equates to one year in perfect health, 0 QALY equates to death, with scores between the two reflecting various levels of ability, experience or incapacity. The alternative health-adjusted life year indicator, Disability-Adjusted Life Years (DALY), represents a year lost due to ill-health, disability or early death.

[ii] The alternative approach quantifies all cases (new and preexisting) cases of health effects in a given period. This is referred to as prevalence. Existing cases cannot be avoided through policy action.

[iii] Ideally, the disutility also to family and friends should be accounted for. However, most SP studies consider the effect only for the patient. Including altruism in SP studies needs to be controlled to avoid the risk of double counting, when the part of the WTP that the individual devotes to reducing the risk to other individuals is already considered by the WTP given by the other individuals.

[iv] Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Rep., Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Iceland, Norway, Switzerland, Türkiye, Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyz Republic, Moldova, Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan, Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Serbia