Assessing the health impacts of waste management in the context of the circular economy
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Abstract

The circular economy (CE) is about increasing re-use, recycling and energy recovery from existing resources, whilst minimizing disposal. This report considers the public health implications for CE transition relevant to the waste sector. The use of health impact assessment (HIA) is considered as a tool to support strategic and project level decisions about waste management policy and infrastructure. Six HIA case-studies and a literature review are presented, pointing to potential win-wins for the CE and population health. This is particularly the case when it is technically and economically feasible to transition from unsanitary landfill that releases hazardous leachate or open air burning of waste, to modern well operated and maintained energy and materials recovery practices that have greatly reduced health risk profiles. HIA that considers the wider determinants of health and health inequalities can articulate the benefits and risks, supporting more sustainable development practices.

Key words

WASTE MANAGEMENT
HEALTH IMPACT ASSESSMENT
SUSTAINABLE DEVELOPMENT
SCOPE OF PRACTICE
HEALTH RISK ASSESSMENT

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**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>AD</td>
<td>anaerobic digestion</td>
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<tr>
<td>As</td>
<td>arsenic</td>
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<tr>
<td>BLD</td>
<td>below the limit of detection</td>
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<tr>
<td>BTEX</td>
<td>benzene, toluene, ethylbenzene and xylene</td>
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<td>CE</td>
<td>circular economy</td>
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<td>CI</td>
<td>confidence interval</td>
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<td>COPD</td>
<td>chronic obstructive pulmonary disease</td>
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<td>CR</td>
<td>carcinogenic risk</td>
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<td>DHB</td>
<td>district health board</td>
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<td>EIA</td>
<td>environmental impact assessment</td>
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<td>EU</td>
<td>European Union</td>
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<td>e-waste</td>
<td>electrical and electronic equipment waste</td>
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<td>HHRA</td>
<td>human health risk assessment</td>
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<td>HI</td>
<td>hazard index</td>
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<td>HIA</td>
<td>health impact assessment</td>
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<td>HQ</td>
<td>hazard quotient</td>
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<td>HR</td>
<td>hazard ratio</td>
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<td>IED</td>
<td>industrial emissions directive</td>
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<td>IR</td>
<td>intake rate</td>
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<td>LTCP</td>
<td>long-term consultation plan</td>
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<td>MSW</td>
<td>municipal solid waste</td>
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<td>MWI</td>
<td>modern waste incinerator</td>
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<tr>
<td>OCDD</td>
<td>octachlorodibenzodioxin</td>
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<td>OR</td>
<td>odds ratio</td>
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<tr>
<td>PAHs</td>
<td>polycyclic aromatic hydrocarbons</td>
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<td>PBDEs</td>
<td>polybrominated diphenyl ethers</td>
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<tr>
<td>PCBs</td>
<td>polychlorinated biphenyls</td>
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<tr>
<td>PCDDs</td>
<td>polychlorinated dibenzo-p-dioxins</td>
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<td>PCDFs</td>
<td>polychlorinated dibenzo-furans</td>
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<tr>
<td>PM</td>
<td>particulate matter</td>
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<tr>
<td>PM$_{10}$</td>
<td>particulate matter with a diameter less than 10 micrometres</td>
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<tr>
<td>PM$_{2.5}$</td>
<td>particulate matter with a diameter less than 2.5 micrometres</td>
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<tr>
<td>POPs</td>
<td>persistent organic pollutants</td>
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<tr>
<td>RAIS</td>
<td>risk assessment information system</td>
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<td>ROS</td>
<td>reactive oxygen species</td>
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<td>RR</td>
<td>relative risk</td>
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<tr>
<td>SEA</td>
<td>strategic environmental assessment</td>
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<tr>
<td>TEQ</td>
<td>toxic equivalent</td>
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<tr>
<td>US EPA</td>
<td>United States of America Environmental Protection Agency</td>
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<td>VCs</td>
<td>volatile compounds</td>
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<td>VOCs</td>
<td>volatile organic compounds</td>
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<td>WDC</td>
<td>Wairoa district council</td>
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<td>WEEE</td>
<td>waste electrical and electronic equipment</td>
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<tr>
<td>WHIASU</td>
<td>Welsh Health Impact Assessment Support Unit</td>
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<td>WHO</td>
<td>World Health Organization</td>
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Executive summary

The circular economy (CE) is a concept of moving the use of resources from a linear model, of extract-use-discard, to a circular model, of reuse-recycle-recover. The CE minimises both the extraction of new virgin resources and the dumping or burning of waste. CE is a part of sustainable development and tackling climate change.

This report discusses the waste sector as one element of a CE. Actions in the waste sector determine whether resources are lost from the system (discarded), or maintained within the system (re-used, recycled or energy recovered).

This report considers how impact assessment (IA) is used to identify the implications for population health that arise from decisions in the waste sector.

IA may be at the strategic level looking at changes in legislation, policy, plans or programmes. IA may also be at the individual project level.

Health impact assessment (HIA) is a process used to systematically judge the potential and sometimes unintended effects of proposals on the health of a population, and the distribution of those effects within the population.

HIA may be undertaken as part of other forms of IA, such as strategic environmental assessment (SEA), environmental impact assessment (EIA), environmental and social impact assessment (ESIA), or as a standalone HIA report.

This report discusses a range of HIA examples to highlight issues of relevance to the CE transition. The examples span decision-making levels and different types of waste management. Importantly, the selected examples do not imply any endorsement of the projects they assessed.

The audience for this report is both those who make policy and planning decisions in the area of waste management and those who are involved in undertaking HIA. The report focuses on the WHO European Region but also considers examples and scientific evidence outside the Region.

The waste management hierarchy is fundamental to CE delivery. In order of preference, it is prevention of waste; followed by re-use; recycle; energy recovery; and finally if other options are exhausted, disposal.

The report focuses on four types of waste management:

- materials recycling, including processes for the dismantling, treatment and recovery of used electrical equipment and components (re-use and recycling);
- bio-organic waste treatment, including open composting and anaerobic digestion (recycling and energy recovery);
- thermal treatment processes, including mass burn incineration, pyrolysis and gasification (energy recovery); and
• landfills, including inert and municipal solid waste landfills (disposal).

The research question asks: how are human health impacts of waste management practices informing strategic and project level decisions that influence the transition to a CE based on HIA examples and the scientific literature?

The report responds in three ways:

• Six case studies of waste management projects, outlining the decision-making level informed, scope, methods applied, assessment output conclusions and useful transferable information.

• A literature review of the health evidence base associated with waste management practices, focusing on thermal treatment, landfill, bio-organic treatment and materials recycling.

• An analysis supporting discussion of the merits of integration of HIA within EIA and SEA to better inform strategic and project level decision-making on the health dimensions of the CE.

The literature review search strategy used PubMed and Google Scholar to review the health evidence base pertinent to waste management and the CE. The search was conducted by two researchers. Being a pragmatic scoping review the coverage of the topic areas is not exhaustive. For each of the four waste management processes between 50 and 200 titles were reviewed. The citations of selected sources were also reviewed and some additional articles included on that basis.

Case study identification and selection used a layered survey approach where examples of HIAs were requested from the intentional HIA practitioner community using international HIA networking platforms. This responded to the risk of selection bias through a snowballing effect to the sampling, which increased the pool of sources geographically and in terms of originating HIA practitioners: 46 candidate case studies were identified through this convenient sampling approach. From these, six case studies were selected on the basis of providing diversity across: type and level of IA; geography; sector; and demonstration of good practice.

The following six case studies were selected. The geographic scope extends beyond the WHO European Region:

• Case study 1: Draft Wales waste strategy (United Kingdom, 2008);
• Case study 2: Hightown Quarry residual waste management facility (United Kingdom, 2014);
• Case study 3: Chisinau solid waste project (Republic of Moldova, 2017);
• Case study 4: Khmelnitsky solid waste project (Ukraine, 2020);
• Case study 5: Vinča energy from waste facility and landfill remediation (Serbia, 2018); and
• Case study 6: HIA on the draft Wairoa District Council waste management activity management plan (New Zealand, 2009).

The literature review found evidence of the benefits of moving away from purely landfill disposal, to increasing materials recovery and energy recovery. Such a transition supports both a transition to a CE and reduced population health risks.

The review found that alternatives to landfill are most beneficial in areas where landfills are poorly managed, for example when landfill waste is not contained and therefore leachates...
contaminate local waters and soils. Such poorly managed landfills have particular health risks where hazardous waste is not removed.

The review found that technologies and operating practices can greatly reduce the potential health hazards associated with recovering materials and/or energy. There remain uncertainties and risks to health, but the evidence indicates that such CE promoting approaches are to be encouraged.

The transition to more sustainable waste management with low health risks entails substantial economic cost. Costs relate to remediation of historic sites, investment in purchasing and maintaining modern technologies and transitioning employment to avoid lost livelihoods.

The pool of candidate case studies included very few explicit references to the CE. Even at the strategic level, assessments focused on implementing a waste management hierarchy, rather than broader implementation of the CE. This likely reflects a waste sector focus to case collection, but also the inherent challenge of CE implementation as an intersectoral endeavour.

In terms of defining health, the case studies showed that rather than using a specific definition of health, it is more common for the HIA to simply list relevant determinants of health in order to set a scope of issues to discuss.

The range of determinants of health covered is consistent with the wider determinants of health approach that is implicit to the definition of health set out in the 1948 preamble to the WHO Constitution. Alignment to that definition, ideally explicitly, is considered good practice.

In general, the case studies covered a suitable range of social, behavioural, economic and institutional determinants. This is consistent with adopting a broad public health approach, rather than solely that of environmental health protection. The most frequent health determinants assessed were air quality, noise, water quality, transport and socioeconomic factors such as employment.

Project level HIAs tended to be more detailed and more likely to adopt a mix of both qualitative and quantitative approaches. However, the strategic health assessments, whilst qualitative and less detailed, tended to have a greater opportunity to inform and influence policy and strategic direction in favour of improved population health.

The case studies demonstrated that the connection between strategic and project levels is crucial in supporting transition to a CE. The strategic level assessment and decision-making needs to create a policy context where the type of projects brought forward support the CE. At the project level there is limited opportunity to change the type of waste management solution being pursued.

A noted trend is that HIA is more common, and perhaps more influential, as a result of SEA, EIA and ESIA requirements, particularly those that are driven by legal requirements established by the European Union (EU). This is due to the explicit requirements to cover health under EU strategic and project level environmental assessment directives.

The inclusion of wider determinants of health in both standalone HIA reports and as part of integrated health assessments in SEA, EIA and ESIA is considered good practice that should be promoted. This supports more informed
decision-making about the public health implications of waste management projects. Where decision-makers have access to the full picture of likely significant public health consequences of a proposal, whether strategic or project level, this is likely to favour selection of options that support a CE transition.

The CE benefits to public health are not only environmental, but also social, behavioural, economic and institutional.

- In general, material recycling and waste recovery is, with modern approaches and technologies, less hazardous to health than unregulated landfilling or open-air burning of waste.
- The CE also promotes more skilled, and therefore potentially better paid, waste industry jobs, with good quality employment being a strong driver of health.
- The CE also adds resources back into economic markets, further promoting health outcomes associated with economic prosperity.
- Environmental quality and its amenity value may also be improved by better waste management practices, increasing food safety, levels of physical activity and well-being associated with community aesthetics and social networking.
- Institutionally, less demand on health services as a result of better population health brings wider societal financial savings, supporting further health investment and a healthier, more productive, society.

The public health benefits of a transition away from landfill to modern energy and material recovery is more evident within the EU than some other parts of the Region. This is linked to legislative and policy drivers that promote CE practices. The benefits and practices are informative for non-EU countries as they progress towards a CE approach.

Whilst the waste sector is influential for the CE, the CE challenge is intersectoral, also covering extractive industries, manufacturing, retail and energy sectors. HIA is a tool that can be used both within and across sectors to facilitate the CE transition and promote population health. Although perhaps outside of the waste sector’s control, the avoidance of waste in the first place is also a critical component of the CE and one that HIA can support in other sectors.

This report shows that HIA can successfully be used to inform strategic and project level decisions that guide the transition to a CE. This is the case even where the CE links are implicit rather than explicit, and where decision-making is limited to a single sector, rather than being intersectoral.

Where HIA covers the wider determinants of health and assesses inequalities, the case can be made for shifting up the waste management hierarchy, away from disposal. This reflects that the health evidence base reviewed finds potential hazards associated with the management of waste, particularly for historic practices of unsanitary landfill and early incinerator technologies.

Population health risks broadly reduce further up the waste management hierarchy, with wider benefits also accrued. This assumes adoption of well designed, operated and maintained modern waste management practices.

Whilst uncertainty remains with some modern technologies, there are more certain known
hazards from historic practices. Historic practises with known hazards include either the open-air burning of waste, or the landfilling of waste without a liner such that hazardous leachate escapes from the landfill and causes contamination.

There are win-win synergies between the CE and health. In practice this would mean diverting more waste from being simply burnt or landfilled, to increasing levels of re-use, recycling and energy recovery using modern practices.

This report concludes that there are examples where HIA is successfully explaining the public health implications of waste management practices.

The extent to which this influences the CE transition is often dependant on the HIA adopting a wider determinants of health approach. This is the case whether the HIA is a standalone report or integrated within other IA.

A key learning point is that the efficacy of HIA in promoting the CE is often dependant on strategic level decisions limiting the project level options to those that are high on the waste managing hierarchy. Without this there is not a driving force to realize the environmental and health benefits.

Waste sector HIA at both the strategic and project level should be promoted and also linked.

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CHAPTER 1

Linking health impact assessment, waste management and a circular economy

This report builds on recent publications by the World Health Organization (WHO) and impact assessment (IA) community on the circular economy (CE) (WHO, 2018; WHO, 2019; IAIA, 2021).

The CE is a concept that seeks to transition the macro level flows of resources within our society from a linear model, of extract-use-discard, to a circular model, of reuse-recycle-recover. In the CE, dumping or burning of resources as waste and the extraction on new virgin resources are both minimised (WHO, 2019).

Inherent to such a shift in approach is the adoption of a CE-supporting waste hierarchy, which is, in order of preference: prevention of waste; followed by re-use; recycle; energy recovery; and finally, if other options are exhausted, disposal (WHO, 2018).

The CE concept is part of the global transition to sustainable development practices, including in response to climate change (IAIA, 2021). A key mechanism being that a CE supports attainment of the Sustainable Development Goals (SDG) (WHO, 2018). There are synergies between all the SDGs. Of particular relevance in the context of the CE and health are SDG-3 “to ensure healthy lives and promote well-being for all at all ages” and SDG-12 “to ensure sustainable consumption and production patterns”.

The concept of a CE is a macro-economic objective. Its full implementation would involve all sectors in all countries globally (IAIA, 2021). The transition is of incremental steps across sectors, markets and localities towards ever greater resource use circularity. Progress will progressively improve levels of circularity and connectivity over time. For example, the CE can be promoted by implementing improved recycling and waste management systems (IAIA, 2021).

The CE is variously defined or described as:

- “a system intended to maintain and increase the stock of capitals by creating cycles” (IAIA, 2021).
- “reducing the use of primary resources, maintaining the highest value of materials and products, and changing utilization patterns” (WHO, 2018).
- “where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised” (European Parliament, 2015).

This report focuses on the waste sector as one element of the transition to a CE. The waste sector is key to resource cycling, governing whether resources are lost from the system (discarded), or maintained within the system (re-used, recycled or energy recovered). The waste sector is also influential in terms of its impact on environmental, social, behavioural, economic and institutional determinants.
of health. These include issues and health outcomes linked to hazards, amenity, product affordability, employment and health care use, including inequalities amongst community and occupational populations.

This report provides examples of how IA has been used to explore the health determinants and health outcomes associated with the waste sector. IA may be at the strategic level looking at changes in legislation, policy, plans or programmes, for example, using strategic environmental assessment (SEA). IA may also be at the individual project level, for example, using environmental impact assessment (EIA). IA may be driven by national legislation or by international finance lending requirements, for example, environmental and social impact assessment (ESIA). In all cases IA aims to support decision-making by analysing, and presenting findings on, the complex interactions that occur between industry, communities and the environment (IAIA, 2021).

Health impact assessment (HIA) is “a process which systematically judges the potential, and sometimes unintended, effects of a project, program, plan, policy, or strategy on the health of a population and the distribution of those effects within the population. HIA generates evidence for appropriate actions to avoid or mitigate health risks and promote health opportunities. HIA guides the establishment of a framework for monitoring and evaluating changes in health as part of performance management and sustainable development” (Winkler et al., 2021).

HIA may be undertaken as part of other forms of IA, such as SEA, EIA, ESIA, or as a standalone HIA report (IPH, 2021). It is noted that there is variation in: how the terminologies of SEA and EIA are used; the extent to which HIA is integrated within such assessments; and how broad a definition of health is used (WHO, 2022).

WHO notes the importance of including HIA, whether integrated or standalone, within both strategic level development for the CE, and also at the project level in terms of specific developments that support the CE (WHO, 2019).

In this, as with other, contexts the way health is defined is important to the IA undertaken and how this can support a transition to a CE that is a win-win for both the environment and human health (WHO, 2019):

• Health should be defined in its broadest sense as reflected in the WHO definition: “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1948).

• “This broad definition is consistent with the conceptualization of health as an outcome of multiple environmental and social determinants” (WHO, 2019).

• It is established that “good health and well-being require a clean and harmonious environment in which physical, psychological, social and aesthetic factors are all given their due importance.” (WHO, 1990).

• The definition of health, “includes ‘hard’ endpoints, such as mortality and morbidity, and ‘soft’ endpoints, such as well-being and quality of life, and their economic, social and environmental determinants” (WHO, 2019).

• The implication for IA is that “human health is greatly influenced by the numerous initiatives associated with CE transition that are beyond the health sector and affect health via a variety of pathways” (WHO, 2019).

• “It is proportionate for guidance on human health in SEA and EIA to require the
consideration of health inequalities, healthy lifestyles, safe and cohesive communities, socioeconomic conditions, environmental conditions and health and social-care services” (WHO, 2022).

• “The broad interpretation of health provides decision-makers with information on how health is affected directly by environmental change, and indirectly by the social, economic, behavioural and institutional consequences of environmental change” (WHO, 2022).

The use of IA in relation to the CE can help to identify at an early stage, and therefore avoid or reduce, areas of trade-off or conflict. For example, unintended consequences of a CE transition in relation to socioeconomic inequalities (IAIA, 2021) and health inequalities (WHO, 2018).

The WHO 2018 report explored the policy objective of a CE and its implications for human health. The report identified the potential for substantial health benefits. It also noted risks and evidence gaps, for example in relation to certain chemical, electrical and electronic wastes (WHO, 2018).

The following actions needed for the CE transition of waste management are highlighted:

- recycling
- efficient use of resources
- utilization of renewable energy sources
- remanufacturing, refurbishment and reuse of products and components
- the extension of product life
- treating products as services
- sharing of products
- prevention of waste, including designing out waste in products
- a shift in consumption patterns
- phasing down of incineration and landfill as options for waste (WHO, 2018).

Importantly CE implementation is more advanced in EU countries than non-EU countries within the WHO European Region (WHO, 2018). Within the EU the legislative and policy drivers for the CE mean that waste management companies have more widely adopted CE practices (WHO, 2018). Such practices, discussed in this report, may be informative for non-EU countries as they progress towards a CE approach within their waste management sectors.

It is acknowledged that the profile of health outcomes associated with waste practices that are less transitioned to CE practices, and/or which do not use modern technologies that minimise hazardous emissions, may differ from those that are associate with the case studies discussed.

Consequently, this report discusses a range of examples where waste is managed. These have been selected to highlight issues, both implicit and explicit, of relevance to the CE transition. This includes energy recovery technology with a lower risk profile in terms of known population health effects compared to alternatives such as unmanaged burning or dumping. However, where such unmanaged practices or technologies are not routinely adopted or regulated, the risks to population health from existing and transitioning waste management may be greater.
Potential positive and negative effects on health associated with the CE are summarized in the report as follows:

- The CE “offers an avenue to sustainable growth, good health and decent jobs, while saving the environment and its natural resources” (WHO, 2018).
- Furthermore, “direct and indirect benefits come from reducing the environmental impacts of manufacturing processes (and making cost savings in households and in the health sector) (WHO, 2019).
- “The potential negative health impacts identified relate to risks in the recycling and reuse of products, components and materials. This refers in particular to the management of chemicals of concern, such as bisphenol A (BPA) and brominated flame retardants (BFRs) in a variety of products, and to emissions from the composting of waste” (WHO, 2019).
- “Where negative impacts have been identified, their effects frequently fall disproportionately on vulnerable groups in Europe and globally. A key concern is the export of waste, such as e-waste, to dumping sites in developing countries, where the local population engaging in informal recycling is often more deprived than the general population.” (WHO, 2019).

This report follows on from previous WHO publications to extend understanding of how HIA has been used in the waste sector as part of the transition to a CE.

This report is intended as a thought piece and resource aid as to the potential health consequences of waste management pertinent to the CE. The target audience is broad, geared towards informing policy and planning decision-makers internationally, through to environmental and HIA practitioners when developing the scope and bespoke assessment of a waste management option.

The remainder of this report sets out the methods used, the results and a discussion. The report concludes with a summary of the salient points, lessons learnt, items for debate and areas of further research and development to build momentum towards a CE.
CHAPTER 2

Reviewing human health impacts and HIA of waste management practices

2.1 Research question

How are human health impacts of waste management practices informing strategic and project level decisions that influence the transition to a CE in the context of the WHO European Region based on HIA examples and the scientific literature?

2.2 Approach

The overarching aim of this report is to:

• highlight methods that best integrate health dimensions at the strategic level, for example, supporting SEA, and at project level, for example, supporting EIA;

• summarize the existing health evidence base most relevant to key aspects of the waste management sector CE transition; and

• provide further technical insight on the health dimensions of the CE.

This has been achieved through the delivery of the following objectives:

• Six case studies of waste management projects, outlining the decision-making level informed, scope, methods applied, assessment output conclusions and useful transferable information.

• A literature review of the health evidence base associated with waste management practices, focusing on thermal treatment, landfill, bio-organic treatment and materials recycling.

• Analysis supporting discussion of the merits of integration of HIA within EIA and SEA to better inform strategic and project level decision-making on the health dimensions of the CE.

To maintain a pragmatic and proportionate scope, this report focuses on the management of municipal waste streams, through the following:

• materials recycling, including waste electrical and electronic equipment (WEEE) processes for the dismantling, treatment and recovery of used electrical equipment and components (re-use and recycling);

• bio-organic waste treatment, including open composting and anaerobic digestion (recycling and energy recovery);

• thermal treatment processes, including mass burn incineration, pyrolysis and gasification (energy recovery); and

• landfills, including inert and municipal solid waste landfills (disposal).

This selection of topics reflects a breath of relevant management processes within a CE transition.

The selection is not exhaustive of all waste streams. Furthermore, even within the selected topics there are component waste streams or specialist management issues that are not covered by this report.
For example, the health consequence of:

- wastewater, clinical, hazardous, radiological and vehicle end-of-life;
- delayed waste management decision-making and illegal practices; and
- pre-treatment processes, such as mechanical biological treatment, mechanical heat treatment and autoclaving.

Across these more specific waste related topic areas there are various hazard profile variations and exposure dose-responses that would warrants a more bespoke review, including the relevance of national level regulation and emissions permitting.

2.3 Literature review search strategy

The objective of this literature review was to provide an update as to the current health evidence base pertinent to waste management and the CE.

Management of municipal waste streams make up the focus of this literature review. However, due to the sometimes-informal nature of some waste management methods (such as landfill), some of the studies included do not only relate to municipal waste.

To ensure the literature review remained focussed on reporting emerging evidence, journal articles published prior to 2011 (that is the past ten years) are generally excluded. However, older articles have been included where either the context is particularly important, or there is a lack of relevant publications in recent years comparative to other waste management methods.

The geographic scope of the literature review was unconstrained, with an international focus of research and practice by waste management option.

Using PubMed and Google Scholar, key search terms were entered in combination with the four specific waste management methods outlined in the introduction above to review the health evidence base pertinent to waste management and the CE. The search was conducted by two researchers. Topic terms considered: “thermal treatment” or “waste incineration”; “landfill”; “bio-organic waste treatment”, “open composting” or “anaerobic digestion”; and “materials recycling”.

The following search terms used were designed to capture literature which broadly investigates or assesses on or more health and well-being impacts: “health impact assessment”, “health impacts”, “health outcomes”, “physical health”, “mental health”, “well-being”, “population health”, “public health”, “mortality”, “hospital admissions”, “disease incidence” and “disease prevalence”.

In addition, the following search terms used were designed to capture more specific literature which focusses on assessing particular health endpoints: “respiratory disease”, “asthma”, “cardiovascular disease”, “adverse birth outcomes”, “congenital anomalies”, “reproductive health”, “cognitive impairment”, “cancer” and “gastrointestinal health”.

Occupational health focussed results were generally excluded unless they provided particular context, as the focus of this report is on community health impacts.

Table 1 summarizes the number of search results returned, and the number of articles included following a title review and accessing the full article. Being a scoping review only the most relevant articles returned by the search were reviewed, as determined by the database presentation of results by relevance. For each of
the four waste management processes between 50 and 200 titles were reviewed. The citations of selected sources were also reviewed and some additional articles included on that basis.

Table 1. Literature review search results

<table>
<thead>
<tr>
<th>Waste Management Process</th>
<th>No. returned</th>
<th>No. included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal treatment — waste incineration</td>
<td>1,940</td>
<td>13</td>
</tr>
<tr>
<td>Landfill</td>
<td>2,791</td>
<td>23</td>
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<tr>
<td>Bio-organic waste treatment:</td>
<td></td>
<td></td>
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<tr>
<td>Open composting</td>
<td>56</td>
<td>10</td>
</tr>
<tr>
<td>Anaerobic digestion</td>
<td>3,850</td>
<td>7</td>
</tr>
<tr>
<td>Materials recycling</td>
<td>1,780</td>
<td>8</td>
</tr>
</tbody>
</table>

2.4 Case study identification and selection

Whilst the academic literature describes certain waste management processes and potential health outcomes, it offers limited insight into current HIA practice in a waste management context.

Responding to this gap in published literature, a layered survey approach was applied where examples of published waste sector HIAs were requested from the intentional HIA practitioner community using international HIA networking platforms. A two-tier request was issued:

- the researchers’ approached their contacts at planning and environmental consultancies active in the waste sector IA field within the WHO European Region; and
- internationally recognized HIA practitioners were approached for further examples and further contacts via the LinkedIn HIA Group, HIANET and with the IEMA Health working group.

The survey should be considered closer to a convenience sampling approach than probabilistic sampling. However, this limitation is considered acceptable within the research aims of this report and yielded a diverse pool of candidate cases. Limitations are discussed below.

The survey was structured to collate the following:

- project name
- country
- waste management type
- date of completion
- the decision-making level it was intended to inform (strategic or project level)
- if it was a stand-alone HIA or integrated assessment.

By limiting the survey request to these parameters, it was possible to stratify candidate case studies obtained through the survey. This had two benefits: Firstly, it provided comparable data that aided in the purposeful selection of a subset of cases to write up. Secondly, the stratification allowed the researchers to perform a high-level analysis as to the nature, location, type and propensity for waste management HIAs. This is reported in the results section.

The collation of waste management HIA case studies was intended to be limited to, and show
breadth across the WHO European Region, to
gauge the general level of practice and inform
the case study appraisal selection. However,
given the range of examples identified,
obtained and shared via the international HIA
community, including those outside of the
Region, the geographic scope was expanded.
Due to the importance of EU legislation as a
driver for the CE and for IA within the WHO
European Region, there is a focus on the
former 28-EU countries to the case studies.
As noted, WHO has identified the EU as being
more progressed with waste management
practices that support a CE (WHO, 2018). The
learning from the presented case studies has
application across the WHO European Region,
particularly in cases where there are still waste
management practices that pose particular
hazards to health, such as uncontrolled burning
of waste, or the landfilling of waste without
leachate management.
Notable EU legislation underpinning the
transition to sustainable EU waste management
practices, includes the Waste Framework
Directive (Directive 2008/98/EC) (2008), the
Industrial Emissions Directive (Directive
2010/75/EU) (2010), which in 2014 replaced
(2000), and the Landfill Directive (Directive
1999/31/EC) (1999). In the EU there is also an
established basis for IA that considers human
health, as mandated by the EU SEA Directive
2001/42/EC (2001), including its regard to the
Protocol on SEA (2017) and, at the project
level, the EU EIA Directive 2014/52/EU (2014),
SEA and EIA directives require the identification
and reporting of the direct and indirect/
secondary likely significant effects of the
proposal on human health.
The 46 candidate case studies listed in Table 3
were subject to an initial review, to inform the
selection of six case studies to write up. The
initial analysis presented the following data for
each candidate case study (see Appendix B):
• project/country
• waste management type
• date
• process
• scope
• method.
Six case studies were purposefully selected
on the basis of providing diversity across the
following sampling framework criteria:
• Type and level of IA: coverage across both
strategic level, for example, SEA, and project
level, for example, EIA.
• Geography: preference for within the WHO
European Region, with a diversity across
Member States. Cases outside the WHO
European Region were also considered if
they contained key learning points.
• Sector: waste management sector, with
a range of approaches or technologies
for managing municipal waste streams,
specifically thermal treatment, landfill,
bio-organic waste treatment or materials
recycling.
• Emerging good practice: a focus on waste
practices that are supportive of the CE
transition, implicitly or explicitly; and which
use technologies or processes that reduce
known hazards to health.
Importantly, the selection of the case studies
does not imply any endorsement of the projects
assessed in the HIA or IA.
The following six case studies were selected:

• Case study 1: Draft Wales waste strategy (Wales, United Kingdom, 2008)
• Case study 2: Hightown Quarry residual waste management facility (Northern Ireland, United Kingdom, 2014)
• Case study 3: Chisinau solid waste project (Republic of Moldova, 2017)
• Case study 4: Khmelnitsky solid waste project (Ukraine, 2020)
• Case study 5: Vinča energy from waste facility and landfill remediation (Serbia, 2018)
• Case study 6: HIA on the draft Wairoa District Council waste management activity management plan (New Zealand, 2009).

While case study 6 is not from the WHO European Region, it has been selected as it demonstrates the benefits of HIA identifying local community values and reflecting them within the assessment.

These six case studies are reported in the results section.

The following analysis framework was used to extract consistent data from the case studies. The approach is based on qualitative thematic analysis, being both structured and flexible. The framework is not intended as a critical evaluation tool, rather it facilitates consistency across case studies to share process commonalities, scoping techniques, assessment protocols and HIA practice pertinent to a CE. The framework comprised the following sections, which are used as subheadings in the reporting of case studies:

• project summary and context
• decision-making level
• process and approach
• aims and objectives
• definition of health
• scope
• assessment methods
• outputs and key findings
• link to CE.

Limitations are covered within the discussion section in chapter 4 of this report. It is however worth noting at this stage that the pool of candidate case studies is heavily skewed towards United Kingdom examples. This reflects a convenience sampling approach, and that IA practice is particularly prolific in the United Kingdom compared to many other Member States of the WHO European Region. This is a limitation in terms of potential selection bias, constraining the extent to which this report reflects practice across the WHO European Region. It is also perhaps a strength in that it highlights elements of IA good practice that are more prevalent in the United Kingdom, including more consistent inclusion of wider determinants of health within assessments. Notwithstanding this skew within the wider sample, the selection of case studies to be written-up purposefully selected examples from across the WHO European Region, and beyond. Trends within the candidate case study pool are discussed in the results section.
CHAPTER 3

Coverage of human health and usage HIA for decision-making of waste management projects

The chapter is divided in three parts:

• a summary of the literature review findings, further details in Appendix A
• the candidate case studies identified, further details in Appendix B
• the six written-up HIA case studies.

3.1 Literature review summary

Introduction

The waste hierarchy includes energy recovery as the final waste management option prior to disposal. Incineration without energy recovery, that is burning waste as a disposal mechanism, is not supportive of the CE (WHO, 2018). This section discusses energy recovery using incinerators that are fed sorted waste streams as fuel, with heat and or electricity generated. The process aims for combustion techniques and use of abatement technologies that reduce the risk of hazardous emissions in comparison to simple open-air mass burning of waste. The more hazardous alternatives are not discussed in this review but may still occur in some Member States and would be associated with greater community and occupational health risks.

The literature reviewed focuses on the impact on respiratory health outcomes (Bae et al., 2020); cancer (Barjoan et al., 2020); reproductive health and adverse birth/childhood outcomes (Ghosh et al., 2019; Freni Sterrantino et al., 2019; Parkes et al., 2020; Vinceti et al., 2018; Xu et al., 2020); and cognitive impairment (Lung et al., 2020).

The scientific literature on waste incineration distinguishes between different technologies. These are variously described as either being more modern, that is third-generation, or being less sophisticated, that is first- and second-generation. Proprietary technologies vary, but the main differences relate to the selectivity of the input waste streams, the combustion process, use of abatement technologies and other design features, such as stack height, that reduce concentrations of any hazardous emissions. For modern, well-designed and operated third-generation facilities, none of the four systematic reviews relating to health impacts of waste incineration analysed identified any statistically significant health risks (de Titto & Savino, 2019; Cole-Hunter et al., 2020; Negri et al., 2020; Tait et al., 2020). This is likely a consequence of the EU Waste

Incinerators were classified according to three generations: first generation, plants active until 1989, (first European directive on waste incineration, 89/429/EEC); second generation, plants active between 1989 and 2006 (transition period: revamping or closing of old plants and building of new plants); third generation, plants active after 2006 (publication of BAT REF Waste incineration).
Incineration Directive (2000/76/EC) that spurred a step change in abatement technology, and associated reduction in the concentration and exposure to pollutants of concern.

Negri et al. (2020) looked at cancer, cardiovascular diseases (CVD) and respiratory diseases, pregnancy outcomes and congenital anomalies. That systematic review analysis found that adverse health impacts, such as a statistically significant excess risk of some cancers, specifically non-Hodgkin lymphoma and soft tissue sarcomas, was reported by studies of ecological or semi-ecological design for first generation incinerators, meaning those operating up to 1989. Studies on second-generation incinerators, operating between 1989 and 2006, found either no association or only borderline excess risk. No third-generation incinerator studies on cancer outcomes were identified by Negri et al., who state their results indicate that any excess risks associated with older first- and second-generation incinerators “were modest at most”. Incinerators in the EU have since introduced better technology that further reduces hazardous emissions, and therefore the risk of adverse health outcomes. Negri et al. conclude that the available evidence indicates that there is “no consistent excess risk” to the health outcomes of the general population or workers from third-generation incinerators.

Due to their relatively recent introduction in 2006, there is a lack of direct evidence relating specifically to third-generation plants. Of the evidence that does exist, the health outcomes are generally limited to short term impacts (Negri et al., 2020). The long latency period of some diseases (for example, cancer) means that more time is needed before any conclusive evidence is published (Tait et al., 2020; Barjoan et al., 2020; Negri et al., 2020). While this is the case, conclusions relating to chronic health outcomes associated with modern facilities are inferred from emission levels from modern plants being several orders of magnitude lower than older facilities (de Titto & Savino, 2019). The trend of lower risks being associated with second-generation incinerators compared to first-generation incinerators likely reflects the much more stringent controls over hazardous emissions. The further reduction in hazardous emissions associated with the third-generation incinerators is likely to extend this trend, further reducing risks to health.

Methodological limitations in the literature that exists (for example, unsophisticated exposure assessment and lack of control for confounding variables) also contribute to the inability to categorically conclude that there is an absence of any health impact associated with modern incinerators.

Being a combustion process modern incinerators have some emissions, including pollutants with non-threshold health effects such as fine particulate matter. However, the reviewed literature found no clear or consistent evidence to suggest significant adverse population health effects associated with modern incinerators (Negri et al., 2020).

The only exception to this was raised by Cole-Hunter et al. (2020) that suggested that using sorted feedstock is very important to reduce potential adverse health effects, whereby poorly fed facilities may emit concentrated toxins with serious potential health risks, such as dioxins/furans and heavy metals. While less relevant to countries complying with EU waste directives, this paper would suggest that countries with less stringent environmental regulations may
present a more substantial hazard, albeit still low risk.

**Landfill**

Regardless of what reduction measures, reuse or recycling is undertaken, without a complete transition to a CE, landfills are likely to continue to play a role in the waste management system for two main reasons. Firstly, not all types of waste can currently be recycled, reused or incinerated for energy recovery; and secondly, the amount of waste determined for recycling, reuse or incineration for energy recovery is, for the time being, likely to exceed available capacity (Vaverková, 2019).

Migration of contaminated leachate and biogas represent the two main types of environmental pollution associated with landfills which have the potential to impact human health. As previously stated, landfilling as a waste management method is popular worldwide, particularly in low- and middle-income countries, due to the relative low cost and low-technical requirement in comparison to incineration, which represents a more costly technology needed (Vaverková, 2019).

Sanitary landfills are engineered structures consisting of bottom liners, leachate collection and removal systems, and final covers in which municipal solid waste (MSW) is deposited by controlled operations in defined layers. Each layer being compacted and covered with soil before depositing the next layer. From the literature reviewed, few relate solely to sanitary landfills (Goorah et al., 2009; Elliott et al., 2001; Dvornic et al., 2011; Feuyit et al., 2019). However, in some cases, these landfills have been upgraded from previous unsanitary status (Dvornic et al., 2011; Feuyit et al., 2019).

Not all landfills are sanitary, and many consist of non-controlled disposals or open dumps where waste is not sorted. Equally, there may be a lack of leachate collection and treatment systems, poor separation of waste from the underlying soil or rock strata, and risk of contaminating ground water. The environmental and potential health implications of such sites are particularly prevalent in low- and middle-income countries, where the unsanitary nature of landfill sites are a contributing factor to potential adverse health impacts. For example, general health outcomes such as throat irritation, nausea, breathlessness, rapid breathing, asthma exacerbation or depression; as well as toxicological outcomes such as vomiting, ataxia, cardiovascular and renal diseases, diarrhoea or neurological diseases (Alawode et al., 2019; Istvan et al., 2019; Boateng et al., 2019; Esphylin et al., 2018; Negi et al., 2020; Odonkor & Mahami, 2020; Parth & Mukherjee, 2019; Rezapour et al., 2018; Norsa'adah et al., 2020). Similar outcomes were also found by two further studies (Tomita et al., 2020; Kumari et al., 2017). Much of the literature analysed is therefore of high relevance in many areas of the WHO European Region, though of less relevance to regulated landfill sites in the EU, for example, under the Landfill Directive (Directive 1999/31/EC).

Another issue with landfills is that even when they are managed to stringent regulations and standards, the deficiency of historic records (particularly for older landfills) means that uncertainties exist regarding the lower strata of waste. On this basis, it can be difficult to compare studies and determine causality of any identified health impacts (Istvan et al., 2019).

The literature reviewed focusses in part on general self-reported health impacts (such as flu, eye irritation, sore throat, nausea and
coughing) (Njoku et al., 2019; Norsa’adah et al., 2020; Tlotleng et al., 2019; Goorah et al., 2009). However, there is significant variation in results between sites, and due to the cross-sectional nature of the studies, and potential for reporting bias, a cause-effect relationship is not able to be determined.

Most of the literature analysed uses environmental and human health risk assessments to model and assess potential for exposure to leachate (Alawode et al., 2019; Boateng et al., 2019; Negi et al., 2020; Parth & Mukherjee, 2019; Rezapour et al., 2018) and biogas (Odonkor & Mahami, 2020). However, some biogas focussed studies were epidemiological (Mataloni et al., 2016; Esphylin et al., 2018; Yu et al., 2018) and analysed health outcomes such as mortality from lung cancer, mortality from respiratory diseases and the prevalence of other general respiratory health outcomes.

Epidemiological studies relating to adverse birth outcomes were analysed for sanitary landfill sites across the United Kingdom (Elliott et al., 2001) and unsanitary/uncontrolled landfill sites in the French West Indies, which are likely to contain hazardous waste (Istvan et al., 2019). Istvan et al. (2019) found that preterm births cluster around one of three landfill sites located in the Guadeloupe archipelago. However, it was not the largest landfill which showed these results and therefore, the specific characteristics of the landfill which are not known (for example, age and waste stream) are likely to be more influential in the higher observed risk ratio. The national study undertaken by Elliott et al. (2001) in the United Kingdom showed that excess risks were found for neural tube defects, abdominal wall defects, hypospadias and epispadias, gastrochisis and exomphalos, low birth weight and very low birth weight. However, it was noted that the considerable uncertainty regarding the extent of any possible exposure to chemicals found in landfills; the lack of understanding of the potential toxicity of landfill emissions, including via groundwater; and possible exposure pathways contributes to the inability to conclude that there is a causal explanation for the findings.

A recent review indicates the quality of literature remains limited and the mixed evidence for significant risks, eg., of adverse respiratory and congenital anomaly outcomes, from living in proximity to landfills tend to relate to older generations of landfills prior to legislation, including due to EU waste directives (2008), (2010), (2000) and (1999), driving improvements in waste sorting and landfill design (2021). The more modern practices that are better established in high income countries are likely to reduce health risks (Mattiello et al., 2013). Further high-quality studies are needed.

Bio-organic waste treatment

In recent years, there has been an increase in composting of bio-organic waste in large scale industrial facilities, as well as the development of more advanced composting technologies in an effort to reduce waste destined for landfill. Composting is conducted in open-air turned windrows with long heaps of composting material, or indoor facilities with enclosed reactor systems.

Open composting

Composting (particularly open-air composting) is known to generate bioaerosols (airborne biological agents, including bacteria, fungi, pollen, and particulate matter), which are associated primarily with adverse respiratory
health outcomes (for example, asthma, bronchitis, rhinitis, chronic obstructive pulmonary disease) (Pearson et al., 2015), although carcinogenic risks have also been explored (Yaghmaien et al., 2019; Kermani et al., 2018; Mustafa et al., 2017). However, literature assessing both exposure and health outcomes is limited, with most studies focusing on occupational exposure of workers (Bonifait et al., 2017; van Kampen et al., 2016; Aghaei et al., 2020; Cheng et al., 2019) and very little on community exposure for nearby residents. The two systematic reviews analysed relating to bioaerosol exposure from composting and health outcomes (Pearson et al., 2015; Robertson et al., 2019) note that the majority of the literature is occupational, that there is an absence of consistent evidence on the toxicity of bioaerosols from composting facilities, and conclude that there is insufficient evidence to provide quantitative conclusions on risks to nearby residents.

Two studies analysed respiratory-related hospital admissions, one of which did not find any statistically significant effect on risk (Roca-Barcelo et al., 2020), and the other which did find a small non-statistically significant association with total respiratory admissions (Douglas et al., 2016).

A further two studies investigated respiratory health risk to compost facility workers from exposure to bioaerosols, one of which found a significant increase in coughs and coughs with phlegm in those who had worked for five years or more. However, a follow up study 13 years later, found no evidence of higher deterioration in lung function in workers (van Kampen et al., 2016). The other study found no difference in worker lung function or most respiratory symptoms, despite a relatively high difference in endotoxin exposure but did find an increased risk of cough and fatigue (Aghaei et al., 2020). While this is the case, due to the self-reported nature of both studies, there is the potential for bias.

All relevant studies assessing cancer risk were human health risk assessments (HHRAs), one of which found a negligible carcinogenic risk (Cheng et al., 2019), two of which found risks that were not negligible (Baghani et al., 2020; Yaghmaien et al., 2019) and another where results were inconclusive (Mustafa et al., 2017).

**Anaerobic digestion**

The literature on health impacts associated with anaerobic digestion facilities is limited, with the few studies available, principally assessing either occupational exposure or indirect impacts from odour and other social factors.

Two occupational studies investigating health impacts of odour pollution at anaerobic digestion and composting facilities found levels of ammonia, dimethyl sulphide and hydrogen sulphide sufficient to impact worker health (Han et al., 2021; Han et al., 2020).

Regarding potential direct health impacts, another occupational study investigating bioaerosol worker exposure found high levels of microbial contamination where organic waste is handled, and several endotoxin concentrations that reach or overtake threshold limits protective of occupational health, and therefore could be hazardous to worker health (Traversi et al., 2018).

An HRA investigated occupational health risks from long-term exposure to volatile organic compounds (VOCs) where it was found that the carcinogenic risk exceeded the safety threshold, but the non-carcinogenic risk was within an acceptable range. In addition, occupational
risk at the facility was used to infer the health risk to neighbouring residents, and suggested a potential community risk (Zheng et al., 2020).

Regarding potential indirect health impacts (that is through consumption of food grown in outputs from anaerobic digestion), one study concluded a negligible risk to human health through the application of quality assured and source segregated outputs to land, under United Kingdom quality protocols and waste standards (Longhurst et al., 2019). Another HHRA which investigated exposure to heavy metal concentrations in lettuce harvested from land using anaerobically digested sludge for cultivation, found increased rates of bioaccumulation, with the potential to pose a risk to human health. However, it should be noted that these samples were created specifically for the study and not representative of real agricultural practice (Shamsollahi et al., 2018).

Materials recycling

The majority of recent literature on the potential health implications of materials recycling relates specifically to electrical and electronic equipment (e-waste). Specifically, the health risks where primitive methods are used by unprotected workers to recover valuable metals, such as open burning of cables or harvesting with sodium cyanide. Furthermore, many studies relate to Chinese case studies. This is likely on the basis that of the circa. 50 million tonnes of e-waste generated worldwide each year, a large portion of it is shipped to China for processing (Luo et al., 2015).

Due to the some of the methods applied, a variety of contaminants which are toxic to human health can be released to the surrounding environment, posing a risk to the pickers, and wider communities alike.

The majority of studies analysed undertook HHRAs to assess potential carcinogenic and/or non-carcinogenic impacts from e-waste recycling (Luo et al., 2015; Zheng et al., 2020; Shi et al., 2019; Shi et al., 2016; Hu et al., 2013; Kyere et al., 2018). This is also an area the WHO has previously reported on, noting particular risks for children (WHO, 2021). The remaining studies analysed the presence of toxic substances associated with e-waste in blood or tissue samples of populations living around e-waste recycling sites to infer potential associated health risks (Leung et al., 2010; Li et al., 2013). While the studies varied in scope and focus, all found some form of an association (or suggested association) between exposure to e-waste and excess carcinogenic and/or non-carcinogenic health risks.

The literature review did not identify findings in relation to health outcomes associated with general materials recovery for recycling or re-use. There are likely implicit health benefits to diverting waste from alternatives such as landfill. Further research into the benefits and potential risks in this is warranted.

3.2 Candidate case studies

Table 3, at the end of this section, provides a summary of the 46 HIAs identified, undertaken for waste management projects. The examples date back to 2007 and range in waste management type, geographic location, decision-making level and approach (for example, standalone HIA or integrated in SEA, EIA or ESHIA).

Each example outlined in Table 3 was reviewed individually to analyse the process, scope and focus followed. The full results of this exercise are outlined in Appendix B and are summarized below.
As shown in Fig. 1 of the 46 waste management HIA project examples identified: 29 (63%) are located in the United Kingdom; three (7%) are located in the EU; 8 (17%) are located in non-EU countries in the WHO European Region; and six (13%) are from outside of the WHO European Region (Australia, New Zealand, United States of America and Canada). The latter were included on the basis that they provide additional context on international approach, methods and outputs.

Fig. 1: Geographic distribution of candidate case study sample

A total of 37 (80%) are project-level (EIA) and 9 (20%) are strategic level (SEA).

As shown in Fig. 2, across the strategic and project levels, and including combinations of different waste management processes, a total of: 36 (45%) discussed thermal treatment; 16 (20%) discussed landfill; 11 (14%) discussed bio-organic waste treatment; and 17 (21%) discussed materials recycling.

Fig. 2: Waste management process within candidate case study sample
Fig. 3 explores the trends within this distribution of waste management processes further, including the use of combinations and differences across the project and strategic levels.

For thermal treatment only all were project level, 16 were from the United Kingdom, three from EU countries and three from outside the WHO European Region. For landfill only, all were project level and all four were from non-EU countries in the WHO European Region. For bio-organic waste treatment only, there was a single project level example from the United Kingdom.

The combinations of waste management process are shown. Where a combination had no candidate case studies it is not shown. At the project level there were combinations of thermal treatment with one of either landfill (one from outside the WHO European Region), bio-organic waste treatment (one from the United Kingdom) or materials recycling (three from the United Kingdom and one from outside the WHO European Region). Also at the project level were a combination of landfill and materials recycling (three from the non-EU countries in the WHO European Region and one from outside the Region); or landfill with materials recycling and bio-organic waste treatment (one from a non-EU country in the WHO European Region).

At the strategic level all examples included a combination of waste management processes. The most common was a combination of all four categories, thermal treatment, landfill, materials recycling and bio-organic waste treatment. All these examples come from the United Kingdom. Two other strategic level examples were identified, both used materials recycling, one combined with thermal treatment and one with landfill — see Fig. 3. In both cases these were from outside the WHO European Region. The authors stress that the extent to which trends can be drawn from these results is limited as a convenience sampling approach as used. Actual trends may differ.
Notwithstanding this limitation, the results point to greater project level use of landfill alone or combination with materials recycling in non-EU countries in the WHO European Region, with seemingly fewer strategic level assessments. Within the former EU-28, particularly the United Kingdom, there are multiple examples of project level thermal treatment, including in combination with materials recycling. The United Kingdom also has many examples of strategic level assessments that consider a range of waste management options. The implications of these trends for the CE are picked up in the discussion section.

Table 2 provides a summary of the health determinants assessed across the waste management processes. The data reflects the information available within the candidate case studies. In seven cases, particularly at the strategic level, the assessment was not framed in terms of health determinants or data was not available. The counts shown are the total number of times that determinant, or the sum or sub-issues, were mentioned for across the candidate case study pool.

The table summaries related issues under one determinant of health where relevant. For example, there was a diversity of community issues assessed under the determinant ‘community identity and society’. In this case sub-issues, included: community gain; community pride; community voice; social capital; community cohesion; and visual impacts on communities. Healthy lifestyles included issues of physical activity, open space and healthy food. Community safety included issues relating to levels of crime, community accidental injury risk and perceptions or understanding of risk where this differs from actual risks. Transport as an issue included road safety as well as changes in community access to amenities or services. The built environment included issues of land use, resource availability and presence of pests or vermin.

The health determinant categories provided are generalised to some extent, due to substantial variations in terminology and grouping of determinants across the project examples reviewed.

Whilst the analysis shows the regularity with which issues such as air quality and noise are discussed, it also shows that wider determinants of health are also included, such as employment and community social impacts. The inclusion of many candidate cases from the United Kingdom may contribute to this trend. The routine coverage of wider determinants is perhaps more common in the United Kingdom than many other parts of the WHO European Region.

Due to many of the candidate case studies including multiple waste management processes, an analysis of determinants by waste management process was not feasible.
As set out in Table 2, the most common determinants of health discussed by the candidate case study pool concerned the bio-physical environmental determinants, in total 99 instances. The most common sub-issues related to air quality (41) and noise (33). The second most common broad health determinant category covered social issues associated with promoting safe and cohesive communities, 88 instances. Within this, issues of transport safety or access (36) and community cohesion or identity (22) were most frequently acknowledged. The third most common health determinant category related to economic issues, 36 instances. Employment dominated (27), but issues of wider economic implications were also cited (9). Implication for health services also featured in some assessments, 23 instances, though mainly in relation to occupational health and safety considerations (11). There were few instances across the assessments that looked at health

<table>
<thead>
<tr>
<th>Determinant of health [adapted from (IAIA, 2020)]</th>
<th>Cumulative count*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental conditions</td>
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</tr>
<tr>
<td>Air quality, dust and odour</td>
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</tr>
<tr>
<td>Climate change</td>
<td>5</td>
</tr>
<tr>
<td>Electro-magnetic fields</td>
<td>4</td>
</tr>
<tr>
<td>Noise and vibration</td>
<td>33</td>
</tr>
<tr>
<td>Soil quality</td>
<td>4</td>
</tr>
<tr>
<td>Water quality</td>
<td>12</td>
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<tr>
<td>Health and social care services</td>
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<td>Disease transmission</td>
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<td>Emergency scenarios</td>
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<td>Health service use</td>
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<td>Occupational health and safety</td>
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<td>Health inequalities</td>
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<tr>
<td>Healthy lifestyles</td>
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<tr>
<td>Safe and cohesive communities</td>
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<td>Built environment</td>
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<tr>
<td>Community identity and society</td>
<td>22</td>
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<tr>
<td>Community safety</td>
<td>10</td>
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<tr>
<td>Housing amenity or resettlement</td>
<td>13</td>
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<tr>
<td>Transport and access</td>
<td>36</td>
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<tr>
<td>Socioeconomic conditions</td>
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<tr>
<td>Employment</td>
<td>27</td>
</tr>
<tr>
<td>Income and economy</td>
<td>9</td>
</tr>
<tr>
<td>Wider societal benefits</td>
<td></td>
</tr>
<tr>
<td>Energy security (for energy recovery)</td>
<td>2</td>
</tr>
</tbody>
</table>

* Any given HIA may have discussed multiple health issues within these categories.

Source: adapted from IAIA, 2020
inequalities (4), healthy lifestyles (7) or wider societal public health benefits of the proposal, for example, for energy security from energy recovery (2).

Table 3. Candidate case studies

<table>
<thead>
<tr>
<th>No</th>
<th>Project</th>
<th>Country</th>
<th>Waste management processa</th>
<th>Date of completion</th>
<th>Decision level</th>
<th>Standalone or integrated HIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yerevan solid waste project</td>
<td>Armenia</td>
<td>L</td>
<td>2015</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
<tr>
<td>2</td>
<td>Maryvale energy from waste plant: health impact assessment</td>
<td>Australia</td>
<td>TT</td>
<td>2018</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
<tr>
<td>3</td>
<td>Zivinice regional solid waste project</td>
<td>Bosnia and Herzegovina</td>
<td>L</td>
<td>2015</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
<tr>
<td>4</td>
<td>Toplofikacia combined heat and power plant</td>
<td>Bulgaria</td>
<td>TT</td>
<td>2014</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
<tr>
<td>5</td>
<td>HIA of biosolids management plan for Highland Creek treatment plant</td>
<td>Canada</td>
<td>TT, MR</td>
<td>2015</td>
<td>SEA</td>
<td>Semi-integrated</td>
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<tr>
<td>6</td>
<td>Ajara solid waste project</td>
<td>Georgia</td>
<td>L, MR</td>
<td>2015</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
<tr>
<td>7</td>
<td>Dublin energy from waste plant</td>
<td>Ireland</td>
<td>TT</td>
<td>2007</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
<tr>
<td>8</td>
<td>Osh and Jalal-Abad solid waste management</td>
<td>Kyrgyzstan</td>
<td>L</td>
<td>2014</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
<tr>
<td>9</td>
<td>HIA on the draft Wairoa District Council waste management activity management plan</td>
<td>New Zealand</td>
<td>L, MR</td>
<td>2009</td>
<td>SEA</td>
<td>Standalone</td>
</tr>
<tr>
<td>10</td>
<td>Olsztyn waste to energy plant</td>
<td>Poland</td>
<td>TT</td>
<td>2015</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
<tr>
<td>11</td>
<td>Chisinau solid waste project</td>
<td>Republic of Moldova</td>
<td>L, MR</td>
<td>2017</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
</tbody>
</table>

*aTT = thermal treatment; L = landfill; BWT = bio-organic waste treatment, MR = materials recycling.

*Case studies conducted by author’s organization (RPS).

References of candidate case studies can be found in Appendix C.
<table>
<thead>
<tr>
<th>No</th>
<th>Project</th>
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<th>Date of completion</th>
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<tr>
<td></td>
<td>Duboko regional landfill extension project</td>
<td>Serbia</td>
<td>L</td>
<td>2016</td>
<td>EIA</td>
<td>Integrated</td>
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<tr>
<td>13</td>
<td>Vinča energy from waste facility, construction of the new landfill and remediation of the existing landfill</td>
<td>Serbia</td>
<td>TT, L, MR</td>
<td>2018</td>
<td>EIA</td>
<td>Integrated</td>
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<tr>
<td>14</td>
<td>Khmelnitsky solid waste project</td>
<td>Ukraine</td>
<td>L, BWT, MR</td>
<td>2020</td>
<td>EIA</td>
<td>Integrated</td>
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<tr>
<td>15</td>
<td>Darwen energy recovery centre*</td>
<td>United Kingdom/ England</td>
<td>TT</td>
<td>2019</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
<tr>
<td>16</td>
<td>Exeter energy from waste facility*</td>
<td>United Kingdom/ England</td>
<td>TT</td>
<td>2007</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>17</td>
<td>Green Hills energy from waste facility*</td>
<td>United Kingdom/ England</td>
<td>TT</td>
<td>2011</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
<tr>
<td>18</td>
<td>Municipal waste management strategy of the mayor of London</td>
<td>United Kingdom/ England</td>
<td>TT, L, BWT, MR</td>
<td>2011</td>
<td>SEA</td>
<td>Integrated</td>
</tr>
<tr>
<td>19</td>
<td>Longridge Road energy centre*</td>
<td>United Kingdom/ England</td>
<td>TT</td>
<td>2019</td>
<td>EIA</td>
<td>Integrated</td>
</tr>
<tr>
<td>20</td>
<td>North London heat and power project</td>
<td>United Kingdom/ England</td>
<td>TT, MR</td>
<td>2015</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
</tbody>
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<th>Standalone or integrated HIA</th>
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<tbody>
<tr>
<td>21</td>
<td>Pinkham Way waste management and recycling facility and North London Waste Authority vehicle depot</td>
<td>United Kingdom/England</td>
<td>BWT, MR</td>
<td>2011</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>22</td>
<td>Roosecote biomass power station*</td>
<td>United Kingdom/England</td>
<td>TT</td>
<td>2012</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
<tr>
<td>23</td>
<td>Rufford energy recovery facility*</td>
<td>United Kingdom/England</td>
<td>TT</td>
<td>2007</td>
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<td>Standalone</td>
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<td>24</td>
<td>Runcorn energy recovery facility*</td>
<td>United Kingdom/England</td>
<td>TT, MR</td>
<td>2009</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>25</td>
<td>Suffolk energy from waste facility*</td>
<td>United Kingdom/England</td>
<td>TT</td>
<td>2011</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
<tr>
<td>26</td>
<td>The Brighton &amp; Hove and East Sussex waste and minerals development framework*</td>
<td>United Kingdom/England</td>
<td>TT, L, BWT, MR</td>
<td>2010</td>
<td>SEA</td>
<td>Integrated</td>
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<tr>
<td>27</td>
<td>The Buckinghamshire waste strategy*</td>
<td>United Kingdom/England</td>
<td>TT, L, BWT, MR</td>
<td>2011</td>
<td>SEA</td>
<td>Integrated</td>
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<tr>
<td>28</td>
<td>The construction of an energy from waste plant in Her Majesty’s Naval Base, Devonport, Plymouth</td>
<td>United Kingdom/England</td>
<td>TT</td>
<td>2011</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
</tbody>
</table>

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<th>Date of completion</th>
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<th>Standalone or integrated HIA</th>
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<tr>
<td>29</td>
<td>The Lancashire waste and minerals development framework*</td>
<td>United Kingdom/ England</td>
<td>TT, L, BWT, MR</td>
<td>2010</td>
<td>SEA</td>
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<tr>
<td>30</td>
<td>Warnham energy from waste facility*</td>
<td>United Kingdom/ England</td>
<td>TT, MR</td>
<td>2018</td>
<td>EIA</td>
<td>Integrated</td>
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<tr>
<td>31</td>
<td>Wheelabrator Kemsley North energy from waste facility*</td>
<td>United Kingdom/ England</td>
<td>TT</td>
<td>2020</td>
<td>EIA</td>
<td>Integrated</td>
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<tr>
<td>32</td>
<td>Willows power and recycling centre*</td>
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<td>TT</td>
<td>2011</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
<tr>
<td>33</td>
<td>Wincham waste treatment plant*</td>
<td>United Kingdom/ England</td>
<td>TT</td>
<td>2009</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>34</td>
<td>Jersey waste disposal facility</td>
<td>United Kingdom/ Jersey</td>
<td>TT</td>
<td>2007 and 2008</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>35</td>
<td>Hightown Quarry residual waste management facility*</td>
<td>United Kingdom/ Northern Ireland</td>
<td>TT, BWT</td>
<td>2014</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>36</td>
<td>Tully Quarry Phase II anaerobic digestion facility*</td>
<td>United Kingdom/ Northern Ireland</td>
<td>BWT</td>
<td>2021</td>
<td>EIA</td>
<td>Integrated</td>
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<td>37</td>
<td>Cardenden biomass facility*</td>
<td>United Kingdom/ Scotland</td>
<td>TT</td>
<td>2011</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>38</td>
<td>Brig y Cwm energy from waste facility*</td>
<td>United Kingdom/ Wales</td>
<td>TT</td>
<td>2010</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
</tbody>
</table>

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*Case studies conducted by author’s organization (RPS).
References of candidate case studies can be found in Appendix C.
### Table 3. contd

<table>
<thead>
<tr>
<th>No</th>
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<th>Standalone or integrated HIA</th>
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<tbody>
<tr>
<td>39</td>
<td>Interim report of the HIA of the waste incineration development planned in Trident Park, Splott</td>
<td>United Kingdom/Wales</td>
<td>TT</td>
<td>2010</td>
<td>EIA</td>
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<td>40</td>
<td>Simec Uskmouth power station conversion project*</td>
<td>United Kingdom/Wales</td>
<td>TT</td>
<td>2020</td>
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<td>Integrated</td>
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<tr>
<td>41</td>
<td>The Wales National Waste Strategy*</td>
<td>United Kingdom/Wales</td>
<td>TT, L, BWT, MR</td>
<td>2008</td>
<td>SEA</td>
<td>Standalone</td>
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<tr>
<td>42</td>
<td>Towards zero waste, Public Sector waste and resource efficiency plan</td>
<td>United Kingdom/Wales</td>
<td>TT, L, BWT, MR</td>
<td>2015</td>
<td>SEA</td>
<td>Integrated</td>
</tr>
<tr>
<td>43</td>
<td>Wales Waste Sector Plan sustainability appraisals, industrial and commercial sector and construction and demolition</td>
<td>United Kingdom/Wales</td>
<td>TT, L, BWT, MR</td>
<td>2013</td>
<td>SEA</td>
<td>Integrated</td>
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<tr>
<td>44</td>
<td>Placer County biomass energy facility (using forest biomass)</td>
<td>United States of America/California</td>
<td>TT</td>
<td>2012</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>45</td>
<td>Metro HIA, evaluation of landfill and waste to energy options for managing municipal solid waste</td>
<td>United States of America/Oregon</td>
<td>TT, L</td>
<td>2017</td>
<td>EIA</td>
<td>Standalone</td>
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<tr>
<td>46</td>
<td>Poultry-litter fired biomass facility</td>
<td>United States of America/Virginia</td>
<td>TT</td>
<td>2013</td>
<td>EIA</td>
<td>Standalone</td>
</tr>
</tbody>
</table>

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*Case studies conducted by author’s organization (RPS). References of candidate case studies can be found in Appendix C.
3.3 Case studies

Based on the criteria explained above, five exemplary case studies within the WHO European Region and one case study outside the Region were selected:

- Case study 1: Draft Wales waste strategy, United Kingdom, 2008 (RPS, 2008)
- Case study 2: Hightown Quarry residual waste management facility, Northern Ireland, United Kingdom, 2014 (RPS, 2014)
- Case study 3: Chisinau solid waste project, Republic of Moldova, 2017 (WSP and Parsons Brinckerhoff, 2017)
- Case study 4: Khmelnitsky solid waste project, Ukraine, 2020 (WSP, 2020)
- Case study 5: Vinča energy from waste facility and landfill remediation, Serbia, 2018 (Beo Čista Energija, 2018)
- Case study 6: HIA on the draft Wairoa District Council waste management activity management plan, New Zealand, 2009 (Hawke’s Bay District Health Board, 2009).

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**Project summary and context**

This strategic level case study discusses the development of a waste management strategy for Wales, a devolved administration within the United Kingdom. The report was undertaken by private sector HIA consultants. The Welsh Assembly Government has a strong HIA tradition aided by a publicly funded support unit, the Welsh Health Impact Assessment Support Unit (WHIASU).

In 2008 the Welsh Assembly Government was in the process of developing an ambitious waste strategy to deliver a more sustainable and environmentally responsible approach to waste generation and management throughout Wales over four decades.

The core aims of the strategy were to:

- embed the principles of sustainable development into waste and resource management throughout Wales;
- facilitate a change in attitude towards waste at the industrial, retail and community level; and
- reassert increased accountability, more effective recycling initiatives and a change in thinking to treat waste as a marketable resource.

The goal was to not only develop a more sustainable and environmentally responsible attitude to waste generation and management throughout Wales; but to optimise material resources for the benefit of the Welsh people, economy and environment, that is driving a CE.

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2 Importantly, the selection of the case studies does not imply any endorsement of the projects assessed in the HIA or environmental assessment.
In keeping with the Welsh Assembly’s strategic priorities, the requirements of Technical Advice Note 21 and following the WHIASU guidance, the Assembly commissioned a stand-alone HIA.

**Decision-making level**

The assessment was strategic in nature, developed through a review of the emerging Draft Strategy (Version 1.5), supplemented by a review of the Regional Waste Strategy HIA to gain transferable knowledge and build upon previous community and stakeholder engagement. However, being an iterative and informative process, the HIA was repeated to take into account changes and additions to the Draft Strategy (Versions 1.7 through to 1.12).

Being at the strategic level, a key feature of the HIA was to provide information to support subsequent decision-making at the regional and local levels throughout Wales. As such, the HIA provided a series of actions through a dedicated Health Management Plan geared to support the development and delivery of the draft strategy; as well as to aid in managing potential community and occupational health risks, enhance the uptake of benefits and to address relative inequality at the national, regional and project level throughout Wales.

Unusually, the strategic level HIA was geared to bridge between the strategic and project level, providing a transferable knowledge base, and HIA scope to be actioned at the project level. In essence, the HIA was packaged as a resource to inform the Wales waste strategy, and then inform a more consistent approach to the HIA of individual waste management projects, as they emerged.

**Process and approach**

The HIA implemented the WHIASU Guidance of the time (WHIASU, 2004), and followed the generic process including: 1) a project profile; 2) a community profile; 3) stakeholder engagement; 4) assessment; and 5) a Health Management Plan.

An independent Steering Group was included to inform the scope of the assessment and comment on findings, and comprised members of the Sustainable Development Commission; WHIASU; the Environment Agency; the Welsh Assembly Government; and the University of Wales.

**Aims and objectives of the HIA**

The overarching aim of the HIA was to reinforce the consideration of health within the waste strategy. The strategy considered options across waste management processes, including thermal treatment, landfill, bio-organic waste treatment and materials recycling. This aim was achieved through the delivery of the following objectives:

- support the iterative development of the draft strategy;
- inform the development of a formal position on potential waste management options;
- investigate and assess the significance and likelihood of potential health outcomes of key policies and waste management options that were under consideration;
- investigate factors that may influence the significance of potential health outcomes or their disproportionate impact upon communities and sensitive groups; and
- provide evidence-based recommendations geared to reduce and remove potential adverse impacts and enhance opportunities to improve health.

The HIA was also intended to further address commonly perceived risks and community concerns and to provide information and recommendations to support more health-
conscious waste-resource management planning and decision-making at the project level (that is during site and technology selection, planning, regulatory assessment and environmental permitting).

**Definition of health**
In accordance with the WHIASU’s guidance of the time (WHIASU, 2004) the HIA was set on a broad socioeconomic model of health that encompasses conventional health impacts such as disease, accidents and risk, along with wider determinants of health vital in achieving good health and well-being (income, employment, quality of the urban environment, crime and the perception of crime, etc.).

**Scope**
A scoping exercise was conducted and discussed with the Steering Group, which agreed the scope, approach and focus of the assessment, while further setting expectations for the necessary outputs. This led to amending the original objectives, most notably to bridge the HIA across the strategic and project level. The intention was to ensure lessons learned, transferable knowledge and opportunities identified at the strategic level were carried across to the project level and formed a resource to local planning and health stakeholders.

**Assessment methods**
Being a strategic document with limited project level information, the HIA was largely qualitative in nature addressing each of the core health pathways identified during the preceding stages and providing an appropriate evidence base to assess the significance and likelihood of potential health outcomes associated with the draft strategy. This included a comprehensive literature review of every waste management option under consideration, and the collation of associated authoritative position papers. A health baseline of existing health conditions for Wales was also included to provide context on burdens of poor health, inequality and associated sensitivity to specific health pathways that might result in a disproportionate outcome or risk.

**Outputs and key findings**
The HIA concluded that the provision of new waste management facilities engenders a number of perceived health impacts and associated community concerns. However, in reality the actual risks to health are minimal, and where they do exist, they are not necessarily in line with community priorities or perceptions.

The waste-resource management options under consideration included a wide range of technologies with varying processes and activities with the opportunity to influence health. The available evidence base at the time indicated that such risks are largely occupational in nature, where wider community health risks are managed at the project level through design and planning, together with specific Waste and Environmental Permitting Regulations. However, it is recognized that for relatively new waste-resource management options and technologies, additional project level HIA will be necessary to further inform site selection, planning and environmental permitting, and to address and alleviate community concerns.

**Link to the CE**
The Draft Wales Waste Strategy constituted a more joined up approach to waste management...
that sought to influence a behavioural change that would streamline industry and retail, reduce costs to consumers, protect the environment and replace the concept of the waste stream, with the waste-resource cycle, that is a CE.

The draft strategy also considered barriers that may limit the effectiveness of the proposed policies at a national and international level, identified and sought to manage potential socioeconomic knock-on effects with the potential to influence consumer behaviour and the vitality of the Welsh economy, and recognized the overlap and opportunities to support wider strategic plans to the benefit of the Welsh people, economy and environment.

Although the concept of zero waste was not new, the environmental health and economic benefits to be achieved are and remain significant and were identified to aid in improving the vitality and economic strength within Wales. However, what was new was the holistic approach the Welsh Assembly was seeking to employ to manage risks, facilitate change and enhance benefits at the industry, retail and consumer level throughout Wales.

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Case study 2: Hightown Quarry residual waste management facility, Northern Ireland, United Kingdom

**Project summary and context**

The project level case study concerns a proposed residual waste management facility within the Hightown Quarry site, near Mallusk. The HIA was undertaken by private sector consultants and was appended to the EIA. The project was designed to meet the needs of the Arc21 region, representing the then eleven constituent councils of the eastern Region of Northern Ireland, including: Antrim, Ards Ballymena, Belfast, Carrickfergus, Castlereagh, Down, Larne, Lisburn, Newtownabbey, and North Down councils.

The proposed facility included a:

- a weighbridge complex
- mechanical biological treatment (MBT) facility
- a refuse derived fuel (RDF) bale storage building
- an energy from waste facility
- Incinerator bottom ash (IBA) treatment facility
- an administration/visitor centre
- upgrading/widening of the servicing Boghill Road.

**Decision-making level**

In keeping with best practice and in response to the formal EIA scoping response from the Public Health Agency to Department of the Environment (DOE) Planning in November 2010, an HIA was commissioned to investigate and address the potential impact of the proposed facilities. The HIA was therefore geared to the project level decision-making, embedded within the EIA process, and formed a technical appendix for consideration during examination. Being embedded within the EIA, meant that the HIA was also updated within the addendum,
was carried through to the public inquiry, and was required to provide a health expert witness. The HIA was therefore required to stand planning rigour and defend the conclusions and recommendations during cross examination.

**Process and approach**

The assessment followed a generic HIA process, but the approach was modified to work alongside, draw from and build upon both the pre-application discussion (PAD) process, and the technical assessments of the environmental statement (ES) from the outset of the proposed project.

Integration with the PAD, planning and EIA process enabled the HIA to iteratively inform the proposed development, to catalogue and address community concerns, but also ensures that the HIA was based upon realistic changes in environmental and socioeconomic conditions directly attributable to the proposed project and suitable for planning submission. Embedding the HIA from the outset also meant that it was proportionate, robust and able to withstand public and planning scrutiny, including public inquiry.

**Aims and objectives of the HIA**

The overarching aim of the HIA was to build upon and complement the outputs of the ES to further integrate health and well-being within the proposed project, identify and assess potential health outcomes and put forward recommendations to maximize health gains whilst minimising potential negative impacts and inequality.

This aim was achieved through the delivery of the following objectives:

- HIA scoping to establish, justify and agree an appropriate scope and focus of assessment with key health stakeholders;
- development and implementation of an integrated EIA and HIA engagement strategy to facilitate meaningful consultation intended to identify, discuss and address local concerns and perceived risks during the PAD process, refining the scope of the final HIA to local needs;
- community profiling to establish local circumstance and relative sensitivity, forming the founding platform to the assessment process;
- iterative HIA support to address local circumstance and community health concerns through the refinement of the proposed project;
- development of an appropriate evidence base to address the key health pathways scoped within the HIA;
- quantifying and appraising the magnitude, distribution and likelihood of potential health outcomes (both adverse and beneficial) directly attributable to the proposed project; and
- development of a bespoke health action plan (HAP) to further address local circumstance, support the uptake of potential health benefits and inform on-going community engagement and feedback.

**Definition of health**

The HIA applied a broad determinants of health model that encompasses conventional health impacts such as communicable disease, accidents and risks, along with wider health determinants vital to achieving good health
and well-being such as income, employment, housing, education, the quality of the urban environment, crime and the perception of crime.

**Scope**

The scope and focus of the HIA was defined and iteratively refined through engagement with key stakeholders; initially through the formal EIA scoping exercise with statutory consultees; and subsequently through a separate HIA scoping exercise with key health stakeholders and local communities via an integrated engagement strategy.

The assessment investigated each of the potential health pathways associated with construction and operation stages of the proposed development, including:

- the potential health risk from changes in emissions of air pollutants (including odour)
- the potential for community disruption from noise and vibration
- the potential health risk from additional road movements (risk of accidents and injuries)
- the potential impact on house value and sales
- the potential socioeconomic health benefits from direct, indirect and induced income and employment opportunities
- the potential health risk from changes in electromagnetic field exposure from underground cables
- risk perception
- general accidents and safety.

**Assessment methods**

Given the range of health determinants covered, quantitative assessment methods were applied where sufficient evidence of an exposure response were available and reinforced with qualitative appraisal for the more subjective and intangible aspects of health.

This included:

- quantitative health outcome modelling based on exposure response functions for changes in particulate matter (PM), specifically PM$_{10}$, PM$_{2.5}$, and nitrogen dioxide concentrations during construction and operation. The approach applied the United Kingdom Department of Health’s Committee on the Medical Effects of Air Pollutants (COMEAP) methodology. The modelling quantified potential changes in life expectancy and local cardiovascular and respiratory hospital admissions;
- qualitative appraisal of the potential health risk from the ingestion of trace, heavy metals and dioxin/furans (building upon the quantitative outputs of the HHRA in the permit application);
- risk assessment from changes in construction and operational road traffic movements and consequent risk of collisions directly attributed to the proposed development;
- qualitative appraisal as to community disruption and potential health outcome from changes in construction and operational noise (drawing from the detailed noise assessment of the ES); and
- qualitative appraisal as to the socioeconomic health benefits from direct, indirect and induced income and employment opportunities (drawing from the socioeconomic section of the ES).
Outputs and key findings

The HIA concluded that all regulatory environmental standards set to protect health were predicted to be achieved; that the assessment from relative changes in air quality, noise and transport upon existing burdens of health are not sufficient to quantify any adverse health outcome; and when considering the approach proposed to address community concerns, perceptions and priorities; operational procedures; and the commitment for on-going community engagement, it was concluded that the proposed development did not constitute a significant risk to local community health.

When further considering the underlying factors defining local burdens of poor health in the area (largely socioeconomic and lifestyle related), the direct, indirect and induced socioeconomic benefits from the proposed development, and that the proposed facility is specifically designed to manage the municipal waste requirements of Arc21. The project would effectively remove the vast majority of municipal waste sent to landfill within the boundary of Arc21. The HIA authors concluded that the proposed project represented an enhancement, in terms of delivering a net beneficial effect on local health.3

Link to the CE

Whilst the project aim was not directly linked to the CE, the project did form an implicit component of a CE, as it was geared to increase recycling, energy recovery and divert waste and resources to landfill.

3 While finalizing this report a final decision was taken by the Infrastructure Minister of Northern Ireland refusing planning permission of the Hightown Quarry Residual Waste Management Facility on the grounds that “This development could result in an increased market for waste disposal and to maintain a facility such as this, in addition to the other approved waste facilities, could discourage recycling.” (https://www.infrastructure-ni.gov.uk/news/minister-refuses-residual-waste-treatment-facility, accessed 07 March 2023). However, the HIA itself was commend by the Public Health Agency, Ballymena in their statement of 13 May 2014 (PAO521926_Public Health Agency Consultation Response_135201414157), for its “work which is clear and comprehensive in terms of both potential negative and positive health implications. The section on risk perception is particularly worthy of note with its recommendation of early and frequent consultation with the local population.” (https://planningregister.planningsystemni.gov.uk/application/149511, accessed 7 March 2023).
Case study 3: Chisinau solid waste project, Republic of Moldova

**Project summary and context**

The project level case study relates to the upgrading and re-opening of a landfill site in the Republic of Moldova. The ESIA was prepared by private sector consultants.

Tintareni landfill site is located in Anenii Noi District, 35 km south-east of Chisinau. This previously operational landfill has an area of approximately 25 ha, was designed in 1984, put into operation in 1990, and operations were put on hold in 2010 due to complaints from the villages regarding the alleged pollution of groundwater.

Since the closure of the landfill, waste was being stored at a temporary dumpsite located at the old “Purcel” quarry on the Uzinelor Street, Ciocana District, in the City of Chisinau. Once Tintareni Landfill is upgraded and re-opened, it will be possible to close the temporary dumpsite site.

The closure of the landfill has also given rise to a number of illegal waste dump sites around the village of Tintareni. These sites have been located on unsurfaced areas, and it is likely that they are a source of groundwater contamination. The proposed project thereby seeks to remedy an existing landfill, facilitate more effective waste management, and resolve illegal dumping with environmental and health consequences.

The landfill site was designed by the Institute IPROCOM in accordance with the Design and Construction Standards and Sanitary Norms adopted by the Soviet Union at that time. In order for the European Bank for Reconstruction and Development (EBRD) to invest in the project, the landfill must be designed and operated in compliance with the Bank's Environmental and Social Policy and EU regulations. It must comply with the EU Landfill Directive and have appropriate systems to manage landfill gas and leachate.

**Decision-making level**

The assessment is geared at the project level, complying with national EIA legislation, regulations and the EBRD lending Performance Standards/lending requirements. This includes an integrated ESIA, of which Performance Requirement 4 directly relates to community health, safety and security.

**Process and approach**

The assessment comprises an integrated ESIA, that embeds health and has been carried out in accordance with:

- The EBRD’s Environmental and Social Policy and Performance Requirements (2014);
- EIA legislation and environmental standards of the Republic of Moldova; and
- International conventions transposed into legislation of the Republic of Moldova.

Public consultation and stakeholder engagement has been applied to further
inform and refine the scope and focus of the assessment and facilitate a meaningful and participatory approach to the ESIA and the project.

The generic HIA process is consistent with that of EIA, and has included scoping, the development of an appropriate baseline and assessment.

The health requirement has in this instance been fully integrated within the overlapping environmental disciplines (air quality, noise etc.), while the social, cultural and economic health pathways are contained within a distinct social, population and human health chapter. In essence, health is woven throughout the ESIA.

Aims and objectives of the ESIA

The overarching aim of the ESIA was to investigate, inform and assess any potential significant, environmental, social or health effects directly attributable to what is proposed, test regulatory planning compliance and lending criteria.

Definition of health

Being an ESIA, a definition of health is not provided, but applies a broad environmental and social model of health, largely structured around the EBRD Performance Standard 4 requirements, and bespoke health determinants identified through the scoping process and during engagement.

On this basis, the health model applied and health determinants investigated tend to focus on risk management, and are tailored to local circumstance, perceptions and priorities, and specific environmental health hazards directly attributable to what is proposed. For example, concerns were raised that leachate from the landfill was contaminating potable groundwater wells in Tintareni village. Other health issues included noise, vibration, dust, odour nuisances, leaks from waste trucks, littering and levels of concern associated with a lack of information on types of waste being landfilled. Other issues explored included employment and economic effects, including due to increased waste tariffs, road safety, health care services and issues of gender equality.

Scope

An integrated ESIA scoping exercise was conducted, including three scoping meetings comprising two community consultation events and a combined key stakeholder and regulator event. The exercise sought to investigate all potential environmental, social and health impacts, while further explore local environmental and health circumstance, sensitivity and gather tacit knowledge.

Assessment methods

Potential health pathways were separated and addressed through the overlapping technical disciplines, largely to regulatory objective thresholds protective of the environment and health. Social and cultural health pathways, as well as the more intangible and subjective determinants of health were addressed qualitatively, supported by an appropriate evidence base to inform a professional judgment on significance.

Outputs and key findings

Overall, construction and operational environmental health pathways (air quality and noise) are not considered significant, presenting more in the way of an occupational hazard, to be addressed through appropriate personal
protection equipment. It was concluded that the project would have no significant effects on biological and ecological resources and would provide ecological protection and enhancements. The construction and operation of the landfill was not expected to have an adverse effect on geology, soils, material or waste, following the implementation of the proposed mitigation, and would improve water quality.

In relation to social and health impacts, the ESIA reports that the construction of the landfill was expected to have a minor beneficial effect on land ownership and local employment. The operation of the landfill was expected to have a moderate long term gender effect due to employment opportunities for women, and major beneficial effects for the residents of Tintareni due to the proposed community benefits.

**Link to the CE**

The ESIA had a very focused scope, and geared to investigating, informing and assessing the specific waste management option considered. On this basis, there was no explicit link to the CE.

The implicit link to the CE relates to landfill remaining a part of the transition to a CE, and likely a necessary element even following the transition to a CE, albeit the need for landfill being greatly reduced.

This reflects that the CE is about minimising waste. There remain, subject to changing technological or economic drivers, some waste produced that are not suitable for re-use, recycling, or energy recovery. Any ongoing role for landfill does however need to be undertaken in a safe manner. This case study demonstrates one project level upgrading of a site to meet modern landfill standards, including to better safeguard community health.

Being a project level example, this case study does not capture any strategic level efforts to over time reduce landfill as a waste management practice. The case study demonstrates that during the CE transition there remain legacy challenges, such as the temporary dumping of waste in unsuitable locations, that need addressing in parallel.
Case study 4: Khmelnitsky solid waste project, Ukraine

Project summary and context
This project level case study concerns a new mechanical biological treatment (MBT) facility and additional modern design landfill capacity in Ukraine. The ESIA was undertaken by private sector consultants. The project aims to transition to increased recycling and consequently reduced and safer landfill. MBT involves both mechanical sorting of the waste stream and also biological treatment of some of these components, for example, for energy recovery and creation of secondary products such as nutrient rich soil improver.

The ESIA reports that as the existing landfill approaches maximum capacity, the City of Khmelnitsky’s MSW generation is set to increase from approximately 94 000 tonnes per annum (recorded in 2017) to 107 000 tonnes per annum by 2027. The principal aim of the Project, to be financed by EBRD, is to provide waste processing capacity for the city. The project also aims to improve the waste management operations and introduce recycling capabilities to the city’s waste management infrastructure, in the form of the proposed MBT facility, and divert waste from landfill. Furthermore, it is anticipated that the project, once constructed, will be integrated in the regional Solid Waste Management (SWM) Plan for the Khmelnitsky Oblast.

The project will result in the creation of a modern integrated SWM system for the city, comprising:
- the closure, capping and rehabilitation of the existing landfill;
- construction of a new engineered landfill cell (total capacity will be between 500 000 to 700 000 tonnes of MSW); and
- construction of a proposed MBT Facility to the north of the existing landfill (processing capacity of approximately 107 000 tonnes of MSW per annum).

Decision-making level
The assessment is geared at the project level, complying with national EIA legislation, regulations and the EBRD lending Performance Standards/lending requirements. This includes an integrated ESIA, of which Performance Requirement 4 directly relates to community health, safety and security.

Process and approach
The approach to the ESIA has been undertaken in accordance with the EU EIA Directive, of which the generic HIA approach is consistent with, including scoping, development of an appropriate baseline, engagement and assessment. The regulatory and lending requirement does however define the structure of the reporting, and the need for significance criteria and an assessment of cumulative effects.

Aims and objectives of the ESIA
The overarching aim of the assessment is to investigate, inform and assess any potential significant, environmental, social or health effects directly attributable to what is proposed, test regulatory planning compliance and lending criteria.
This was achieved through the delivery of the following objectives of the ESIA:

- Set the legal framework;
- Document the consultation process;
- Consider the alternatives to the project;
- Establish baseline environmental conditions at the project site and within the surrounding area;
- Identify likely significant effects during the design process so that some effects can be avoided, prevented, reduced or, if possible, offset prior to the assessments within the ESIA;
- Identify, predict and assess the environmental effects associated with the project: beneficial and adverse; permanent and temporary; direct and indirect and short/medium/long term; significant or not significant;
- Identify, predict and qualitatively assess the cumulative effects of the project including those associated with the other developments; and
- Identify suitable mitigation measures to prevent, reduce or, if possible, offset likely significant adverse effects on the environment and identify the likely significant residual effects following the implementation of these measures; and
- Identify monitoring measures where likely significant residual effects are identified.

**Definition of health**

The ESIA doesn’t specifically define health but applies a broad environmental and social model of health, largely structured around the EBRD Performance Standard 4 requirements, and bespoke health determinants identified through the scoping process and during engagement. On this basis, the health model applied and health determinants investigated tend to focus on risk management, and are tailored to local circumstance, perceptions and priorities, and specific environmental health hazards directly attributable to what is proposed.

**Scope**

A formal ESIA Scoping exercise was conducted, and the report was submitted to EBRD outlining the proposed methodology for the ESIA and identified likely significant effects for key environmental topics. This included

- consideration of alternatives (chapter 3)
- air quality (chapter 6)
- noise and vibration (chapter 7)
- ecology (chapter 8)
- cultural heritage (chapter 9)
- landscape and visual (chapter 10)
- surface water environment (chapter 11)
- geology and hydrogeology (chapter 12)
- social (chapter 13)
- materials and waste (chapter 14)
- climate change (chapter 15)
- cumulative effects (chapter 16).

A dedicated health chapter was not included within the ESIA. This was not a shortcoming, but an approach that can be taken, where health is woven throughout the report and expanded upon within the relevant overlapping technical disciplines.

**Assessment methods**

Fully integrating health within the ESIA with no distinct health chapter means health is woven into the overlapping technical
disciplines, often to objective thresholds protective of the environment and health. On this basis, the majority of the assessment is quantitative, drawing from physical air water, and noise quality modelling and discussion of occupational and community health effects. These include in relation to biological, chemical and potentially radiological hazards arising from municipal, medical, industrial and sanitary wastes streams. Exposures include dermal contact without protective clothing, aerosols and gases inhaled, contaminated water ingested and the presence of disease vectors. Potential health outcomes discussed include respiratory health, throat and eye infections, and chronic demagogical infections. Qualitative appraisals relate to less tangible health determinants including odour and pest nuisances, and the social chapter covers a wide range of socio-cultural and economic health determinants, including the consideration of residential communities, community cohesion and well-being, vulnerable groups and Romani families as pickers on the existing landfill.

**Outputs and key findings**

The ESIA delivered the agreed scope, addressing all credible environmental and social health effects during construction and operation, as well as cumulative and in-combination effects. While the bulk of environmental hazards were addressed through compliance with objective thresholds protective of health, the social assessment component explored local community and health circumstance, varying community sensitivity and even aspects of equality impact assessment.

**Link to the CE**

Being at the project decision-making level, there was little opportunity to inform or influence an aspect of the CE, where the project was solely seeking to investigate assess and address the issues and opportunities directly attributable to the proposed infrastructure.

Notwithstanding the limited opportunity for an individual project to influence the wider CE strategic system change agenda, project level examples are an important checkpoint on whether such transitions are occurring and are an opportunity for innovation in processes and design that facilitates the CE (IAIA, 2021).

In this case the case study includes a MBT, which facilitates the CE transition through greater recycling and energy recovery. Whist not a fully CE aligned solution, given there is also ongoing large scale landfill, the project is a step towards greater resource circularity.
Case study 5: Vinča Energy from waste facility and landfill remediation, Serbia

Project summary and context

This project level case study involves the closure of the existing landfill site at Vinča and establishment of a new EU-compliance solid waste facility at the same site. The ESIA was undertaken by private consultants. The site is 40 years old and receives around 550 000 tonnes of MSW each year from 13 of the 17 Belgrade municipalities.

Vinča is located just west of Belgrade, approximately 12 km from the city centre and adjacent to the Danube. It covers approximately 70 ha. The new capacity will add an additional 60 ha forming a ring around the existing site. Vinča currently lacks any lining, leachate collection or systematic waste separation. The entire site is fenced, and access is controlled by a manned checkpoint at the entrance. Waste is delivered by around 200 trucks per day, which are weighed at entry and exit. The dump is located on a hill that slopes north and west towards the Danube. There is a wetland area located between the site and the river. The site is experiencing land slippage problems, with ground movement in the direction of the Danube. Work is underway to develop measure to stabilize the slope.

The project includes:

- closing the existing site after remediation and stabilization (introducing leachate treatment and landfill gas extraction and use), with final capping;
- introducing a management system for municipal waste on a site of approximately 60 ha, located at the Vinča site. This system will be composed of:
  - an energy from waste facility, which may consist of a mass burn incineration plant with the maximum combustion capacity of 43.6 t/h (about 340 000 t/year) of municipal waste;
  - a landfill for all municipal waste not pre-treated or not treated thermally, designed in accordance with EU regulations, performance standards on environmental and social sustainability of the International Finance Corporation (IFC), EBRD performance requirements, World Bank Group and Serbian standards;
  - a landfill for treatment residues (from the incineration plant) designed in accordance with EU and Serbian standards;
  - a treatment facility for construction and demolition waste (CDW) to produce recoverable inert CDW, recovery and storage of recoverable inert CDW, and landfill of the respective treatment residues; and
  - leachate and landfill gas treatment facilities, and landfill gas energy recovery facility.

The site is currently operated by a waste management company owned by the city.
The overall objectives of the project are:

- consider in an integrated manner the potential social and environmental risks, benefits and impacts of the project;
- identify specific mitigation measures and actions necessary for the Project to comply with applicable law and international environmental and social standards and other applicable EU requirements, to reduce risks and enhance benefits; and
- flag the need for any further studies, plans and/or programs that will support positive social and environmental development outcomes of the Project.

The ESIA includes the following sections:

- project description
- legal requirements (including ESIA methodology specific and referential)
- baseline study
- justification for the project’s layout
- technical and organization choices
- study of the relevant alternative scenarios (including the ‘do-nothing’ scenario)
- potential impacts
- characterization of impacts
- management of impacts and estimation of residual impacts
- monitoring plan
- mitigation and management plan.

**Decision-making level**

The project was seeking local planning consent, and funding through the IFC, thereby requiring compliance with Serbian environmental regulations and standards, EU Directive and the lending requirements that include amongst others, IFC Performance Standards:

- 1: Assessment and Management of Environmental and Social Risks and Impacts
- 3: Resource Efficiency and Pollution Prevention
- 4: Community Health, Safety and Security.

This informed the content, approach and structure to the integrated assessment, and while termed an ESIA, included health.

**Process and approach**

While the process includes the generic HIA approach (scope, baseline, assessment etc.), it is integrated within the main ESIA report. The approach responds to the regulatory and lending requirements, including assessment of residual and cumulative impacts and the use of significance criteria. On this basis, health, social and quality impacts are fully integrated within the one assessment.

The assessment considers the pre-construction, construction and operational phase, and also includes a dismantling phase.

**Aims and objectives of the ESIA**

The objective and the purpose of the ESIA was to analyse the current state of the environment, to determine the impact of the planned project on the environmental components and propose protection measures and environmental monitoring program that would mitigate the negative impacts to acceptable levels.

In essence the ESIA aim and objectives remain consistent with that of EIA and HIA, and is a process to facilitate more environmental and health conscientious planning, and then inform the decision-making process.
Definition of health

The ESIA didn’t specifically define health, but is structured instead on environmental social and economic determinants, under a broad model of environmental and public health. The assessment further touches on elements of equality impact assessment through the consideration of vulnerable groups and any risk of a disproportionate impact.

Scope

A formal scoping process preceded the ESIA with statutory consultees and a scoping report produced. This set the scope, process and focus of the assessment, including health and social assessment parameters.

Assessment methods

Quantitative and qualitative environmental assessment protocols are applied, and inform the social and health assessment sections, which includes the consideration of residential communities, vulnerable groups and Romani families and pickers on the existing landfill.

Outputs and key findings

The ESIA covered all credible environmental and social health pathways, investigating not only tangible hazards, but opportunities and ways in which to mitigate risk and facilitate the uptake of benefits. The assessment considered environmental thresholds protective of health to inform an evidence based professional judgement on social and health outcomes, and mitigation and community support initiatives offered to further manage potential risk and inequality.

Link to the CE

The project seeks to better manage current waste streams, while also including remediation to address the legacy of a 40-year-old unlined landfill. Being a project level development, there is inherently less opportunity to address the strategic level shifts in waste practices necessary to achieve the CE. However, against an alternative of landfill only with no energy or material recovery, the project, whilst not a fundamental re-imagining of waste management, is a step towards a CE.

The energy recovery element and the CDW recovery for re-use are elements that support greater resource cycling and therefore, implicitly, the transition to a CE. The transition to better managed and safer landfill, whilst it facilitates disposal, remains a relevant activity during the CE transition.
Project summary and context

This strategic level case study of a district waste management plan is a public sector lead assessment with high levels of community involvement. The case study is not from the WHO European Region but has been selected as it demonstrates the benefits of HIA identifying local community values and reflecting them within the assessment. This is a reminder of the diverse social and cultural traditions across the WHO European Region. When relevant traditions are recognized within an IA, areas of concern or inequalities can be better understood. Articulating community desire for sustainable development, particularly where there are strong traditions of alignment between the health of people and their environments, can also support the case for investment, including in the CE.

The Hawke’s Bay District Health Board (DHB) in New Zealand was working with local governments in its region to incorporate HIA into their planning processes. Following an ‘HIA advocacy seminar’ conducted by the DHB in March 2008 the DHB was approached by a Wairoa District Council (WDC) staff member who had attended the seminar, about the possibility of undertaking an HIA on its draft waste management activity plan. Following discussions both parties agreed to proceed with an HIA, in partnership with HIA consultants from Wellington.

The WDC’s draft Waste Management Activity Plan 2008 was developed by the Council to determine an effective waste management plan following several past attempts to find a model that would best suit its predominantly rural, geographically isolated communities.

The Wairoa district, with its population of 8,916 people, is made up of a number of small rural and seaside holiday communities. The district’s economy is largely based on pastoral farming, fishing and forestry.

The Council’s draft plan was informed by its previous waste management models, a recent community survey, that elicited a relatively low response rate, and a number of follow-up, community-focused forums. A standalone HIA was seen by the Council as an additional approach to accessing community input into the planning process.

The draft plan on which the HIA focused proposed the three service levels and their associated service components. Each service component is followed by a set of options, as outlined in Table 4.
The HIA was strategic in nature, intended to inform the selection of high-level waste management options, but interestingly wasn’t solely focused on waste management, but behavioural precursors to waste generation, and included recycling and reuse. In essence, the example centred on key principles of the CE, albeit without terming it.

The HIA was applied as an additional mean to engage with communities, and ensure that health, well-being and equity were considered as part of “policy development in all sectors”. It was seen as a means to facilitate policy-making that was based on evidence, focused on outcomes and encouraged collaboration between a range of sectors and stakeholders.

Table 4. Proposed service levels and associated service components

<table>
<thead>
<tr>
<th>Level of service</th>
<th>Options</th>
</tr>
</thead>
</table>
| Whether the Council provides a landfill facility for disposal of domestic and commercial refuse | 1a) Long-term disposal options  
- Option 1: Close landfill (that is truck all residual waste out of district)  
- Option 2: Status quo (charges would need to rise as current gate charges not covering costs)  
1b) Accepting waste at the landfill  
- Option 1: Compulsory to sort refuse otherwise not accepted at landfill  
- Option 2: Status quo (that is individual choice whether to recycle)  
- Option 3: Users encouraged to sort refuse (landfill users directed to recycling at point of entry) |
| Whether the Council actively promotes and educates the public about waste minimization | - Option 1: No waste education (discontinue school and general public education initiatives)  
- Option 2: Status quo (maintain school education programme, with some extension into marae (Māori meeting place), businesses and general public)  
- Option 3: Increase expenditure (target broader cross section of the community) |
| Whether the Council provides a domestic refuse collection service | - Option 1: Status quo (full user-pays refuse collection with choice of collection service supplier, for example, Council’s contractor service or different contractor of choice)  
- Option 2: Partially subsidised system (set bag rate, with remainder funded through rates)  
- Option 3: Fully subsidised system (totally funded through rates) |
Process and approach

The HIA was led by the Hawke’s Bay DHB’s HIA team and was undertaken in partnership with the WDC’s senior planner. The HIA team was assisted by HIA consultants. The HIA consultant’s services – facilitation, mentoring and a review of the literature, were funded by the Ministry of Health, HIA Support Unit’s Learning by Doing fund, as was the evaluation.

Aims and objectives of the HIA

The overall aim of the HIA was to apply an HIA process to the draft waste management activity plan with the overall purpose of informing the decision-makers of its potential health and well-being impacts on the identified populations.

The objectives of the HIA as applied to the plan were to:

- enhance a working partnership between the WDC and Hawke’s Bay DHB through shared planning and resourcing;
- assist the WDC to build on the positive aspects of the waste management activity plan and reduce any unintended negatives impacts, hence developing a well-rounded plan;
- to build capacity within the Hawke’s Bay DHB and WDC to use HIA;
- to support the WDC’s consultation process with the community;
- to provide recommendations to the decision-makers regarding the implementation of the waste management activity plan based on the HIA’s findings; and
- to disseminate the HIA findings into the wider policy arena of all relevant agencies.

In essence, the HIA was used as a means to test, refine and inform the strategic level decision-making process, but also facilitate engagement and explore community and social barriers that might detract from the delivery of the waste management plan.

Definition of health

While the health definition applied within the HIA centred on the WHO definition of health (WHO, 1948), the assessment was further tailored to local health perception, priorities and values, specifically Maori models of well-being, including Te Pae Mahutonga, a Maori conceptual framework which can be used as a guide in developing strategies (Durie, 1999).

Te Pae Mahutonga is the constellation of stars popularly referred to as the Southern Cross. Each pointer describes an element of well-being:

- Mauriora — access to te ao Maori, which can lead to a secure cultural identity;
- Waiora — acknowledges environmental protection. It acknowledges the link between people and the natural environment. It encourages people to take care of their communities and the natural environment;
- Toiora — promotes health lifestyles;
- Whaiora — participation in the wider community;
- Nga Manukura — supporting Maori leadership; and
- Te Mana Whakahaere — autonomy, self-governance.

(Adapted from Professor Mason Durie’s Te Pae Mahutonga Model (Durie, 1999))

Scope

A scoping exercise and meeting were included to explore, discuss and highlighted the key issues that needed to be considered and set out what was going to be done in the HIA.
The meeting included key stakeholders and was facilitated by the HIA consultants and the Hawke’s Bay DHB.

**Assessment Methods**

While the HIA was qualitative in nature, it included several sources of evidence to assist in undertaking the appraisal and inform decision-making. These included:

- a literature review focusing on:
  - What interventions are effective in changing waste behaviour?
  - What domestic refuse collections are effective in changing waste behaviours?
  - What is the relationship between waste and health?
- a community profile, establishing local health circumstance, priorities, and structure;
- interviews with community and key stakeholder groups, gaining tacit knowledge on waste generation and management practice; and
- a review of relevant policy and strategy documents.

**Outputs and key findings**

The HIA report was submitted to the WDC in time for its full Council meeting in May 2009. The timing was arranged to assist the Council’s decision-making with respect to its long-term consultation plan (LTCP).

The final HIA report included five recommendations. These appeared closely aligned to the international and national evidence emanating from the HIA’s literature review and the HIA community stakeholders’ input.

In summary, as set out in Table 5, the HIA report’s recommendations linked to the Table 4 objectives as follows.

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**Table 5. HIA recommendation links to proposed service levels**

<table>
<thead>
<tr>
<th>Level of service</th>
<th>Commentary on HIA support for options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whether the Council provides a landfill facility for disposal of domestic and commercial refuse</td>
<td>The HIA recommendations did not directly relate to this issue. The HIA emphasized the importance of waste prevention, rather than a community view on whether or not to close the existing landfill. Similarly, the HIA did not conclude on whether there should be compulsory or voluntary sorting of waste and recycling. Instead, the HIA recommended that joint council-community management options are a promising approach to minimise waste, reduce fly-tipping, promote recycling and composting and for collection of domestic refuse.</td>
</tr>
</tbody>
</table>
The HIA report includes an executive summary, a description and overview of the legislative basis, community setting, and historical context in which the Council’s Waste Management Activity Plan was developed. The WDC Plan’s expected community outcomes, principles, goals and objectives are also presented in a concise but informative manner. The complex well-being and health pathways were illustrated with flow charts.

Each of the Council’s service options like the HIA recommendations are discussed in light of the HIA-generated evidence. The report and the attached literature review were well received by the Council and its rural community partners, and valuable when developing and implementing the HIA-recommended joint council-community waste management and minimization pilot initiatives. The report was also of value to health promoters and others working in this field, as its spans both health protection and health promotion.

<table>
<thead>
<tr>
<th>Level of service</th>
<th>Commentary on HIA support for options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whether the Council actively promotes and educates the public about waste minimization</td>
<td>The HIA supported Option 2: Status quo (maintain school education programme, with some extension into marae, businesses and general public). There was neither community support for ceasing education nor for increasing funding for education. Options for enhancing existing community and school education without further funding were listed.</td>
</tr>
<tr>
<td>Whether the Council provides a domestic refuse collection service</td>
<td>The HIA supported Option 2: Partially subsidised system. Fully subsidising was found to work against principles of waste minimization. Full user pays risks fly-dumping and community resentment for costs.</td>
</tr>
</tbody>
</table>

The case study does not specifically make reference to a CE but recognizes that waste disposal is in itself not enough to offer a sustainable solution. The case study places weight on cultural and societal change and the need for education and community responsibility to facilitate this. In effect, it identifies aspects of the CE, and sets actions to addressing components of this within the decision-making sphere it can influence.

The lesson to take from this, is that the scope of a strategic level waste management decision-making can be expanded to explore and influence the root cause of waste generation, and set actions, initiatives and programmes to positively influence them. As you move away from the strategic to the project level, this opportunity reduces, as you only consider the waste management option.
CHAPTER 4

Patterns of human health consideration and usage of HIA for a transition to more sustainable waste management

4.1 Literature review implications

The scoping review of scientific literature identified a range of sources on waste management processes. The review purposefully focused on health outcomes and issues relevant to each of thermal treatment, landfill, bio-organic waste treatment and materials recovery. In the context of the CE transition the value of the literature review is in considering the benefits of moving away from purely landfill disposal, to increasing materials recovery and energy recovery. Bio-organic waste treatment has features of both recovery of resources, for example, for soil improver, and energy recovery, for example, district heating and/or electricity generation. Moving away from landfill is particularly important where waste is not contained such that leachates contaminate water sources, an issue exacerbated where hazardous waste streams are not removed.

Overall, from the literature reviewed, there are technologies and operating practices that greatly reduce the potential health hazards associated with diverting waste from landfill and into waste management systems that recover materials and/or energy. There remain uncertainties and risks to health, but the evidence indicates that such CE promoting approaches are to be encouraged. This is particularly the case where the alternative is open-air burning of waste or unmanaged landfill, both of which have much higher health risk profiles for workers and communities.

Adverse health impacts associated with disposal-only waste management are likely to be more prevalent in countries within the WHO European Region that are not subject to EU environmental and waste regulations. These instances are a particular opportunity to transition to modern thermal treatment, bio-organic waste treatment and materials recycling that benefit both the CE transition and health. The challenge in such transition is likely to include the substantial economic cost. These may include remediating legacy landfill sites as well as the purchasing, and maintaining of, modern technologies and abatement systems. International finance, supported by ESIAs, are one means of overcoming some of the economic barriers. Transitioning jobs associated with waste disposal to jobs associated with materials recycling and energy recovery would also be important to avoid adverse health outcomes associated with unemployment or lost livelihoods.

For each waste management process, studies show that where good practice methods and sound engineering are applied (often prompted by regulatory regimes), risk of associated adverse health impacts can be reduced significantly. This is best demonstrated within the literature.
for thermal treatment facilities, many from the United Kingdom, whereby epidemiological studies show a consistent decline in directly attributable health outcomes, associated with progression in abatement technology.

4.2 Candidate case study trends

CE links

Very few of the project-level HIA examples refer directly to a CE, where the scope and focus is geared to assessing the environmental and health consequences of the specific project and technology proposed. This is a consequence of the cascade of decision-making that precedes this stage.

The strategic level assessments have a broader remit, often considering local, regional and even national waste management options. They are often geared towards achieving a waste management hierarchy (a varying derivative of reduce, reuse, recycle and energy recovery), which is a component of, and important to delivering a CE. They rarely, however, address the full remit of the CE, as this tends to span material selection and manufacturing, retail, commercial behaviour and even education. The extensive remit of a CE thereby doesn’t sit in any one strategic level assessment but is a feature that needs to span almost every national policy to facilitate a consistent and cumulative approach to delivery.

For example, in this context the Draft Wales waste strategy was wide ranging and recognized that multidisciplinary input is needed to achieve a more sustainable and environmentally responsible attitude to waste generation and management throughout Wales. This active, holistic and targeted approach to waste-resource management linked more clearly to the wider CE agenda. The assessment was also able to make the links to a range of likely health consequences, including potential benefits. The assessment does however remain waste sector focused and not a wider CE delivery policy and IA.

Scope and focus

While the scope and focus of each of the HIA is bespoke, tailored to the decision-making process it is intended to inform, and the local regulatory, environmental and community circumstance; the generic HIA approach (notably screening, scoping and assessment) is consistent between almost every example. This demonstrates a commonly accepted international process to HIA, regardless of country or decision-making level (IAIA, 2020). This conclusion is influenced by the high number of candidate case studies from the United Kingdom, where HIA practice is perhaps more established than many other parts of the WHO European Region. However, the trend holds for the other non-United Kingdom examples as well.

A specific definition of health is rarely included in the HIAs. Rather than defining health, the HIAs more frequently list relevant determinants of health, which set a scope for the health assessment. This defines health in an indirect way. As shown in Table 2 above, although influenced by the United Kingdom HIA context, the range of determinants of health covered across the candidate case studies is consistent with the wider determinants of health approach that is implicit to the definition of health set out in the 1948 preamble to the WHO Constitution:

“Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1948).
The breadth of coverage of determinants of health, including social, behavioural, economic and institutional determinants, within the candidate case studies also shows consistency with adopting a broad public health, rather than solely environmental health protection, approach. Health protection, health improvement and health service implications are implicit within the public health definition: “The science and art of preventing disease, prolonging life and promoting health through organized efforts of society”. (Acheson, 1998).

It is acknowledged that in many instances a narrow bio-physical approach is the focus of waste sector projects, particularly those project level assessments focusing on a single waste management process, such as a single thermal treatment plant. In such cases, including within the United Kingdom, there can be a focus on issues like air quality, noise and water quality, with less or no coverage of social, behavioural, economic or institutional implications for population health. A narrow approach may be appropriate in some cases based on specific projects features. However, as a general approach, a narrow bio-physical focus to HIA, whether the HIA is integrated or standalone, is not consistent with the WHO definition of health and is not good practice (WHO, 2022).

Whilst these trends in the conceptualization of health are noted, it is also observed that there are varying international definitions of health, as well as varying health priorities, IA traditions, stakeholders and understandings that can, and do differ between communities. Such contextual differences reinforce why a bespoke HIA tailored to local social and cultural norms is required.

For example, the draft Wairoa District Council waste management activity management plan, New Zealand, case study. As definitions and priorities of health, can and do vary significantly between nations and even communities, the assessment was based upon appropriate community values. The ‘Te Pae Mahutonga’ approach used is also interestingly as it reflects common themes in a way similar to the wider determinants of health (Dahlgren & Whitehead, 1991) and the health fields concept developed before that (Lalonde, 1974). This aligns with the observed trend where the WHO definition is implicit and wider determinants of health are used as the basis for setting the parameters of the health assessment.

The scope of the assessments collated varied between practitioners. Some include a scoping statement as a technical appendix, rationalising the approach and focus of the assessment, and justifying any health issues scoped out. This is particularly the case for examples that are integrated within EIA, SEA or ESIA (see the last column of Table 3 above). Such detail may reflect the increased rigour the assessment must meet within such regulatory led processes.

This report did not collect information on the specific qualifications or backgrounds of those undertaking the health assessments. It is however noted that many were undertaken by private sector consultants within environmental and engineering consultancies. The level of public health knowledge within these teams was not clear within the assessments. The draft Wairoa District Council waste management activity management plan, New Zealand, case study is one example where there was specialist HIA expert input specifically referenced.
**Decision-making level**

The core variation between strategic and project level HIA is the level of information available to inform the HIA. Inevitably this means a more qualitative appraisal at the strategic level, with greater opportunity for quantitative health assessment at the project level, where appropriate and proportionate. The value for both, however, are clear. At the strategic level, there is often less opportunity for detailed assessment, but greater opportunity to inform and influence more health-conscientious policy and strategic development (IPH, 2021).

On this basis, a qualitative HIA that communicates potential health hazards, pathways and any disproportionate risk, can not only aid in refining the strategic level policy or plan, but direct the scope of HIA at the project level (IPH, 2021).

This connection between strategic and project level HIA is a key point, as it reinforces the consideration of health at all stages of decision-making, prevents unnecessary repetition of effort, and can even help drive the delivery of local health objectives more consistently, through consistent healthy urban design principles directed at proponents.

For transitioning to a CE the connection between strategic and project levels is crucial. The strategic level needs to set a policy context and planning framework within which individual projects that support the CE transition can be brought forward. The CE is however a concept that is even above most strategic level assessments, which tend to be sector specific rather than intersectoral. Waste sector strategic assessments are mainly promoting of materials recycling and energy recovery, but as this is only one component of the CE, are often not explicit that this is a CE related objective. Even more so at the project level, the CE links are rare, as any given project is not in itself influential of systems change across sectors and population behaviour.

Notwithstanding this, even if the CE agenda is implicit rather than explicit, the strategic waste sector objectives for greater circularity in resource use need to be established and influence the types of projects that come forward, that is promote waste recycling and energy recovery over simple landfill. In some cases a single project may include multiple waste stream management processes, for example, landfill plus materials recycling and/or energy recovery. In other cases projects deal with a single waste management process, for example, providing a modern contained landfill, or an application for a thermal treatment plant independent of the waste stream sorting process it relies on. In such cases the strategic level overview of ensuring the right mix of such individual projects to achieve the desired combination that promotes a CE transition is imperative.

For example, the Vinča energy from waste and landfill remediation project in Serbia case study exemplifies that a project is only able to effect change in areas over which it has control. In this case how to manage waste once it arrives at the landfill location. Given that the landfill site is managed by a city owned operator, there are other strategic and project level opportunities outside of this application for the city to influence the volume and nature of the waste arriving at the landfill site. Such wider opportunity to progress towards a CE is outside of the individual project, but within the remit of stakeholders involved.
In this case, the extent to which a hierarchical IA and decision-making system was in operation, such that strategic level IA (for example, SEA) and decision-making informed project level IA (in this case ESIA) and decision-making, was not established by this review. This case study does however suggest that such relationships would be valuable in increasing the extent to which project level decisions are able to progress a CE agenda and its health benefits.

Integrated or standalone

The authors note that, while historically, standalone HIA appear to be the most common output, in reality they often formed part of the planning submission. So, while physically separate from the EIA Report, they were still linked with the application, and often drew from and built upon the technical outputs of the submission.

There is, however, an increasing trend for integrated assessments to be viewed as best practice (IAIA, 2020). The reason for this seems to be driven by EU SEA and EIA Directive transposition into member country regulations, reinforcing the consideration of “population and health”, and requiring a discussion of any likely significant effects for human health as part of the EIA or SEA report. The authors note that integrating HIA is seen as an effective tool to delivering the SEA and EIA health assessment requirement, as long as it complies with the regulatory requirements that is the inclusion of significance criteria (IPH, 2021).

A similar trend is also observed outside of the EU, where varying national obligations coupled with practice driven by internationally lending requirements. For example, the Equator Principles and IFC Performance Standard 4 have promoted integration of health as part of ESIA reports required by the lender.

Where these assessments are considered integrated, there are two main approaches. The first is where a full HIA is appended to the SEA or EIA, carrying across the salient points to the main body text, and including the addition of significance criteria. The second is full integration within the SEA or EIA process, where the generic HIA approach is imbedded in the main body text, albeit more concisely, and meeting regulatory EIA reporting requirements. This report’s pool of candidate case studies showed an even split between the two approaches, with 23 standalone HIAs, 22 fully integrated HIAs and one that was semi-integrated, see Table 3 above.

The trend would indicate that HIA is being increasingly mainstreamed as a result of SEA, EIA and ESIA requirements, particularly those that are EU led, for reporting on the health effects of a proposal. However, there remains an absence of consistent guidance or training across the WHO European Region to promote good practice, such as the coverage of wider determinants of health and health inequalities (WHO, 2022) (IPH, 2021). What is clear however, is that defining and justifying the scope, approach and methods is central to delivering a proportionate and robust health assessment (IAIA, 2020).

For example, the Khmelnitsky solid waste project, Ukraine, adopted an approach of integrating the discussion of health through the ESIA rather than as a dedicated chapter. While this meets both EIA and EBRD requirements, it can reduce transparency. In this case, to appreciate the health consequences, a review is required of the entire ESIA (346 pages) and
supporting technical appendices. A dedicated health chapter would have allowed public health stakeholders, decision-makers and the public a more accessible understanding of the proposal’s health implications.

A final observation between the integrated and standalone HIA was in the way the fully integrated assessments generally frame their improvements to the proposal as secured mitigation measures. In contrast, standalone HIAs tend to make recommendations to which the proponent is less committed. Some of the integrated HIAs reviewed, particularly in the United Kingdom, were able to frame measures to address any potentially significant health effects as committed changes to design or management practices, or through committed community support initiatives or financial contributions.

Decision-making that is able to identify and achieve the win-win synergies for health and a CE from better waste management practices, is likely to be facilitated by IAs including a dedicated health chapter and committed measures on how to improve the proposal form the public health perspective. This is in contrast to optional recommendations in a standalone report that may be buried within appendices. This applies at both the strategic and project level.

**Common health determinants assessed**

Of the candidate cases reviewed, the core health determinants assessed across all waste management processes comprised air quality, noise, transport and socioeconomic factors, such as employment. Impacts on health associated with the water environment (abstraction, discharge, and surface and groundwater impacts) are also commonly assessed, but as these overlap with permitting requirements, either separate from IA or addressed through dedicated IA chapters, the HIA discussion of such issues tends to be high level and qualitative.

The other health determinants assessed are more specific to the type of waste management option under consideration, and may also be site-specific feature, or relate to specific community concerns.

For example, visual impacts, that is community views of a waste management facility or site, are often associated with thermal treatment and bio-organic waste treatment plants. This is because they include tall buildings and/or stacks that protrude above ground level to ensure air quality remains within objective thresholds protective of the environment and health (defined by the stack height determination process). Conversely, landfills are largely filling an existing void, and are therefore, typically, less likely to be visible from the surrounding area. Locations and final landform do however vary, which may give rise to views with reduced aesthetic or amenity value or may raise concerns associated with the visibility and nuisance of pests.

Another example is non-ionising radiation (electric and magnetic fields), which only warrant being scoped in where the project has potential for electrical energy generation and transmission. This is largely confined to energy from waste and biomass facilities that export electrical energy. As an issue this was only discussed four times across the candidate case studies.

Environmental determinants of health are more likely, due to their nature, to be regulated to comply with regulatory thresholds protective of the environment and health. HIA coverage
of the public health implications of these assessments therefore tend to have clearer links to technical input data, including from other IA chapters. Social, behavioural, economic and institutional health determinants tend to be less regulated and threshold based. Consequently, although there may be a socioeconomic chapter to draw inputs from, in general there may often be a need to explain the impact, for example, social impact, itself, as well as its public health implications.

As noted, the strength of the trend for assessing wider determinants of health in these results is influenced by the number of United Kingdom examples. This is acknowledged but is not an exclusively United Kingdom trend. The inclusion of wider determinants of health is considered good practice that should be promoted throughout the WHO European Region to support more informed decision-making about the public health implications of a proposal. Under EU SEA and EIA Directives decision-makers should have regard to not only the direct effects on human health, but also the indirect or secondary effects on human health. The former is likely to be dominated by environmental determinants such as air quality. However, the latter may include the social, behavioural, economic and institutional implications for population health of the environmental changes (WHO, 2022).

Understanding the full picture of likely significant public health consequences of proposals that seek to change waste management processes is likely to be supportive of a CE transition. For example, IA has the opportunity to articulate where there are social, behavioural, economic and institutional benefits of proposals that: move away from hazardous, wasteful landfilling with poor quality employment and no financial return; and shift towards modern technologies for materials and energy recovery, that are less hazardous, support better community amenity that influence health prompting behaviour, require higher skilled better-quality employment and result in economically valuable resources being returned to society.

4.3 Limitations

**Literature review**

Being a pragmatic scoping review the coverage of the topic areas is not held out to be exhaustive. Whilst the researchers were rigorous in their approach, it was not intended that the review meet systematic review standards. The search was pragmatic and targeted as fitted the aims of this research. A title search of research literature articles was undertaken using Google Scholar. Other databases were not included due to resource constraints, which is a noted limitation.

Searches were limited to the English language. Publication bias is always a consideration, with the literature skewed to reporting of significant correlations and less publication of null results. Neither bias nor strength of evidence within reviewed publications was not formally evaluated as part of this review. Reviewers used their judgement to select the most relevant articles.

**Case studies**

Collecting a representative sample of HIA case studies has inherent challenges. There is a risk of selection bias because, across the WHO European Region, there are:
• a relatively small number of known HIA practitioners, due to a lack of HIA accreditation systems and/or registers; and
• a relatively small number of known published HIA reports, due to a lack of maintained and centralized or linked public HIA databases.

The implication for this research is an associated risk of reporting bias as to the HIA field’s approach, methodology and outputs. The issue of both overall sample size and representative sampling within this, is compounded when considering HIAs from just one sector, in this case the waste sector.

This report responded to the risk of selection bias through an approach that used collaborative case study collation. This involved using international HIA community networking platforms, to canvas for a pool of candidate case-studies. The use of practitioner networks allowed for a snowballing effect to the sampling, with the request passed on through the network beyond the researchers’ known connections. Snowballing, or chain sampling, is a recognized qualitative research sampling approach (Ritchie & Lewis, 2003). The approach improved the return of case studies and reduced the risk of selection bias by having a wider pool of sources geographically and in terms of originating HIA practitioners. Whilst not completely eliminating selection bias, the approach is considered pragmatic and appropriate given the nature of this research, which is akin to a scoping review, rather than a systematic review.

A second internal validity challenge concerned the international scope, and with it, the varying language and terminology. The varying terminology was addressed in part, through the research team’s industry experience of working across HIA, EIA, SEA, and ESIA. The language barrier does however remain a limitation to the study, where it is likely to have influenced the case study collation exercise. This would explain the almost exclusive return of health assessments reported in English despite the use of international practitioner networks. Notwithstanding this limitation, perhaps in part to English being one of the official languages of the EU, a geographically diverse range of candidate case studies was identified, allowing a geographically diverse range of case studies to be written up.

A third challenge relates to external validity, that is the generalisability of findings to other contexts. Specifically, the challenge relates to the interpretation and application of the international health waste management evidence base given that varying environments and community circumstance can modify and enhance certain hazard profiles, exposure pathways and community sensitivity. This limitation is noted within the discussion of the evidence base, and within the concluding chapter. The external validity limitation can be reduced in applying the findings of this report by ensuring a robust IA scoping exercise is undertaken for a given proposal to set and rationalise a bespoke health assessment tailored to local circumstance and conditions.

As is appropriate to this research, no opinion on, or endorsement of, the selected case studies’ authors, quality, validity, scope, methods or conclusions is reached by this report.
CHAPTER 5

Implementing HIA to support sustainable waste management as part of a transition to a CE

5.1 Current HIA practice

Following a review of the collated HIA case studies, there is an increasing trend towards integration within regulatory assessments, and with it, their refinement to confirm to necessary rigour. One feature of good practice that should be promoted in IA is a coverage of the wider determinants of health and consideration of health inequalities. This is particularly the case for waste management projects, which can engender a wide array of community health concerns, often associated with both direct hazards and indirect social consequences from facilities. Whilst this may be less of an issue with the EU, due to Directives governing waste, this remains a challenge in parts of the WHO European Region where waste is less regulated or there are greater economic or legacy challenges to transitioning to newer technologies.

The approach to integration varies, as do the methods and outputs derived. However, the key message to effective integration is scoping. It is here that the aim and objectives are considered, as is the overlap with any wider technical disciplines, and a proportionate, objective focused assessment is defined and rationalised. Equally, it is here that any aspect to be scoped out is justified and agreed with health stakeholders. On this basis, the scoping stage defines the approach, model of health, key health determinants, necessary outputs and the rigor that is required (depending on what level of decision-making it is geared to). Get this right, and the assessment regardless of nation, varying regulatory requirement and decision-making level will be proportionate, fit for purpose, robust and support better decision-making.

5.2 Health evidence by waste management option

The overarching health evidence base reinforces the potential hazards associated with the management of waste, particularly for historic practice. The evidence also shows the known risks to public health are low for well designed, operated and maintained modern, CE supporting, waste management practices for materials recycling and energy recovery. Such risks, although including areas of uncertainty, should be viewed against the more certain known hazards of alternatives such as open-air burning of waste and landfilling that does not contain hazardous leachates. Such knowledge should support those WHO European Region Member States and municipalities that have yet to adopt waste management approaches that both better protect and promote public health and support a transition to a CE.

The health evidence base increasingly points towards waste sector related exposure-response functions being increasingly understood. Where it is appropriate and proportionate to do so this
may support a better understanding of impact magnitude and distribution, as well as the significance, in IA terms, of any public health implications.

5.3 Gaps and areas of future work

The authors observed a general trend of an inverse relationship between increasing regulation or environmental protection measures, and evidence of health impact from waste management. This is indicated in the health evidence base, where fewer epidemiological studies are forthcoming on modern waste management technologies, partly due to diminishing risk factors that can be attributed to such waste facilities, and the challenge of separating this from other confounding factors.

Notwithstanding this trend, there remain uncertainties with regards to more modern waste management practices, as is the case with all innovation. Further research into specific health pathways and outcomes may focus on occupational and laboratory based toxicological studies. Where environmental precursors are known to be emitted as part of a waste management process, such as fine particulate matter or bio-aerosols, it may be more pragmatic to focus on determining these emissions profiles by monitoring and or modelling. The associated population health outcomes can then be inferred or calculated from known exposure-response relationships derived from in other contexts.

5.4 Health, waste and the CE

Following a review of strategic and planning level HIA, a common theme emerged with reference to the CE. As soon as you explore waste management in isolation, it is possible to investigate, assess and communicate any potential health risk from what is proposed, but the opportunity to inform or drive a CE is diminished. Put another way, the CE requires all sectors to shift and align their practices to promote resource cycling. This cannot be fully achieved by considering one sector in isolation, however any given sector, for example, waste, can be supported towards more CE promoting practices using HIA.

CE is a cross-sectoral endeavour. Health-in-All-Policies (HiAP) is a cross-sectoral public health initiative to promote health improvement outside of the health sector. A feature of HiAP is the promotion of HIA as a tool that can be used across decision-making levels and across sectors to identify and promote opportunities to improve population health. Within the waste sector HIA can be used to articulate the public health implications of a given strategic or project level decision. Links between health and the CE may be explicit but are often implicit.

A reflection of the authors is that, as the concept of a CE increases momentum, it drives the diversification of new policy, regulation, technology, practice and industry, and with it, the need to consider how such changes might affect the environment and health. This is necessary to not only facilitate more health-conscious planning, decision-making and development, but to also explore wider health improvement opportunities. HIA can raise awareness to (and improve management of) unintended health consequences, health inequalities and potentially disproportionate impacts to particularly vulnerable groups and communities, as highlighted by the WHO (WHO, 2018).
There are win-win synergies between the CE and health. In general, material recycling and waste recovery is, with modern approaches and technologies, less hazardous to health than unregulated landfilled or open-air burning of waste. The CE also promotes more skilled, and therefore potentially better paid, waste industry jobs, with good quality employment being a strong driver of health. The CE also adds resources back into economic markets, further promoting health outcomes associated with economic prosperity. Environmental quality and its amenity value may also be improved by better waste management practices, increasing food safety, levels of physical activity and well-being associated with community aesthetics and social networking. Such benefits to public health are not only environmental, but also social, behavioural, economic and institutional. The latter including the health service, and wider societal, financial savings from better population health.

Where HIA articulates the full picture of public health outcomes, beneficial and adverse, decision-making can be better informed. Where public health would be improved, as demonstrated through a robust HIA, this may support decision-makers to progress a more rapid transition to a CE. In practice this would mean diverting more waste from being simply burnt or landfilled, to increasing levels of recycling and energy recovery using modern practices.

Although perhaps outside of the waste sector’s control, the avoidance of waste in the first place is also a critical component of the CE and one that HIA can support in other sectors.

The strategic level HIA examples reviewed reinforce this point, but also highlight how improved education and societal responsibility are essential to driving and maintaining a CE. Strategic IA, and the decisions it supports, can maximize public health and other societal benefits with interlinked policies, for example, spanning not only waste, but minerals, materials, manufacturing, retail and energy policy.

Such connectivity is needed not only at the national level, but also internationally. HiAP and the CE have global synergies to explore and to capitalise on.
References


APPENDIX A

Waste management and CE literature review

This appendix represents the results of the scoping review on health impacts related to four different types of waste management methods: thermal treatment, landfill, bio-organic waste treatment and materials recycling.

A.1 Thermal treatment

Introduction

None of the four systematic reviews relating to health impacts of waste incineration analysed as part of this literature review (de Titto & Savino, 2019; Cole-Hunter et al., 2020; Negri et al., 2020; Tait et al., 2020) identified any significant health risks associated with modern, well-designed and operated facilities.

Analysis undertaken by Negri et al. (2020) suggests that the adverse health impacts associated with older first- and second-generation incinerators across the EU were modest at most and have improved with the introduction of better technology. As an example, Negri et al. (2020) report excesses of non-Hodgkin lymphoma in older studies analysed, but not for those relating to more modern second-generation plants.

Due to their relatively recent introduction in 2006, there is a lack of direct evidence relating specifically to third-generation plants; of the evidence that does exist, the health outcomes are generally limited to short term impacts (Negri et al., 2020). The long latency period of some diseases likely to be associated with incineration (eg., cancer) means that more time is needed before any conclusive evidence is published (Tait et al., 2020; Barjoan et al., 2020; Negri et al., 2020). While this is the case, conclusions relating to chronic health outcomes associated with the newest plants can be inferred from factors such as emission levels from modern plants being several orders of magnitude lower than for older plants in which epidemiological studies have found some kind of negative health association (de Titto & Savino, 2019).

Methodological limitations in the existing literature (eg., unsophisticated exposure assessment and lack of control for confounding variables) also contribute to the inability to decisively conclude that there is an absence of health impacts associated with modern incinerators. However, there is also a clear

Footnote:
4 Incinerators were classified according to 3 generations: first generation, plants active until 1989, (first EU Directive on waste incineration, 89/429/EEC); second generation, plants active between 1989 and 2006 (transition period: revamping or closing of old plants and building of new plants); third generation, plants active after 2006 (publication of BAT REF Waste incineration). These terms are used throughout the literature review.
lack of strong and consistent evidence on the adverse health effects associated with incinerators which contributes to the confidence that this is the case (Negri et al., 2020).

Cole-Hunter et al. (2020) states that using sorted feedstock is very important to reduce potential adverse health effects, whereby poorly fed facilities may emit concentrated toxins with serious potential health risks, such as dioxins/furans and heavy metals (which may remain problematic in bottom ash as a combustion by-product). As such, countries with less stringent environmental regulations may be susceptible to disproportionate impacts from thermal treatment of waste and associated health inequalities.

**Respiratory disease**

Bae et al. (2020) state that results from previous studies exploring proximity to incinerators and respiratory health outcomes have been largely inconclusive. Results from this study showed that the relative risk of asthma-related hospitalization decreased with increasing distance from incinerators, but increased significantly among those living within a 2 km radius (1.13 [95% CI: 1.10–1.17] for all ages, 1.12 [95% CI: 1.08–1.17] for those aged <15 years, and 1.18 [95% CI: 1.10–1.27] for those aged 65 years and older). This higher asthma risk in the oldest age category reflects the general trend in the Republic of Korea, where the study was undertaken.

While this study is the first to observe an increased risk of asthma-related hospitalization in relation to a person’s distance from an incinerator in Seoul, Republic of Korea, there are uncertainties associated with using a less-sophisticated exposure assessment approach (i.e. distance from the incinerator). In addition, despite traffic being among the major causes of air pollution in Seoul, data limitations meant that the study did not adjust for this potential confounder or other sources of air pollution, such as factories (Bae et al., 2020).

**Cancer**

As previously stated, there is a lack of direct evidence relating specifically to third-generation plants. However, Barjoan et al. (2020) provides analysis on cancer incidence in proximity to an incinerator which achieved compliance with the EU 2000/76/EC Waste Incineration Directive (2000) (that limits dioxin emission levels to less than 0.1 ng TEQ/m³, i.e. a third generation plant) in December 2005. Overall, the results suggested that as time passed following the upgrading of the incinerator to a third-generation plant, the excess incidence rates reduced. Specifically, the study showed a significantly higher incidence of multiple myeloma, lung cancer and soft-tissue sarcoma among men during the 2005–2009 period. Among women during the same period, there was a significantly higher incidence of acute myeloid leukaemia, myelodysplastic syndromes and multiple myeloma. Between 2010 and 2014, there was no excess incidence among women; however, among men, incidence of myeloma and lung cancer remained significantly higher (Barjoan et al., 2020).

It is possible that the excess incidence in men for myeloma and lung cancer during the 2010 and 2014 period could be attributed to long latency periods and improved diagnostic procedures. As such, incidence rates for men in the exposed area could continue to reduce beyond 2014, resulting in a comparable incidence rate with the non-exposed area. Due to data limitations (no control for tobacco
use, proximity to other polluting agents and socioeconomic factors) causal relationships could not be established and results should be interpreted with caution (Barjoan et al., 2020).

**Reproductive health and adverse birth/childhood outcomes**

While previous studies have reported associations between modern waste incinerators (MWIs) and adverse birth outcomes, these relate to older incinerators. A national study by Ghosh et al. (2019) investigating foetal growth, stillbirth, infant mortality and other birth outcomes near modern, third-generation municipal waste incinerators in Great Britain operating to the current more stringent 2010/75/EU Industrial Emissions Directive (IED) (2010) standards was commissioned as one of the largest studies on health risks of incinerators to date. The study concluded that results showed no evidence of an increased risk for the range of birth outcomes assessed and that these study conclusions should be generalisable to other incinerators operating to similar regulations and with similar waste streams. Similar results were found in a study by Freni-Sterrantino et al. (2019), whereby no associations were found between the opening of a new MWI in Great Britain and changes in infant mortality trends or sex ratio.

Another national study by Parkes et al. (2020) investigating the risk of congenital anomalies near modern, third-generation municipal waste incinerators in the United Kingdom operating to the current more stringent EU IED standards was also commissioned at the same time. Similarly, the study found no increased risk of congenital anomalies in relation to mean modelled PM10 concentrations from MWIs. However, for all congenital anomalies combined, congenital heart defects and genital anomalies (specifically hypospadias) small increased risks were observed (2–7%). However, it is stated these findings may reflect residual confounding.

Adverse pregnancy outcomes (including miscarriage and birth defects) associated with exposure to MSW emissions during the 2003–2013 time period, including discrete consideration of 2009 when a progressive shutdown of old incineration lines and operation of a new line caused considerably higher emissions, were investigated by Vinceti et al. (2018). The study concluded that the relative risk (RR) of miscarriage in women residing in the exposed area was 1.04 [95% CI: 0.80–1.32], with little evidence of a dose-response relationship. Similarly, no evidence of increased birth defect risk at birth in the offspring of women residing in the exposed area emerged 0.64 [95% CI: 0.29–1.26]. Overall, results do not suggest adverse reproductive health impacts associated with exposure to the emissions of the municipal solid waste incinerators.

A study by Xu et al. (2019) showed that children living in the vicinity of a municipal waste incinerators suffered increased body burdens of heavy metals (chromium, cadmium, and lead) associated with genotoxicity and epigenetic modifications. While this is the case, a follow up cross-sectional study assessing urinary metal levels and renal impairment on school-age children living near a municipal waste incinerator indicated that children living around municipal waste incinerators may not suffer considerable long-term accumulation of cadmium or chromium and that no distinct early renal impairment was found in these children (Xu et al., 2020).
Cognitive Impairment

A birth cohort study investigating childhood social development in children residing near an incinerator in Taiwan showed a negative impact on childhood social development for children living within 3 km of a municipal solid waste incinerator. However, the impact was transitory on the basis that it was apparent at six months but not at 18 months. While a negative impact was reported, limitations include use of a coarse exposure assessment approach and subjective reporting of health outcomes by parents (Lung et al., 2020). This study was analysed as part of a systematic review by Cole-Hunter et al. (2020) and Tait et al. (2020) where it was concluded by Cole-Hunter et al. (2020) that the results provide little evidence of an adverse impact on health outcomes.

A.2 Landfill

Introduction

Regardless of what reduction measures, reuse or recycling is undertaken, landfills will always play a role in the waste management system for two main reasons: Firstly, not all types of waste can be recycled or incinerated, and secondly, the amount of waste determined for recycling, reuse or incineration sometimes exceeds available capacity (Vaverková, 2019).

Migration of contaminated leachate and biogas represent the two main types of environmental pollution associated with landfills which have the potential to impact human health. As previously stated, landfilling as a waste management method is popular worldwide, particularly in low- and middle-income countries, due to the relative low cost and low-technical requirement in comparison to incineration, which represents a very costly technology needed for the solution of all possible risks associated with emissions to air (Vaverková, 2019).

Sanitary landfills are engineered structures consisting of bottom liners, leachate collection and removal systems, and final covers in which MSW is deposited by controlled operations in defined layers, each layer being compacted and covered with soil before depositing the next layer. However, not all landfills are sanitary, and many consist of non-controlled disposals or open dumps where wastes are not sorted, there is a lack of leachate collection and treatment systems, there is no attempt to separate the waste from the underlying soil or rock strata and where there is potential for waste to be dumped directly into the groundwater should the hole extend to below the groundwater level. The environmental and potential health implications of such sites are particularly prevalent in low- and middle-income countries, where the unsanitary nature of landfill sites is a contributing factor to potential adverse health impacts in addition to lack of planning and precaution (for example, where communities are not sufficiently set back from such sites).

Much of the literature analysed relate to circumstances where this is the case (Alawode et al., 2019; Istvan et al., 2019; Boateng et al., 2019; Esphylin et al., 2018; Negi et al., 2020; Odonkor & Mahami, 2020; Parth & Mukherjee, 2019; Rezapour et al., 2018; Norsa’adah et al., 2020) and as such, are not necessarily transferrable to more regulated landfill sites. Another issue with landfills is that even when they are managed to stringent regulations
and standards, the deficiency of records — particularly for older landfills — means that uncertainties exist regarding the type of waste within stored. On this basis, it can be difficult to compare studies and determine causality of any identified health impacts (Istvan et al., 2019).

The remainder of this section explores the evidence base relating to general self-reported health impacts on local residents and landfill waste recyclers; potential health impacts associated with migration of contaminated leachate; potential health impacts associated with biogas; and adverse birth outcomes potentially associated with both.

**General health impacts**

A review of MSW and adverse health outcomes by Vinti et al (2021) included studies from China, Denmark, Italy, South Africa, the United Kingdom and United States of America. The review found the evidence for an association to be mixed, with multiple studies reporting no significant adverse health effects, but some reporting significant findings linked to lung cancer mortality, congenital anomalies, respiratory conditions and mild symptoms. Findings also pointed to reduced mental health. All reviewed studies were observational with inherent bias risks, including due to study design, sample size, lack of control for confounders, self-reported data and lack of clear case definitions. The review explains that the significant adverse health effects were identified in the context of older generations of landfill before legislative requirements were implemented to improve practices and reduce environmental risks, such as through the use of liners to contain hazardous leachate.

A review of health outcomes and landfill proximity by Mattiello et al (2013) references studies from Italy, Slovakia and the United Kingdom. The review finds evidence from older landfill studies that supports a relationship with adverse outcomes, such as congenital anomalies and respiratory conditions. The quality of the evidence is limited. The review also finds such an association is less likely with modern landfill practices, including very accurately waste sorting.

The Thohoyandou MSW landfill in the Limpopo Province of South Africa is situated very close to receptors, approximately 100 m away. A study by Njoku et al. (2019) evaluated self-reported health problems in communities living close to (100–500 m) and far away from (1–2 km) the landfill site. Results from the study showed illnesses such as flu, eye irritation and weakness of the body were frequently reported by participants living closer to the landfill than those living far from the landfill.

A similar study by Norsa’adeh et al. (2020) compared the self-reported prevalence of health symptoms and diseases diagnosed among residents exposed (within a 1 km radius) to the unsanitary solid waste open dumpsite in the suburb of Sabak, Malaysia with a non-exposed community (between a 2.5 and 4 km radius). It is noted that domestic, commercial, construction/demolition debris, agricultural waste, non-hazardous sludge from municipal sewage treatment facilities, and non-toxic industrial waste is mainly dumped at the site. Results showed that following adjustment for confounders (such as age, smoking status, and duration of exposure), dumpsite exposure was significantly associated with sore throat (1.88 [95% CI: 1.05–3.38]), diabetes mellitus (2.84 [95% CI: 1.10–7.30]) and hypertension (2.56 [95% CI: 1.27–5.13]).
A Hazard Quotient is the ratio of the potential exposure to a substance and the level at which no adverse effects are expected.

Goorah et al. (2009) followed a similar approach, but for the Mare Chicoose landfill in Mauritius, the first-ever and only controlled sanitary landfill of the country, which opened in 1997. The landfill permits municipal solid wastes and also a limited quantity of hazardous wastes (less than 0.01% of waste input). After adjusting for confounding variables and elimination of reporting bias, nausea and vomiting were found to be the only significant self-reported health outcomes.

In low- and middle-income countries, waste sorting and recycling at non-controlled disposals or open dumps is a source of income for poorer communities. However, as observed by Tlotleng et al. (2019) at two randomly selected landfill sites at Johannesburg, no proper or occupationally recommended PPE was worn by waste collectors. Combined with the poor working conditions, this is likely to contribute to a 58.5% prevalence of respiratory symptoms in the population, of which a persistent cough was the most common symptom (46.8%), followed by breathlessness (19.6%) and rapid breathing (15.8%). The analysis showed that landfill workers exposed to airborne dust reported twice the odds of respiratory symptoms, compared to those not exposed. While the results were self-reported, data on smoking status and medical history were collected to control for potential confounding variables.

However, due to the cross-sectional nature of the studies and potential for reporting bias, a cause-effect relationship cannot be determined.

**Leachate-related health impacts**

Exposure to heavy metals components from leachate in water that penetrates through landfill sites above recommended levels can lead to carcinogenic and non-carcinogenic health impacts such as biometal poisoning-related symptoms and diseases which includes, asthma, depression, vomiting and convulsion, ataxia, cardiovascular and renal diseases, diarrhoea, neurological diseases, hypertension, pneumonitis, skeletal deformities, anaemia, and gastrointestinal disorders (Alawode et al., 2019; Boateng et al., 2019).

Alawode et al. (2019) analysed soil and groundwater samples from six sites around a prominent uncontrolled landfill in the fast-growing Ogeese community of Oyo in Nigeria for heavy metal components. Results showed that the heavy metal concentration for most water and soil samples exceeded the WHO standard, but no clear trend in the way the values vary from location to location was identified. In particular, the presence of copper was relatively high for all groundwater samples collected. For the soil samples collected, there was a clear increase in heavy metal concentration where there was a sludge or soil/sludge mixture for all tested elements except manganese.

Groundwater sampling undertaken by Boateng et al. (2019) around the uncontrolled Oti landfill site in Kumasi, Ghana showed that the levels of iron, lead, and cadmium had their average concentration in all the well water samples above the recommended limits for drinking-water. A human health risk assessment (HHRA) was carried out using the groundwater samples and recorded a hazard quotient (HQ) output value for all groundwater samples of <1, which suggests acceptable non-carcinogenic adverse health risk even if the water is used for drinking.
However, the hazard index (HI)\(^6\) values at two sites was >1, which does signify adverse health effects.

Negi et al. (2020) also use groundwater sampling in India, around uncontrolled landfill sites in Chandigarh, Mohali, and Panchkula, to inform an HHRA. Similarly, the results of sampling showed an exceedance of the permissible limits, with the concentration of measured parameters decreasing with distance and depth, confirming that leachate is the source of contamination. HI outputs for the Chandigarh, Mohali, and Panchkula landfill sites was 0.61, 0.53, and 0.01 mg/kg/day respectively in pre-monsoon and 0.38, 0.24, and 0.01 mg/kg/day respectively in post-monsoon, indicating that there is potential for non-carcinogenic health risks.

In addition to non-carcinogenic risks, Parth & Mukherjee (2019) also assessed the carcinogenic risks associated with heavy metal contamination of subsurface water in the neighbourhood of an uncontrolled MSW disposal site in Kolkata metropolitan city, India. Carcinogenic risk (CR)\(^7\) was established only for arsenic in subsurface water where the ingestion-based risk was higher than the critical level, but the dermal-based risk was very low. For non-carcinogenic risks, an HQ output of >1 was observed primarily due to the presence of arsenic and manganese in groundwater samples. Overall, arsenic was established as the most significant pollutant of concern among ten heavy metals examined as both its values of HQ and CR indicated potentially undesirable health risks for the neighbouring inhabitants.

Both carcinogenic and non-carcinogenic risks were also assessed by Rezapour et al. (2018), who collected soil samples near a landfill site located 20 km from Miandoab City in north-western Iran to investigate the accumulation and potential health risk of heavy metals using HHRA. This landfill is uncontrolled in the sense that there is a lack of any barrier system or a leachate collection system, which has resulted in release and transport of its leachate into the surrounding wheat crop land. The only heavy metal which exceeded the relevant threshold concentration in the agricultural soil samples was cadmium.

For the various population groups, the mean HQ was <1, which suggests acceptable non-carcinogenic adverse health risk for local residents. However, cadmium and lead contributed the most to HI, the average of which was 2.3 for people aged 0–5 and 1.1 for 6–18 years age group, respectively, suggesting a moderate non-carcinogenic health risk for these specific demographic groups. Referencing methods set out by the risk assessment information system (RAIS) (RAIS, 2017) and the United States of America Environmental Protection Agency (US EPA) (EPA, 2004), CR were established for Cd, where analysed values for all population groups were lower than the maximum allowable range (1 \times 10^{-4}), suggesting no remarkable carcinogenic risk to the local residents (Rezapour et al., 2018).

The results from the environmental and HHRA outlined above differ from case to case and is a function of not only the specific landfill characteristics such as waste composition,

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\(^6\) A Hazard Index is the sum of Hazard Quotients for all pathways and similar toxic effects.

\(^7\) Carcinogenic risk is the likelihood of cancer manifestation in an individual from lifetime exposure to carcinogenic element.
which is often unknown, and mitigation measures applied (if any), but also the exposure characteristics specific to each community. As a result, the results differ somewhat with no common heavy metal consistently most prominent in the surrounding environment.

**Biogas-related health impacts**

Malatoni et al. (2016) evaluated the potential health effects associated with airborne contamination from landfills, using exposure to hydrogen sulfide as a tracer. After controlling for several confounders, results showed that hydrogen sulfide exposure was associated with mortality from lung cancer and respiratory diseases (hazard ratio (HR) for increments of 1 ng/m³ 1.10 [95% CI: 1.02–1.19] and 1.09 [95% CI: 1.00–1.19], respectively). There were also associations between hydrogen sulfide and respiratory disease-related hospital admissions HR 1.02 [95% CI: 1.00–1.03], particularly for acute respiratory infections among children (0–14 years), HR 1.06 [95% CI: 1.02–1.11].

Where waste is disposed of in unsanitary landfills, microbial air pollution is possible with the potential for human exposure at nearby receptors. Odonkor & Mahami (2020) assessed the microbial air quality and associated environmental health hazards of landfill sites in selected districts in the Greater Accra region of Ghana where some landfill sites are located just 100 m from residential receptors. Results showed that the landfills analysed contributed significantly to bioaerosol concentrations nearby as the control air samples collected from neighbourhoods 2 km away had substantially lower microbial counts. Of the microbes identified, almost every species (particularly those belonging to the bacteria domain) are capable of causing serious diseases that could subsequently lead to deaths of people they infect. Therefore, it was concluded that people living in these areas are prone to adverse health impacts.

As toxic, mutagenic, teratogenic and carcinogenic chemicals, Petrovic et al. (2018) sampled residues of polycyclic aromatic hydrocarbons (PAHs) and persistent organic pollutants (POPs) in the ambient air surrounding an MSW landfill in Novi Sad, Serbia, to inform an HHRA. When originally opened in 1964, the landfill comprised a non-sanitary, semi-controlled operation; however, systemic land filling began in 1980 (Dvornic et al., 2011). The highest risk was obtained for PAHs (significant contributors to genotoxicity and carcinogenicity) which may be a consequence of uncontrolled solid waste combustion as PAHs are formed during incomplete combustion of organic matter. However, the total calculated risk values for all investigated substances were lower than the relevant limit values for exposure of human populations (as defined by the US EPA (EPA, 2003)) and therefore does not pose a relevant threat to humans by inhalation of PAHs and POPs.

A cross-sectional study by Esphylin et al. (2018) investigated the association between reported respiratory symptoms in exposed children living close (within a 3 km radius) to four MSW landfills in Malaysia (varying in level of unsanitary nature) with heavy metal levels in PM₁₀, using the accumulation of heavy metals in fingernails as biomarker. The cadmium, chromium, copper, manganese, nickel and lead concentrations in PM around the MSW landfills and residential areas exceeded the standard permissible limit. Symptoms were reported by parents, showing that exposed children (56.4%) were reported to experience coughing with flu more than
unexposed children (25.2%). In addition, the number of respondents having runny noses and sneezing differed significantly between the exposed and unexposed groups (higher in the exposed group and lower in the unexposed group). Heavy metals in fingernails of the exposed group were significantly higher than in the unexposed group.

Another cross-sectional study by Yu et al. (2018) investigated the association between respiratory health of children residing near an MSW landfill in northern China and air pollution. It was reported that unexposed children had significantly higher levels of antibacterial proteins in saliva (specifically, lysozyme and secretory immunoglobulin A) and better lung capacity than exposed children. Hydrogen sulfide and sulfur dioxide pollutants were the most robustly related with reduced lung function while lysozyme levels exhibited a consistent negative association with methane and hydrogen sulfide and secretory immunoglobulin A levels were negatively associated with hydrogen sulfide and ammonia (Yu et al., 2018).

Nkolfoulou landfill, in Cameroon, was first operated in 1990 as a dump site but was upgraded to a controlled landfill in 1998. Feuyit et al. (2019) assessed the air quality in the residential areas surrounding the landfill in order to inform an HHRA. Sampling recorded that 30% of the daily mean concentrations of PM$_{2.5}$ and PM$_{10}$ and all detected levels of formaldehyde exceeded the daily maximum safe limit, while the concentrations of carbon monoxide, ozone, nitrogen dioxide, sulfur dioxide, and hydrogen sulfide were within the emission standards. The CR values due to inhalation of formaldehyde were $>10^{-6}$ and the HI values due to the inhalation of formaldehyde, hydrogen sulfide, and sulfur dioxide were <1. As such, it was concluded that there may be an increased cancer risk for communities residing near the landfill, whereas the increased non-cancer risks were low.

Landfill emissions also contain volatile organic compounds (VOCs) which comprise a specific class of air pollutants that are potentially hazardous to health. VOCs include benzene, toluene, ethylbenzene and xylene, which are collectively known as BTEX, are carcinogenic even at low concentrations and can cause acute or chronic illness. Lakhouit & Alsulami (2020) have collected biogas samples from the surface of Saint Nicephore landfill in Quebec, Canada since 2006. Recorded concentrations of BTEX are in the range of below the limit of detection (BLD) to 3.76 mg m$^{-3}$. The Intake Rate (IR) values ranged from 0.27 to 0.39 mg/kg-day, while the estimated CR directly attributable to the VOCs associated with the landfill ranged from 0.007 to 0.010.

**Adverse birth outcomes**

A high rate of preterm birth of 15.8% (more than three times the figure for mainland France) is observed in the Guadeloupe archipelago (French West Indies). Despite African ancestry being a strong risk factor for preterm birth, the high rates observed in the Guadeloupe archipelago cannot be fully explained by the African origin of its population. This has raised the hypothesis of potential harmful environmental exposures, such as landfilling (Istvan et al., 2019).

Istvan et al. (2019) aimed to evaluate preterm birth clusters around the three official, but uncontrolled and uncovered, landfills located in the Guadeloupe archipelago, namely La Gabarre, Saint-François and Baillif. As these
landfills are uncontrolled in nature, each includes hazardous waste in addition to municipal waste. A significant cluster was identified within 2 km around the Saint-François landfill with a preterm birth RR of 4.82. While the Saint-François landfill is not the largest landfill, the specific characteristics of the landfill which are not known (e.g., age and waste stream) are likely to be more influential in the higher observed RR. While the study included several strengths, such as precision of residential data for pregnant women and the absence of heavy industry and other potentially confounding pollution sources in the areas which surround the three sites, limitations include the lack of consideration for potential exposure to pollution from illegal landfill sites and the less-sophisticated exposure assessment method (i.e. distance from source).

A larger study by Elliott et al. (2001) examined the risk of adverse birth outcomes in populations living within 2 km of 9,565 sanitary landfill sites across the United Kingdom operational at some time between 1982 and 1997 compared with those living further away. The findings showed that for non-special waste sites (i.e. municipal waste), excess risks were found for all but three health outcomes analysed (cardiovascular defects; surgical corrections of hypospadias and epispadias; and stillbirths) ranging up to 1.18 [99% CI: 1.03–1.34] for surgical corrections of gastroschisis and exomphalos.

Specifically, the RR for all congenital anomalies combined was 1.02 [99% CI: 1.01–1.03], 1.06 [99% CI: 1.01–1.12] for neural tube defects, 1.07 [99% CI: 0.99–1.16] for abdominal wall defects (and 1.05 [99% CI: 0.94–1.16] for hospital admissions), 1.07 [99% CI: 1.04–1.11] for hypospadias and epispadias, 1.18 [99% CI: 1.03–1.34] for surgical correction of gastroschisis and exomphalos, and 1.06 [99% CI: 1.052–1.062] and 1.04 [99% CI: 1.03–1.06] for low and very low birth weight respectively. While a causal mechanism should be considered, the considerable uncertainty regarding the extent of any possible exposure to chemicals found in landfills and lack of understanding of the potential toxicity of landfill emissions and possible exposure pathways contributes to the inability to conclude that there is a causal explanation for the findings (Elliott et al., 2001).

A.3 Bio-organic waste treatment

Open composting

Introduction

In recent years, there has been an increase in composting of bio-organic waste in large scale industrial facilities, as well as the development of more advanced composting technologies, in an effort to reduce waste destined for landfill. Composting is conducted in open-air turned windrows with long heaps of composting material or indoor facilities with enclosed reactor systems.

Composting (particularly open-air composting) is known to generate bioaerosols (airborne biological agents, including bacteria, fungi, pollen, and particulate matter), which are associated primarily with adverse respiratory health outcomes (e.g., asthma, bronchitis, rhinitis, chronic obstructive pulmonary disease) (Pearson et al., 2015), although carcinogenic risks have also been explored (Yaghmaien
et al., 2019; Kermani et al., 2018; Mustafa et al., 2017). However, literature assessing both exposure and health outcomes is limited, with most studies focusing on occupational exposure of workers (Bonifait et al., 2017; van Kampen et al., 2016; Aghaei et al., 2020; Cheng et al., 2019) and very little on community exposure for nearby residents.

The two systematic reviews analyzed relating to bioaerosol exposure from composting and health outcomes (Pearson et al., 2015; Robertson et al., 2019) note that the majority of the literature is occupational, that there is an absence of consistent evidence on the toxicity of bioaerosols from composting facilities, and conclude that there is insufficient evidence to provide quantitative conclusions on risks to nearby residents.

**Respiratory Impacts**

Using *Aspergillus fumigatus* concentrations as an indicator for bioaerosol emissions, Williams et al. (2019) found that bioaerosol concentrations deplete rapidly with distance, reaching background levels at approximately 2 km (Williams et al., 2019). While the study did not assess health outcomes and concludes that better exposure estimations are needed to assess health risks, it does provide useful dispersion model estimates for bioaerosol concentrations in England.

Using these national dispersion model estimates for *A. fumigatus* concentrations provided by Williams et al. (2019), Roca-Barcelo et al. (2020) investigated possible associations between *A. fumigatus* concentrations emitted by composting facilities and respiratory-related hospital admissions in England. Hospital admissions for diagnoses of respiratory conditions, respiratory infections, asthma, chronic obstructive pulmonary disease (COPD), diseases due to organic dust, and cystic fibrosis were considered for areas within 4 km of 76 composting facilities. The study did not find any statistically significant effect on risk of respiratory-related hospital admissions (RR 0.99 [95% CI: 0.96–1.01]) or cystic fibrosis admissions (RR 1.01 [95% CI: 0.56–1.83]) in the highest quartile of exposure. However, given that hospital admissions represent severe respiratory episodes, the study concludes that further assessment is needed to investigate any less severe impacts or respiratory symptoms on those living near composting facilities (Roca-Barcelo et al., 2020).

Another study investigating health effects of bioaerosols from composting facilities in a community setting was by Douglas et al. (2016), who examined the risk of respiratory-related hospital admissions in relation to distance from composting facilities in England. The study did not find clear evidence for increased risk of respiratory-related hospital admissions in communities further than 250 m of facilities, but did find a small non-statistically significant association with total respiratory admissions and distance as a continuous measure for exposure (Douglas et al., 2016). Given that distance is a relatively simple proxy for exposure, further studies using more sophisticated methods such as dispersion modelling (although with its own limitations) are needed to gain a better understanding of potential respiratory health effects to populations living near composting facilities.

Two studies investigated respiratory health risk to compost facility workers from exposure to bioaerosols (van Kampen et al., 2016; Aghaei et al., 2020). Van Kampen et al. (2016) found a significant increase in RR for cough (RR 1.28
[95% CI: 1.2–1.4]) and for cough with phlegm (RR 1.32 [95% CI: 1.2–1.5]) in those who had worked for five years or more compared to non-exposed controls. However, during a follow up study 13 years later, they found no evidence of higher deterioration in lung function in workers. Aghaei et al. (2020) undertook a similar study in Tehran, Iran, where no difference in lung function or most respiratory symptoms were found between workers and controls, despite a relatively high difference in endotoxin exposure. The study did find an increased risk (odds ratio (OR)) of cough (OR 7.8 [95% CI: 1.6–39.1] in a highly exposed group), fatigue (OR 3.7 [95% CI: 1.2–11.7]), and headache (OR 6.02 [95% CI: 1.4–24.5]) in exposed groups compared to controls after adjusting for age and smoking. However, this study does not investigate any long-term impacts of chronic exposure and was done over a very short time period. Limitations from both studies include self-reporting bias and intra and inter-subject variability. Occupational studies also do not provide any insight into community level exposure and any associated health outcomes.

Cancer

Two HHRAs were found, both conducted in Iran, assessing risk of cancer from exposure to BTEX substances from composting facilities and other waste management methods. Yaghmaien et al. (2019) investigated different units of a municipal solid waste disposal facility including a composting unit, landfill and leachate treatment plant and found that the maximum carcinogenic risks of benzene in all waste management units exceeded the 1 x 10^{-4} limit set to protect health. However, hazard ratios of BTEX were sufficiently low and therefore no significant risk to workers’ health was found. Furthermore, although not significant, the study found that the landfill posed a higher risk to workers compared to the composting and leachate treatment plant units analysed (Yaghmaien et al., 2019). Kermani et al. (2018) conducted a health risk assessment of PM_{2.5} concentrations and heavy metals from composting facilities in Tehran, and found that cancer risk from five carcinogenic metals (lead, chromium, arsenic, nickel and cadmium) exceeded 1 x 10^{-4}, concluding that the risk factor is not negligible (Kermani et al., 2018).

Another cancer risk assessment study examined the distribution of PAHs in PM_{10} particles and associated health effects from the largest composting facility in Tehran, Iran (Baghani et al., 2020). The study found that the average cumulative excess lifetime cancer risk for PAHs-PM_{10} surpassed the US EPA limit (1 x 10^{-6}) and is therefore not negligible.

An HHRA in China (Mustafa et al., 2017) investigated odour nuisance and health risks from volatile compounds (VCs) from composting facilities, including seasonal variations. The study found higher average concentrations of VCs in winter, however also found that individual carcinogenic and non-carcinogenic risks were within acceptable limits, however cumulative non-carcinogenic risk exceeded the threshold limit in both summer and winter, and cumulative carcinogenic risk exceeded limits at one unit during summer. Although these results are inconclusive, it provides insight to potential patterns and provokes further investigation.

Another odour nuisance study in China (Cheng et al., 2019), found negligible carcinogenic risk to workers from composting facilities as well as landfills investigated. However, it did find significant correlations between odour concentrations and halogenated compounds and sulphides in composting facilities, with these facilities performing the worst for odour nuisance.
It should be noted that all the HHRAs and studies investigating cancer risk detailed above relate to occupational exposures and are therefore not directly transferrable to assess public health risk. However, it is likely that public health risk is lower than occupational health risk due to likely lower levels of exposure intensity.

**Anaerobic digestion**

**Introduction**

Although there are numerous environmental studies on anaerobic digestion (AD) and its potential as a producer of green energy, literature on health impacts associated with anaerobic digestion facilities is limited, with the few studies available principally assessing either occupational exposure or indirect impacts from odour and other social factors.

**Odour-related impacts**

An occupational study investigating health impacts of odour from anaerobic digestion and composting facilities that treat sewage sludge found excessively high odours at the site, particularly in winter (Han et al., 2020). The study further states that levels of ammonia and dimethyl sulphide found in the ambient air were sufficient to harm worker health.

A similar study by Han et al. (2021) found odour pollution occurring at all AD sites tested, particularly in certain stages in the process, and concludes that levels of ammonia and hydrogen sulphide were sufficient to impact the health of on-site employees (Han et al., 2021).

**Direct Health Impacts**

One HHRA was found investigating occupational health risks from long-term exposure to VOCs from an AD facility in Suzhou, China. The study found that VOC concentrations varied greatly between seasons and different working units within the facility, and that the carcinogenic risk exceeded the US EPA safety threshold (ILCR \( <1 \times 10^{-6} \)), while the non-carcinogenic risk was within acceptable range (HI \( <1 \)). It is noted that although not assessed in this study, non-carcinogenic risks of inorganic substances (such as ammonia and hydrogen sulfide) and possible synergistic and antagonistic effects of mixed VOCs could still pose risks to human health. The study also assessed the carcinogenic risk at the facility boundary, used to infer the health risk to neighbouring residents, and found a risk of \( 1.2 \times 10^{-6} \), indicating potential community risk (Zheng et al., 2020).

An occupational study investigating bioaerosol exposure and potential risk to workers in AD facilities in Italy found high levels of microbial contamination where organic waste is handled, and several endotoxin concentrations that reach or overtake threshold limits established by the Dutch Expert Committee on Occupational Safety (Traversi et al., 2018). However, no health outcomes are investigated so although the study states that the bioaerosol levels found can be hazardous to worker health, no conclusions can be made relating to health impacts.

**Indirect health impacts**

The use of outputs from composting (fibre, organic carbon, nitrogen and phosphorus nutrients) and AD facilities (nitrogen and phosphorus nutrients) in agriculture, forestry and land restoration as part of a circular economic framework is a potential benefit of these bio-organic waste treatment methods. However, as noted by Longhurst et al. (2019), concerns have been raised by trade bodies, consumers and regulators on the potential for onward contamination of food chains, loss
of land value and degradation of receiving environments.

The study by Longhurst et al. (2019) analysed risk research findings over ten years and performs risk assessments for several sources and receptors of compost and AD outputs in the United Kingdom. Using worst-case scenarios, the study found that microbial risks such as the risk of \textit{E. coli} illness associated with human consumption of food (particularly ready to eat vegetables and food that is generally eaten fresh) produced through quality assured and source segregated compost was negligible. Risks of infection in humans and livestock following land application of quality-assured and source segregated AD digestate was higher than that of composts, but also negligible. Chemical contamination (e.g., polychlorinated biphenyls (PCBs), PAHs, heavy metals) was also assessed, and likelihood of harm from chemical exposure was deemed to be low. The study concluded that there is negligible risk to human health through the application of quality assured and source segregated outputs to land, under United Kingdom quality protocols and waste standards. The authors also note that extending these findings to the international community are dependent on similar regulatory and contextual environments, and offer further insight into issues and opportunities for agreed standards and policies (Longhurst et al., 2019).

Another study, in Iran, investigated heavy metal concentrations in lettuce harvested from land where anaerobically digested sludge was used for cultivation found increased rates of bioaccumulation of heavy metals with potential to pose a risk to human health. However, the samples used were created specifically for this study and are therefore not wholly representative of real agricultural practices where regulations are in place, and furthermore no conclusions can be made on specific risks to health (Shamsollahi et al., 2018).

A study by Nag et al. (2020) in Ireland investigated the most hazardous pathogens and their ability to survive the AD process, routes of transmission and severity of illness. Bio-aerosols, water, ingestions of soil through food and direct contact with infected animals were identified as the main hazard pathways. The top-ranking pathogens associated with agricultural application of anaerobic digestate and linked to disease outbreaks and mortality statistics included \textit{Cryptosporidium}, \textit{Salmonella spp.}, \textit{E. coli}, and norovirus. \textit{Cryptosporidium} was identified as a greater issue in Ireland. Although the study does not assess quantitative risks to human health, it provides a useful risk ranking methodology and data on pathogens of significance for further investigation (Nag et al., 2020).

A.4 Materials recycling

There is a growing body of research showing that exposure to toxic contents of electrical and electronic equipment (e-waste) impacts multiple organs of the body and multiple biological systems simultaneously, and that infants and children are at high risk of health effects due to their special vulnerabilities (WHO, 2021). The majority of literature that exists on the potential health implications of materials recycling relate specifically to e-waste recycling sites where primitive methods (such as open burning of cables and unsound dismantling to recover valuable fraction or metals from
this stream of waste) are often used to recover materials by unprotected workers. When such methods are applied, a variety of contaminants which are toxic to human health are released to the surrounding environment. Many studies relate to Chinese case studies; likely due to the fact that of the circa. 50 million tonnes of e-waste generated worldwide each year, a large portion of it is shipped to China for processing (Luo et al., 2015).

A study by Luo et al. (2015) conducted a sampling campaign in Qingyuan (a typical e-waste recycling zone) and Guangzhou (a typical urban site), China, to verify whether PAHs in e-waste recycling zones posed a comparatively high cancer risk in unprotected workers and nearby residents. Results showed that the lifetime incremental cancer risks for inhalation of PAHs were size-dependent, with accumulation mode particles contributing the most, and were up to 360 cases per million people on average in Qingyuan (the e-waste recycling zone) compared to up to 184 cases per million people on average in Guangzhou.

Guiyu in China has been one of the world’s largest e-waste recycling sites for more than 20 years. Three studies analysed as part of this section of the literature review focussed on Guiyu as a case study (Zheng et al., 2016; Shi et al., 2016; Shi et al., 2019):

a. Zheng et al. (2016) characterized the concentration of heavy metals in PM$_{2.5}$ in Guiyu, whereby the geometric mean concentrations of PM$_{2.5}$, lead and cadmium in Guiyu were all higher than in the reference area (PM$_{2.5}$: 49.9 μg/m$^3$ vs. 37.6 μg/m$^3$; lead: 160 ng/m$^3$ vs. 69 ng/m$^3$; cadmium: 5.7 ng/m$^3$ vs. 3.4 ng/m$^3$). However, chromium and manganese concentrations were not statistically different. Using these outputs to inform an HHRA, results showed that total potential cancer risk for both adults and children are higher than the safe acceptable range and carcinogenic and non-carcinogenic elements in PM$_{2.5}$ pose higher public health risk to children than adults.

b. Due to its location near Haimen Bay (the estuary of Lian River, less than 30 km from Guiyu), Shi et al. (2016) assessed the potential health risks of PAHs via fish consumption. Overall, the concentrations of 16 PAHs were determined in collected marine fish with a median summed PAH concentration of 1478 ng g (wet weight), of which the contamination may be mainly influenced by Lian River runoff. This equated to a lifetime excess cancer risk for local dwellers which was much higher than the serious risk level (10$^{-4}$).

c. Another study by Shi et al. (2019) analysed PCBs in soils and plants from Guiyu, whereby high concentrations of PCBs were found in soil and plant samples up to 234 ng g and 236 ng g (dry weight), respectively.

Hu et al. (2013) collected workshop dust, soil and sediment samples at an intensive e-waste recycling site in Longtang, China to investigate the level and spatial distribution of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzo-furans (PCDDs/Fs). All the samples were characterized by abnormally high concentrations of octachlorodibenzodioxin (OCDD) (which is a PCDD) and an extremely low portion of PCDFs. Overall, while the daily intake of PCDDs/Fs through soil ingestion and dermal absorption was found to be negligible, the estimated total PCDD/Fs intake dose far exceeded the tolerance daily intake value recommended by WHO, indicating that
residents in Longtang were at a high risk of exposure to dioxins, especially children.

Two further studies from China analysed the presence of toxic substances associated with e-waste in blood or tissue samples of populations living around e-waste recycling sites to infer potential associated health risks (Leung et al., 2010; Li et al., 2013):

a. Polybrominated diphenyl ethers (PBDEs) can cause thyroid homeostasis disruption, neurodevelopmental deficits, reproductive changes and cancer. Leung et al. (2010) analysed the concentrations of PBDEs in different human tissues for individuals living near an e-waste site in Taizhou, China. PBDE body burdens of women from near the e-waste site showed significantly higher levels than those from the reference site. Furthermore, the estimated intake of PBDEs of 6-month-old breastfed infants living near the e-waste site was 57 times higher than that of infants from the reference site.

b. Li et al. (2013) analysed blood samples from individuals living in proximity to an e-waste recycling site located in northern China to analyse concentrations of e-waste-related pollutants and reactive oxygen species (ROS) in comparison to a reference population. Results showed that geometric mean concentrations of PCBs, dechlorane plus, and 2,2’,4,4’,5,5’-hexabromobiphenyl in plasma from the exposure group were 2.2, 3.2, and 2.2 times higher than in those from the reference group. Correspondingly, ROS levels in white blood cells from the exposure group were significantly higher than in those from the reference group, suggesting potential ROS related health effects for residents near the e-waste site. In contrast, fewer ROS were generated in the respiratory burst of neutrophil granulocytes for the exposure group, indicating a depressed innate immune function for the individuals living near the e-waste site. The findings suggest a potential linkage between exposure to pollutants from e-waste recycling and both elevated oxidative stress and altered immune function.

The only study outside of China included in this literature review is a study by Kyere et al. (2018), which assessed the carcinogenic and non-carcinogenic health risk of heavy metals on workers and residents around the Agbogbloshie e-waste processing site, located in the suburb of Ghana’s national capital Accra. Agbogbloshie has a population of about 40 000 inhabitants with the active age group of 11 to 35 years involved in e-waste recycling, which is estimated to bring in about US$ 105 million in revenue per annum to the economy.

Mean concentrations of cadmium, chromium and nitrogen (carcinogenic) and mercury (non-carcinogenic) from all sites within the Agbogbloshie e-waste processing site were lower than the Dutch and Canadian soil regulatory limit. However, copper, lead and zinc (non-carcinogenic) had mean concentrations between 100–500% higher than regulatory limits of Dutch and Canadian soil standards. Further analysis of possible health risk suggested that there is significant potential non-carcinogenic health risk (developmental and neurological disorders) to children under 6 years due to exposure of chromium, copper, mercury and lead with hazard indexes in the burning and dismantling areas above the reference value of 1 (Kyere et al., 2018).
A.5 References


### Waste management HIA example analysis

Table B. Process, scope and method used of candidate case studies

<table>
<thead>
<tr>
<th>No</th>
<th>Project</th>
<th>Country/region</th>
<th>Waste management process*</th>
<th>Decision level</th>
<th>Standalone/Integrated HIA</th>
<th>Process</th>
<th>Scope</th>
<th>Method</th>
</tr>
</thead>
</table>
| 1  | Yerevan solid waste project | Armenia | L | EIA | Integrated | - Baseline/community profile  
- Assessment  
- Environmental management plan | - Air quality  
- Disease transmission  
- Health and safety  
- Noise | Qualitative |
| 2  | Maryvale energy from waste plant: health impact assessment | Australia | TT | EIA | Standalone | - Scoping  
- Project profile  
- Baseline/community profile  
- Stakeholder engagement  
- Assessment | - Air quality  
- Community cohesion  
- Health and safety  
- Income and economy  
- Noise  
- Social capital  
- Traffic and transport  
- Water | Qualitative and quantitative |
| 3  | Zivinice regional solid waste project | Bosnia and Herzegovina | L | EIA | Integrated | - Feasibility study  
- Stakeholder engagement plan  
- Baseline/community profile (demographic)  
- Assessment  
- Environmental and social action plan | - Air quality  
- Disease transmission  
- Employment  
- Noise  
- Traffic and transport | Qualitative |
| 4  | Toplofikacija combined heat and power plant | Bulgaria | TT | EIA | Integrated | - Baseline/community profile  
- Occupational health baseline  
- Health care capacity  
- Risk assessment | - Air quality  
- Electromagnetic fields  
- Health and safety  
- Noise | Qualitative |

*TT = thermal treatment; L = landfill; BWT = bio-organic waste treatment, MR = materials recycling.

*Case studies conducted by author’s organization (RPS).

References of candidate case studies can be found in Appendix C.
### Table B. contd

<table>
<thead>
<tr>
<th>No</th>
<th>Project</th>
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<th>Process</th>
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<td>6</td>
<td>Ajara solid waste project</td>
<td>Georgia</td>
<td>L, MR</td>
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<td>- Crime and community safety</td>
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<td>Osh and Jalal-Abad solid waste management</td>
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</table>

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<tr>
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<th>Country/region</th>
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<th>Process</th>
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<td>HIA on the draft Wairoa District Council waste management activity management plan</td>
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<td>Scoping</td>
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<td>Olsztyn waste to energy plant</td>
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<td>TT</td>
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<td>Integrated</td>
<td>Baseline/ community profile</td>
<td>Air quality</td>
<td>Qualitative and quantitative</td>
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<td>11</td>
<td>Chisinau solid waste project</td>
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<td>Duboko regional landfill extension project</td>
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<td>L</td>
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<td>Integrated</td>
<td>Scoping</td>
<td>Air quality</td>
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<td>13</td>
<td>Vinča energy from waste facility, construction of the new landfill and remediation of the existing landfill</td>
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<td>TT, L, MR</td>
<td>EIA</td>
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<td>Scoping</td>
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<th>Standalone/ integrated HIA</th>
<th>Process</th>
<th>Scope</th>
<th>Method</th>
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</table>
| 14 | Khmelnitsky solid waste project | Ukraine | L, BWT, MR | EIA | Integrated | - Scoping  
- Stakeholder engagement plan  
- Baseline/community profile  
- Assessment  
- Environmental and social action plan | - Air quality  
- Community cohesion  
- Emergency scenarios (e.g., fire)  
- Employment  
- Health and safety  
- Income and economy  
- Noise  
- Odour and nuisance  
- Pests and vermin  
- Traffic and transport  
- Well-being | Qualitative |
| 15 | Darwen energy recovery centre* | United Kingdom/ England | TT | EIA | Integrated | - Scoping  
- Baseline/community profile  
- Stakeholder engagement  
- Assessment  
- Mitigation | - Air quality  
- Noise  
- Traffic and transport  
- Employment | Qualitative and quantitative  
- Quantitative: applying the WHO health risks of air pollution in Europe exposure response coefficients |
| 16 | Exeter energy from waste facility* | United Kingdom/ England | TT | EIA | Standalone | - Project profile  
- Scoping  
- Baseline/community profile  
- Assessment  
- Health management plan  
- Evidence base review | - Air quality  
- Built environment (inc. housing)  
- Employment  
- Land use  
- Noise  
- Traffic and transport  
- Water | Qualitative |
| 17 | Green Hills energy from waste facility* | United Kingdom/ England | TT | EIA | Standalone | - Project profile  
- Assessment | - Air quality | Quantitative: applying the United Kingdom Department of Health’s Committee on the medical effects of air pollutants exposure response coefficients |

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### Table B. contd

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<tr>
<th>No</th>
<th>Project Description</th>
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<th>Process Scope</th>
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<td>18</td>
<td>Municipal waste management strategy of the Mayor of London</td>
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<td>TT, L, BWT, MR</td>
<td>SEA</td>
<td>Integrated</td>
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| 19 | Longridge road energy centre* | United Kingdom/England | TT | EIA | Integrated | - Scoping  
- Baseline/community profile  
- Stakeholder engagement  
- Assessment  
- Mitigation | - Air quality  
- Employment  
- Noise  
- Traffic and transport | Qualitative and quantitative  
- Quantitative: applying the WHO health risks of air pollution in Europe exposure response coefficients |
| 20 | North London heat and power project | United Kingdom/England | TT, MR | EIA | Standalone | - Scoping  
- Baseline/community profile  
- Stakeholder engagement  
- Assessment  
- Recommendations | - Access  
- Air quality  
- Built environment (inc. housing)  
- Climate change  
- Community cohesion  
- Noise  
- Physical activity and open space  
- Resource use  
- Social capital | Qualitative |
| 21 | Pinkham Way waste management and recycling facility and North London Waste Authority vehicle depot | United Kingdom/England | BWT, MR | EIA | Standalone | Data not available | Data not available | Data not available |
| 22 | Roosecote biomass power station* | United Kingdom/England | TT | EIA | Standalone | - Project profile  
- Scoping  
- Baseline/community profile  
- Stakeholder engagement  
- Assessment  
- Health action plan | - Air quality  
- Emergency scenarios (e.g., fire)  
- Electromagnetic fields  
- Employment  
- Noise  
- Traffic and transport | Qualitative and quantitative  
- Quantitative: applying the United Kingdom Department of Health's Committee on the medical effects of air pollutants exposure response coefficients |

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<td>Runcorn energy recovery facility*</td>
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<td>- Air quality - Built environment (inc. housing) - Employment - Noise - Traffic and transport</td>
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<td>- Air quality - Built environment (inc. housing) - Emergency scenarios (e.g., fire) - Employment - Noise - Traffic and transport</td>
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<td>26</td>
<td>The Brighton &amp; Hove and East Sussex waste and minerals development framework*</td>
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<td>The Buckinghamshire waste strategy*</td>
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</table>
| 28 | The construction of an energy from waste plant in Her Majesty’s Naval Base, Devonport, Plymouth | United Kingdom/ England | TT | EIA | Standalone | - Scoping  
- Evidence base review  
- Baseline/community profile  
- Stakeholder engagement  
- Assessment  
- Recommendations | - Access  
- Air quality  
- Built environment (inc. housing)  
- Climate change  
- Community cohesion  
- Crime and community safety  
- Food  
- Noise  
- Physical activity and open space  
- Resource use  
- Social capital  
- Traffic and transport  
- Water | Qualitative |
| 29 | The Lancashire waste and minerals development framework* | United Kingdom/ England | TT, L, BWT, MR | SEA | Integrated | - Project profile  
- Baseline/community profile  
- Assessment  
- Evidence base review | N/A | Qualitative |
| 30 | Warnham energy from waste facility* | United Kingdom/ England | TT, MR | EIA | Integrated | - Scoping  
- Baseline/community profile  
- Assessment  
- Mitigation | - Air quality  
- Noise  
- Traffic and transport | Qualitative |
| 31 | Wheelabrator Kemsley North energy from waste facility* | United Kingdom/ England | TT | EIA | Integrated | - Scoping  
- Baseline/community profile  
- Stakeholder engagement  
- Assessment  
- Mitigation | - Air quality  
- Employment  
- Noise  
- Traffic and transport | Qualitative and quantitative  
- Quantitative: applying the WHO health risks of air pollution in Europe exposure response coefficients |
| 32 | Willows power and recycling centre* | United Kingdom/ England | TT | EIA | Standalone | - Project profile  
- Scoping  
- Baseline/community profile  
- Stakeholder engagement  
- Assessment  
- Health action plan  
- Evidence base review | - Air quality  
- EMF  
- Employment  
- Noise  
- Perceived risk  
- Traffic and transport | Qualitative and quantitative  
- Quantitative: applying the United Kingdom Department of Health’s Committee on the medical effects of air pollutants exposure response coefficients |

*TT = thermal treatment; L = landfill; BWT = bio-organic waste treatment, MR = materials recycling.

Case studies conducted by author’s organization (RPS).

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<table>
<thead>
<tr>
<th>No</th>
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<th>Country/region</th>
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<th>Decision level</th>
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<td>33</td>
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<td>Hightown Quarry residual waste</td>
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<td>BWT</td>
<td>EIA</td>
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<td>Qualitative and quantitative: applying the WHO health risks of air Pollution in Europe exposure response coefficients</td>
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</tbody>
</table>

*TT = thermal treatment; L = landfill; BWT = bio-organic waste treatment, MR = materials recycling.

*Case studies conducted by author’s organization (RPS).

References of candidate case studies can be found in Appendix C.
Table B. contd

<table>
<thead>
<tr>
<th>No</th>
<th>Project</th>
<th>Country/region</th>
<th>Waste management process*</th>
<th>Decision level</th>
<th>Standalone/integrated HIA</th>
<th>Process</th>
<th>Scope</th>
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<tr>
<td>37</td>
<td>Cardenden biomass facility*</td>
<td>United Kingdom/Scotland</td>
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<td>Brig y Cwm energy from waste facility*</td>
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<td>EIA</td>
<td>Standalone</td>
<td>- Project profile - Scoping - Baseline/community profile - Stakeholder engagement - Assessment - Health action plan - Evidence base review</td>
<td>- Air quality - Employment - Noise - Traffic and transport</td>
<td>Qualitative and quantitative - Quantitative: applying the United Kingdom Department of Health’s Committee on the medical effects of air pollutants exposure response coefficients</td>
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<td>39</td>
<td>Interim report of the HIA of the waste incineration development planned in Trident Park, Splott</td>
<td>United Kingdom/Wales</td>
<td>TT</td>
<td>EIA</td>
<td>Standalone</td>
<td>- Scoping - Evidence base review - Baseline/community profile - Stakeholder engagement - Assessment - Recommendations</td>
<td>- Air quality - Built environment (inc. housing) - Community gain/investment - Employment - Income and economy - Noise - Perceived risk - Traffic and transport - Visual</td>
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<td>Integrated</td>
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<td>- Air quality - Noise - Traffic and transport</td>
<td>Qualitative and quantitative - Quantitative: applying the WHO health risks of air pollution in Europe exposure response coefficients</td>
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</tbody>
</table>

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<table>
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<tr>
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<th>Standalone/integrated HIA</th>
<th>Process</th>
<th>Scope</th>
<th>Method</th>
</tr>
</thead>
</table>
| 41 | The Wales National Waste Strategy* | United Kingdom/Wales | TT, L, BWT, MR | SEA | Standalone | - Project profile  
- Scoping  
- Baseline/ community profile  
- Stakeholder engagement  
- Assessment  
- Health management plan  
- Evidence base review | N/A (waste management method led rather than determinant led) | Qualitative |
| 42 | Towards zero waste, Public Sector waste and resource efficiency plan | United Kingdom/Wales | TT, L, BWT, MR | SEA | Integrated | - Scoping  
- Baseline/ community profile  
- Stakeholder engagement  
- Assessment  
- Recommendations | | Qualitative |
| 43 | Wales Waste Sector Plan sustainability appraisals, industrial and commercial sector and construction and demolition | United Kingdom/Wales | TT, L, BWT, MR | SEA | Integrated | - Scoping  
- Baseline/ community profile  
- Stakeholder engagement  
- Assessment  
- Recommendations | | Qualitative |

*TT = thermal treatment; L = landfill; BWT = bio-organic waste treatment, MR = materials recycling.

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<th>Standalone/ integrated HIA</th>
<th>Process</th>
<th>Scope</th>
<th>Method</th>
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</table>
| 44 | Placer County biomass energy facility (using forest biomass) | United States of America/ California | TT | EIA | Standalone | - Scoping  
- Evidence base review  
- Baseline/ community profile  
- Stakeholder engagement  
- Assessment  
- Recommendations | - Climate change  
- Emergency scenarios (e.g., fire)  
- Employment  
- Energy security  
- Income and economy  
- Noise  
- Traffic and transport  
- Water | Qualitative |
| 45 | Metro HIA, evaluation of landfill and waste to energy options for managing municipal solid waste | United States of America/ Oregon | TT, L | EIA | Standalone | - Scoping  
- Baseline/ community profile  
- Stakeholder engagement  
- Assessment  
- Recommendations  
- Evidence base review | - Access  
- Air quality  
- Climate change  
- Community voice  
- Disease transmission  
- Emergency scenarios (e.g., fire)  
- Employment  
- Energy security  
- Health and safety  
- Income and economy  
- Pests and vermin  
- Resettlement and property values  
- Soil  
- Traffic and transport  
- Water | Qualitative |
| 46 | Poultry-litter fired biomass facility | United States of America/ Virginia | TT | EIA | Standalone | - Scoping  
- Evidence base review  
- Baseline/ community profile  
- Stakeholder engagement  
- Assessment  
- Recommendations | - Air quality  
- Employment  
- Income and economy  
- Odour and nuisance  
- Traffic and transport  
- Visual  
- Water | Qualitative |

*TT = thermal treatment; L = landfill; BWT = bio-organic waste treatment, MR = materials recycling.

*Case studies conducted by author’s organization (RPS).

References of candidate case studies can be found in Appendix C.
APPENDIX C

Candidate case study bibliography

1. Yerevan solid waste project:

2. Maryvale energy from waste plant: health impact assessment:

3. Zivinice regional solid waste project:

4. Toplofikatsia combined heat and power plant:

5. HIA of biosolids management plan for Highland Creek treatment plant:

6. Ajara solid waste project:

7. Dublin energy from waste plant:

8. Osh and Jalal-Abad solid waste management:

9. HIA on the draft Wairoa District Council waste management activity management plan:

10. Olsztyn waste to energy plant:

11. Chisinau solid waste project.

12. Duboko regional landfill extension project:

13. Vinča energy from waste facility, construction of the new landfill and remediation of the existing landfill:

14. Khmelnitsky solid waste project:

15. Darwen energy recovery centre:
16. Exeter waste to energy facility:

17. Green Hills energy from waste facility:

18. Municipal waste management strategy of the mayor of London:

19. Longridge Road energy centre:

20. North London heat and power project:

21. Pinkham Way waste management and recycling facility and North London Waste Authority vehicle depot:

22. Roosecote biomass power station:
23. Rufford energy recovery facility:

24. Runcorn energy from waste facility:

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26. The Brighton & Hove and East Sussex waste and minerals development framework:

27. The Buckinghamshire waste strategy:

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   files/FD96AFD8E3F7104A21602B3C2B08EC20/pdf/09_02430_WAS-Health_Impact_
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35. Hightown Quarry residual waste management facility:
   Environmental Statement Appendix 16.2. Northern Ireland: EEW Energy from Waste United
   Kingdom Ltd. (https://becon.co.uk/becon-project/downloads/#73-44-wpfid-16-population-and-
36. Tully Quarry Phase II anaerobic digestion facility:

37. Cardenden biomass facility:

38. Brig y Cwm energy from waste facility:

39. Interim report of the HIA of the waste incineration development planned in Trident Park, Splott:

40. Simec Uskmouth power station conversion project:

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44. Placer County biomass energy facility (using forest biomass):

45. Metro HIA, evaluation of landfill and waste to energy options for managing municipal solid waste:

46. Poultry-litter fired biomass facility:
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