# Health Task Group Final Report


Prepared by the
Health Task Group
for the
Odour Management Team

6 March 2015

**Table of Contents**

**Important Notice:**
The content contained in this report is being provided to the Odour Management Team (OMT) for their consideration as they develop the 'Good Practice Guide' and their Final Report. It may or may not be included in the final versions of these documents that will be submitted to CASA Board of Directors for their approval.

**Acknowledgements**

The Health Task Group would like to thank all current and past members for their hard work and dedication over the life of the team.

The Health Task Group would like to thank Alberta Health for their in-kind contribution to the development of the backgrounder on odour and health.

The Health Task Group would like to thank Natasha Windsor from Alberta Health for preparing the tool prototypes.

The Health Task Group would like to thank all reviewers and pilot testing participants.

**About Clean Air Strategic Alliance (CASA)**

**Vision:**
The air will have no adverse odour, taste or visual impact and have no measurable short or long term adverse effects on people, animals or the environment.

**Mission:**
The Clean Air Strategic Alliance is a multi-stakeholder alliance composed of representatives selected by industry, government and non-government organizations to provide strategies to assess and improve air quality for Albertans, using a collaborative consensus process.

**Health Task Group Members**

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# Executive Summary

The Odour Management Team (OMT) formed the Health Task Group in 2013 to undertake the work listed under 'Health' in the OMT's Project Charter. The OMT developed a workplan for the Health Task Group which tasked them with two streams of work with specific deliverables:

1. Stream 1: Develop background material on odour and health that can be included in the Good Practice Guide which the OMT can use to help build a common understanding of the topic amongst team members.
2. Stream 2: Develop a tool for individuals to track any symptoms they are experiencing that they feel may be related to an odour exposure.

The task group reviewed literature and other background materials on odour and health in order to define the issue and to provide background information for the team and build common understanding of odour and health. Table 1 below explains the key deliverables and status for this Stream of work.

| **Task Group Deliverables** | **Completion Status and Details** |
|---|---|
| A document/presentation to the team to use as background information and to build common understanding, including a glossary of terms. | Complete.<br>– The task group developed a backgrounder on odour and health (see Appendix I), which includes a glossary of terms.<br>– The task group will provide a presentation to the OMT summarizing their work. |
| Consensus background material for inclusion in the Good Practice Guide. | Complete.<br>– The task group developed a backgrounder on odour and health (see Appendix I). |

**Table 1: Health Task Group Stream #1 Workplan Deliverables.**

The task group's Stream 2 work included the development of a tool that could be used by a multitude of organizations for individuals to track any symptoms they are experiencing which they feel may be related to an odour exposure. Table 2 below explains the key deliverables and status for this Stream of work.

| **Task Group Deliverables** | **Completion Status and Details** |
|---|---|
| An inventory of best practices and tools for individuals (and potentially health care professionals) to track the health-related impacts of odour. | Complete.<br>– The task group undertook a search for currently available tools.<br>– The task group agreed not to develop a tool for physicians. |
| An analysis of the inventory of best practices to track the health-related impacts of odour. | Complete.<br>– The task group reviewed these tools for relevance to the final deliverable. |
| A tool for individuals (and potentially health | Complete. |

| | |
|---|---|
| care professionals) to track the health-related impacts of odour. | – The task group developed a tool for individuals (see Appendix II).<br>– The task group agreed not to develop a tool for physicians. |
| A plan for distributing the record keeping tool to relevant organizations. | Complete.<br>– The task group prepared distribution advice for the OMT to incorporate in to the roll-out plan for the Good Practice Guide. |

**Table 2: Health Task Group Stream #2 Workplan Deliverables.**

# 1. Introduction

The Odour Management Team (OMT) formed the Health Task Group in 2013 to undertake the work listed under 'Health' in the Odour Management Team's Project Charter. The Project Charter outlines one objective under 'Health':

1. To improve the management of odour and odour complaints by identifying, understanding, and developing tools and strategies to address health concerns and issues.

The OMT further defined a workplan for the Health Task Group which identified two distinct streams of work with specific deliverables:

1. Stream 1: Develop background material on odour and health that can be included in the Good Practice Guide which the OMT can use to help build a common understanding of the topic amongst team members.
2. Stream 2: Develop a tool for individuals to track any symptoms they are experiencing that they feel may be related to an odour exposure.

In order to complete these two streams of work, the task group has:

- Met 12 times, including two 1.5 day workshops,
- Read over 500 pages of background material, and
- Spent over 550 in-kind hours in and between meetings developing and reviewing deliverables.

This report outlines the work of the task group and presents the deliverables the group has prepared for the OMT review for inclusion into the Good Practice Guide.

## 1.1 Clean Air Strategic Alliance (CASA) Process

A task group is responsible for completing a piece of work that will subsequently be reviewed by the team and incorporated into the overall work of the team. This will help the team to complete their work in a timely manner by making efficient use of resources. A task group reports to and coordinates with the team on a regular basis. The team provides oversight for all task groups. As CASA is composed of stakeholders from three sectors – government, industry, and non-government organizations – as a new task group forms this multi-stakeholder approach is used. All groups and teams make decisions and recommendations by consensus, which are more likely to be innovative and longer lasting than those reached through traditional negotiation processes. Each item and deliverable of the Health Task Group were achieved through working together and by consensus agreement of the whole group.

The group established ground rules for how they plan to work together; these were basic rules of procedure and behaviour. All participants of the group agreed on maintaining these basic principles throughout the task group work. These include coming to meetings prepared and

keeping discussions focused on the set goals and outcomes for each meeting, using a "SMART" approach (Specific, Measurable, Action-oriented, Realistic, Time-bound) principle as a lens for discussion, and being patient and understanding of task group members' opinions.

# 2. Stream One – Backgrounder on Odour & Health

## 2.1 Overview of Original Task

The OMT Project Charter and Health Task Group workplan described the objective for the group. This was to improve the management of odour and odour complaints by identifying, understanding, and developing tools and strategies to address health concerns and issues. Under Stream 1, the task group was asked to review background material on odour and health, agree on what information sources would be used, and then summarize this information into an easily digestible format including a glossary of terms. The primary deliverable of Stream 1 was a document presenting this information, which the task group called the backgrounder on odour and health (hereafter referred to as the 'backgrounder'). The backgrounder can be found in Appendix I.

Table 3 below describes the task group's workplan deliverables for Stream 1 and an overview of outcomes of this work.

| **Task Group Deliverable** | **Completion Status and Details** |
|---|---|
| A document/presentation to the team to use as background information and to build common understanding about odour and health, including a glossary of terms. | Complete.<br>– The task group developed a backgrounder on odour and health (see Appendix I), which includes a glossary of terms.<br>– The task group provided a presentation to the OMT summarizing their work. |
| Consensus background material for inclusion in the good practice guide. | Complete.<br>– The task group developed a backgrounder on odour and health (see Appendix I). |

**Table 3: Health Task Group Stream #1 Workplan Deliverables.**

## 2.2 Development of Backgrounder on Odour and Health

### 2.2.1 Vision and Intended Audience

The task group began by developing a vision for the backgrounder in order to guide and focus its development. The task group determined that the backgrounder should:

- Clarify what is known and not known about the relationship between odour and health,
- Build an understanding about odour and health, and
- Use a non-judgemental tone.

As the backgrounder is meant to be a part of the Good Practice Guide, the task group kept in mind that the audience for the backgrounder is mainly government and industry but should be easily understood by the public.

### 2.2.2 Scoping and Assumptions

During the initial scoping phase, the task group agreed that the backgrounder should be short and easy to read. The OMT also provided guidance regarding writing style.

The task group developed the backgrounder based on the following agreed upon assumptions. The backgrounder will:

- Be based on currently available literature.
- Focus on human health only (the OMT agreed that animal health was out of scope).
- Use the WHO definition of health.
- Focus on health effects caused by the trigeminal and olfactory neural systems as these are stimulated by odorants and can cause both irritant and nuisance effects (i.e. watery eyes and insomnia, respectively).
- Focus on epidemiology and exclude physiological and toxicological mechanisms in order to simplify the document and make it easier to read.
- Assume that all symptoms are valid through its review of literature.
- Avoid industry specific or chemical specific notations.
- Focus on odours, not chemicals.

### 2.2.3 Methodology

The task group began by developing a vision for the backgrounder in order to guide and focus its development. A literature search was conducted using the databases PubMed, Scopus, and ISI Web of Science. Articles considered relevant were human toxicology and epidemiology studies. Only original articles published in English were accepted. Supplementary searches included use of the 'Related Citations' function in PubMed and citation sourcing of relevant original and review articles. The literature search included studies published from the 1970's up to July 2013. Although attempts were made to obtain all relevant material, due to the broad and extensive nature of the topic, there is the potential that pertinent studies were not identified by the literature search. The literature was synthesized into a review that the task group members used to inform their work.

In addition, the task group reviewed:

- components of the Alberta Energy Regulator (AER) Peace River Proceedings,
- many grey literature sources (such as government documents from Texas and New Zealand).
- additional materials that were brought to the group by various members as they deemed them relevant.

After reviewing the list of documents, the task group prepared a draft table of contents, assigned references that spoke to each topic, and assigned a member to draft each section. It is important to note that many documents were reviewed and not all were relevant for the specific work,

therefore the task group decided to focus on those cited in the backgrounder included in Appendix A of the document.

During the writing process the task group members agreed to:

- Write from a health perspective,
- Keep it at a basic level of understanding, and
- Focus on themes and trends.

The task group worked together to refine the content of the backgrounder and to align it with the overall vision and then hired a writer to edit the document for readability and prepare an executive summary and glossary.

After a final review, the task group agreed by consensus to accept the backgrounder and to submit it to the OMT with the recommendation for inclusion in the Good Practice Guide.

### 2.3 Uncertainties and Gaps

There is a lack of information available on the relationship between odour and health. There are also many research gaps and unknowns. As such, the task group's vision for the backgrounder was to clarify what is known and not known about the relationship between odour and health.

There is also ambiguity around odour-related definitions in this field. The task group acknowledged that much of the language around odour and health can have specific connotations (for example, the term 'nuisance' can have legal connotations as described in public health acts). The task group tried to be sensitive to these language considerations and included a glossary in the backgrounder that describes how the terms are used.

### 2.4 Reflections on the Backgrounder

The relationship between odour and health is an evolving field and new information is being produced on an on-going basis. As such, although the task group's review was extensive, they acknowledge that they likely have not captured all available information.

In addition, it is acknowledged that there is a broad spectrum of opinions on the subject of odour and health. The backgrounder attempts to reflect the diversity and varying interpretations of the task group members. All parties have agreed to the backgrounder by consensus.

## 3. Stream Two –Symptom and Odour Tracking Tool

### 3.1 Overview of Original Task

The objectives for the Health Task Group also included developing tools and strategies to address health concerns and issues. Under Stream 2, the task group was asked to review currently available tools for tracking health-related impacts of odour, develop a tool for individuals to track health-related impacts of odour, and prepare advice for how such a record keeping-tool would be distributed. The task group was also asked to determine if a tool aimed at health professionals should be developed. The primary deliverable of Stream 2 was the

Symptom and Odour Tracking Tool (hereafter referred to as the 'tool') for individuals to track symptoms they are experiencing that they feel may be related to an odour exposure. The tool is in Appendix II of this final report.

Table 4 below outlines the task groups work including deliverables under Steam 2.

| **Task Group Deliverables** | **Completion Status and Details** |
|---|---|
| An inventory of best practices and tools for individuals (and potentially health care professionals) to track the health-related impacts of odour. | Complete.<br>– The task group undertook a search for currently available tools.<br>– The task group agreed not to develop a tool for physicians. |
| An analysis of the inventory of best practices to track the health-related impacts of odour. | Complete.<br>– The task group reviewed these tools for relevance to the final deliverable. |
| A tool for individuals (and potentially health care professionals) to track the health-related impacts of odour. | Complete.<br>– The task group developed a tool for individuals (see Appendix II).<br>– The task group agreed not to develop a tool for physicians. |
| A plan for distributing the record keeping tool to relevant organizations. | Complete.<br>– The task group prepared distribution advice for the OMT to incorporate in to the roll-out plan for the Good Practice Guide. |

**Table 4: Health Task Group Stream #2 Workplan Deliverables.**

## 3.2 Development of the Odour and Health Symptom Tracking Tool

### 3.2.1 Vision and Intended Audience

The task group began by developing a vision for the tool in order to guide and focus the development of the tool. The task group determined that the tool should be:

- Generic (not industry or chemical specific)
- Capture all self-reported symptoms
- Make no judgement about symptoms
    - i.e. is not a diagnostic tool
- Short (1-page)
- Focus on the individual

The task group also determined that the tool could be:

- Used to help individuals capture their thoughts and be heard;
    - This could be a base layer of information for other steps (see next bullet)
- Used as a tool for collected information to be used by physicians and researchers in the future.

### 3.2.2 Scoping and Assumptions

The task group developed the tool based on the following goals and assumptions:

- The tool must focus primarily on the individual and their needs (as opposed to focused on government and academic needs).
- The user will use the tool as often as they experience odour exposure and/or health effects.
- The tool is flexible enough that people can fill it out once or frequently.
- The tool assumes that there is an odour.
    - NB: the tool also includes a 'No odour' rating to account for the possibility of latent symptoms.
- The tool is developed using open-ended questions based on the reasoning that the user may have made a cognitive link between their symptom and a particular odour source, but that the odour source is not always clear.
- The tool should be freely available online (i.e. use a free software such as Adobe Reader).
- It may be possible to use this tool for collecting research data at a future time noting that it does not collect symptom data at the same level of detail as odour data.

This tool is meant to help individuals speak to their health professional about the symptoms they are experiencing. It is not meant to validate or prove causation, or to lay blame. It is hoped that both industry and government would direct individuals to this tool.

The task group discussed creating an app but felt that it may be premature, given the evolving nature of knowledge on odour and health. Developing an app was also not realistic within the overall team's budget.

The task group also considered developing a tool for health care professionals. It was agreed that health care professionals respond to symptoms and use tests to make a diagnosis. There are currently no medical tools to test for health impacts from odour. At this time it would not be practical as not all physicians receive training in environmental health and there are limited clinical guidelines and tools to aid diagnoses. As such, a tool was not developed for health care professionals. However, health care professionals could use the symptoms listed in the tool to treat symptoms and, if necessary, to refer individuals to a specialist. Individuals can use the tool to engage in a conversation with their health care professional about the symptoms they are experiencing.

### 3.2.3 Methodology

Once the task group had developed a vision for the tool, members developed a list of documents, including several odour diaries that could potentially contribute to the tool. The task group found that while there were several current tools that recorded odour-related information, none allowed individuals to record their symptoms. The following related tools and documents provided particular guidance as the task group developed their tool:

- SYMPLE (a generic symptom recording app)
- Healthwise diary (a generic fillable pdf form from MyHealth.Alberta.ca for recording symptoms

- E. Ferguson, H.J. Cassaday, J. Ward, and A. Weyman. Triggers for non-specific symptoms in the workplace: Individual differences, stress and environmental (odour and sound) factors. Research report prepared by the University of Nottingham and the Health & Safety Laboratory. 2006.

After reviewing the available list of documents, the task group brainstormed what information the tool might record. The task group refined this list over time, discussed the physical format for the tool, and designed the first draft. The task group then worked to refine the tool and developed a prototype for testing. The tool was formatted into a one page pdf that could be filled out electronically or printed and completed by hand. The pdf allows symptoms and odours to be added or removed for easy tracking.

The task group then tested the prototype for clarity and ease of use (see sections 3.2.3.1 and 3.2.3.2 for details on pilot testing). Testing did not look at the validity of the tool as this would have been quite complex due to legal, ethical and confidentiality issues.

The task group refined and updated the tool based on the results of the pilot testing and noted that the overall tool design could be improved by a graphic designer. It was assumed that a graphic designer would be engaged to develop the Good Practice Guide and could likely improve the design of the tool as part of that work.

After a final review, the task group agreed by consensus to accept the tool and to submit it to the OMT for inclusion in the Good Practice Guide.

#### 3.2.3.1 Pilot testing overview

The goals of pilot testing the tool were:

- To ensure ease of use, comprehensiveness and comprehensibility.
- To test aesthetics and format.
- To test wording of symptom intensity scale.

The task group discussed the possibility of testing the validity of the tool. The task group decided that this type of testing would be complex due to legal, ethical and confidentiality issues. The task group noted that this would be more appropriate to undertake as part of future work (see section 4.1.2).

The task group took a pragmatic approach to pilot testing that focused on the goals listed above using the existing networks of task group members. The task group asked a variety of participants to test the tool and then complete a short survey. The survey was left open for 2 weeks (see Appendix III for the survey questions).

#### 3.2.3.2 Pilot testing results

The pilot test had 24 respondents. Overall the tool was well received. Survey results highlighted some areas where the tool could be improved. The task group used the results of the pilot testing to update the tool to improve overall ease of use.

## 3.3 Advice to the OMT

The task group discussed advice for the distribution of the tool, for the OMT's consideration as they develop the roll-out plan for the Good Practice Guide (GPG), as follows:

1. Advice related to graphic design.
    - The 'Symptom Description' and 'Odour Description' boxes should look like boxes rather than empty space.
    - Consider having the 'Symptom Details' and 'Odour Details' side by side rather than stacked for ease of use.
    - Use as many drop boxes as possible for ease of use (ex. time and date).
    - Make the tool as computer-friendly as possible.
    - Make the tool as print-friendly as possible.
    - Brand the tool as appropriate and ensure consistency with the rest of the Good Practice Guide.
    - Adobe LiveCycle was used in the creation of the document.

2. Advice related to distributing the tool.
    - Ideally, a team member would agree to host the tool on their website.
    - If possible, some metrics should be employed to help evaluate the usefulness of the tool (ex. hits on website).
    - Stakeholders and partners could provide a link on the host's websites or post to the tool itself. For example:
        - NGOs interested in health, Alberta Occupational Health and Safety, Alberta Health Services, Health Canada, industry websites, CASA, Air Quality Health Index (AQHI), the Weather Channel, city and municipal websites, MLA offices, The Lung Association, academics/universities, Alberta Medical Association / other medical licensing bodies, local environmental public health offices.
    - There should be consideration for access by remote populations Roll-out and distribution of the tool could be used as a training opportunity for health professionals.
    - The tool may need to be available in French.
    - The OMT should consider leveraging the outreach plan for the AQHI.

It is also important that the OMT consider linkages with other task groups' deliverables and tools created. In particular, the Health Task Group highlighted a linkage with the Complaints Task Group. The OMT should consider how the tool and backgrounder fit with the complaints process, and perhaps add phone number(s) to the tool.

# 4. Conclusions and Recommendations

## 4.1 Future Work

### 4.1.1 Backgrounder – Advice about future work/iterations of the backgrounder (ex. update frequency)

The task group has identified advice to the OMT about future work for the backgrounder that includes the following:

- The backgrounder should be updated regularly to be kept current. A reasonable review period is every 5 years.
- Future work could focus on information on mixtures, information on new emerging challenges, updates to existing information, and regulatory changes.
- Looking at similar work undertaken by other CASA teams, an updated literature review could cost up to $20, 000.

### 4.1.2 Tool – Future research options and issues collecting health data

Odour and health is an ongoing research question. The task group noted that the tool is a first version (although it is the final product for the task group) and will likely evolve in the future as new research becomes available. The task group prepared the following considerations for future versions of the tool:

- The development of an app would need to be properly supported with funding as it is an expensive undertaking.
- An updated tool could include coding of symptoms (similar to University of Nottingham research report) so that the information can be used for research.
- There is a need for a legal opinion around gathering health information. It should be noted that any future research on health and odour may be subject to review by the research ethics board, and they would require specific information about how the information would be used.
- A formal validation study of the tool should be undertaken.
- With respect to research, there is a need for an objective, unbiased evaluation of the relationship between odour and health.
- A methodologist should be engaged to help ensure the tool can be used for research.
- There is a need to understand the statistical limitations of epidemiology.
- There is a need to link odour and monitoring data.

## 4.2 Recommendations

The task group has prepared four recommendations for consideration by the OMT:

**Recommendation 1: Accept the Health Task Group's final report.**
The Health Task Group recommends that the OMT accept their final report and deliverables for consideration as the Good Practice Guide is developed.

**Recommendation 2: Disband the Health Task Group, after review of the GPG.**

Since their workplan is complete, the Health Task Group recommends that the OMT disband the task group, after review of the task group's applicable sections within the GPG.

**Recommendation 3: Engage a graphic designer to review the tool.**
The OMT should consider engaging the GPG graphic designer to review the tool for ease of use and align it with the rest of the GPG.

**Recommendation 4: Engage champion to host the tool.**
The OMT should consider having a champion to host the tool on their website.

# Appendix I: Backgrounder on Odour & Health

# Odour and Health Backgrounder

**prepared for**
**Clean Air Strategic Alliance**

**version 19**
**January 30, 2015**

**Table of Contents**

## Executive Summary

This backgrounder aims to build a basic understanding about odour, health, and the relationship between the two, cited in existing studies. As well, limitations of current knowledge about odour and its effects on health and the shortcomings of current research tools used to understand odour and health will be discussed.

The sense of smell is one of the most primal human senses, with a powerful connection to our brains. *Olfaction*, the mechanism that allows people to smell, relies on two essential processes. Volatile chemicals in the air—called *odorants*—bind to *olfactory receptors* on special olfactory neurons in the nasal lining that are sensitive to their specific chemical structures. Those olfactory receptors signal the brain, which then makes associations with a person's surroundings and between the odour and their past experiences. Our noses contain roughly 400 different types of receptor on neurons, each sensitive to a specific type of odorant.

The nasal lining also contains *trigeminal neurons*, which transmit information on temperature, pressure, and pain, and also respond to noxious stimuli. Volatile chemicals can trigger olfactory neurons or trigeminal neurons but odours often trigger both simultaneously. This report will only focus on health effects related to the stimulation of the trigeminal and olfactory neurons.

Stimulation of trigeminal neurons by odorants can cause irritant effects, while stimulation of olfactory neurons by odorants can cause nuisance effects. Some odorants can stimulate both neurons and can cause both irritant and nuisance effects. Irritant effects are a bodily reaction to trigeminal nerve stimulation (e.g. watery eyes). Nuisance effects are tied to the perception of odour, with no mechanistically understood cause (e.g. insomnia). While the reason why certain odours cause nuisance effects is not fully understood, there's no denying the resulting symptoms are real.

Odours can affect a person's health physically (e.g. nausea), psychologically (e.g. stress), and socially (e.g. embarrassment). This report describes many of the different health effects cited in existing studies.

That said, there are challenges in studying the relationship between odour and health. Different people experience odours in different ways—a nuisance smell to one may be undetectable or pleasant to another. It's also difficult to measure odours in an objective way. These two factors make it challenging to assess the health effects caused by odours.

This report details some resulting limitations of current knowledge, problems scientists face in monitoring odours, and shortcomings in current research tools. In order to fully understand the health effects of an odour, many other pieces of knowledge are required including composition and chemical properties. Professionals in this field must continue to do the best they can with the knowledge they have, while also working to contribute better data and research to improve the overall understanding of the issues.

## 1 Introduction

This backgrounder is intended to build a basic understanding about odour and health. It will also examine what is known (and what is not known) about the relationship between the two.

First, let's look at the definition of health.

> *Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.*
>
> (Constitution of the World Health Organization).

In other words, health is not always something that can be objectively measured. It often involves subjective, intangible judgement—how people *feel.*

Given the unknowns associated with the chemical composition of odours and their interactions within a mixture, one cannot always rely on people's perception of an odour as a direct indicator of other serious health effects. In order to fully understand the health effects of an odour, many other pieces of knowledge are required including composition and chemical properties.

Smelling an *odour*, refers to the sensations people experience when chemical compounds, in the air that they breathe, stimulate receptor neurons in their noses.

On the other hand, when discussing the odour of a substance, people are generally referring to the specific chemical combination that gives that substance its characteristic scent or smell.

In North America, and particularly in the field of air quality, the term *odour* is usually understood to have a negative connotation. Something might be described as smelling nice, or having a pleasant aroma, but it wouldn't be described as having a good odour.

In this report, the relationship between odour and health refers to unwelcome smells and any related negative impact on people's overall wellbeing.

## 2 Why do people have a sense of smell?

People have senses to collect information about their surroundings, and their brains use this information to construct an image of the world around them. This is only a partial picture, but from an evolutionary perspective it is essential to the survival and reproduction of the human species.

The *olfactory sense*—the sense of smell—is one of the oldest and most primal human senses. It contributes to people's picture of the world by allowing them to detect chemicals in the environment. Human ancestors used smell to evaluate food, select reproductive mates, and identify dangers and enemies. Those instincts remain embedded in people to this day, providing a powerful connection between the olfactory sense and their brains.

Odours are made up of volatile chemicals—called *odorants*—that people can detect through the mechanism called *olfaction*.

Olfaction consists of two essential processes:

1. Odorants binding to *olfactory receptors* that are sensitive to their specific chemical structures.

2. Olfactory receptors signalling the brain, which then makes associations and determines a person's reaction.

### 2.1 Chemical binding of odorants

The nasal lining (*olfactory epithelium*) contains millions of *olfactory neurons*. People have roughly 400 different types of receptors, each sensitive to a specific type of odorant. When an odorant bonds to a corresponding receptor, it causes that neuron to send a signal to the brain (Malnic et al., 1999).

With 400 different types of receptors, spread amongst millions of neurons, the olfactory system can detect an endless number of different odours. It can differentiate between odorants of similar structure, and between varying concentrations of a single odorant.

In short, the nose is an extremely sophisticated and sensitive instrument for detecting chemicals in the environment.

The nasal lining also contains *trigeminal neurons,* which transmit information on temperature, pressure, and pain, and also respond to noxious stimuli.

Odours can be caused by a mixture of volatile compounds. These compounds can be classified as pure olfactory, pure trigeminal, or mixed olfactory/ trigeminal, depending on which systems they trigger (Nagata et al., 2005).

A mixture of volatile compounds that has an odour can activate both the olfactory and trigeminal systems. The olfactory and trigeminal processing systems exist independently, but appear to converge and interact during brain processing (Hummel et al., 2009a; Boyle et al., 2007b; Savic, 2001). When both of these systems are triggered (bimodal), they activate more regions of the brain together than they would individually (Boyle et al., 2007a). In other words, some bimodal odorants may directly affect the central nervous system.

## 2.2 Processing of olfactory signals in the brain

Although scientists have identified the general regions of the brain involved in the sense of smell, it is still not fully understood how human brains decode those smells.

To complicate things further, different areas of the brain may be involved depending on the properties of the odour (e.g., pleasantness or familiarity) or the task at hand (e.g., identifying the odour, or discriminating between smells) (Livermore and Laing, 1998). An odour can also involve brain structures controlling emotion (the limbic system), reflecting the ways in which smell is connected with emotion, memory, and behaviour (Gottfried, 2010; Wilson and Rennaker, 2010; Savic, 2005). People respond to odours differently based on how intense, pleasant, or familiar they seem to us, and based on their past experiences with those odours.

## 2.3 Factors influencing the sense of smell

Sense of smell can vary greatly from one person to another. Factors such as age, gender, health status, and culture can significantly affect how people perceive odours (Ferdenzi et al., 2011; Doty and Cameron, 2009; Doty et al., 1985).

- The sense of smell generally declines with age. Elderly people are typically less able to detect or identify odours than younger adults.
- Women generally perform better than men on tests of olfactory threshold sensitivity, odour discrimination, and odour identification
- Certain diseases can also reduce or eliminate the sense of smell (e.g., Parkinson’s disease, Alzheimer’s disease, and multiple sclerosis).

Also, when people are consistently exposed to an odour, we may eventually lose our ability to smell it. This is called odour fatigue (Sears, 2013).

## 3 How do irritant and nuisance effects differ?

Odours can cause two types of health effects: irritant and nuisance effects. These can occur in isolation or simultaneously.

Exposure to odorous compounds can cause long-term health outcomes, but these are caused by the chemical properties of the compound in question, other than the odour itself. Generally, the only long-term outcome associated with odours is *sensitization*, which is addressed in the section on nuisance effects.

### 3.1 Irritant effects:

Irritant effects result from the stimulation of the trigeminal nerve in the nose (Bromley, 2000). Pressure, pain, temperature, or noxious substances detected by the trigeminal nerve can sometimes trigger a physical response (Bromley, 2000; Boyle et. al., 2007b). For example, when you chop onions your eyes may water.


Different people may react differently to an odorant, even under identical circumstances, depending on their age, gender, lifestyle, health status, and other factors. In relation to irritant effects, some people will react to a smaller concentration of the chemical than the average person; these people are described as having a low response threshold. Common examples are infants, young children, the elderly, and people with medical conditions. On the other hand, some people have high response thresholds, and are less likely to experience irritant effects.

Depending on the properties of the chemical, an irritant effect can occur above, at, or below the threshold of odour perception (the concentration at which one can detect the odour). In other words, just because you can't smell something doesn't mean it isn't a problem.

### 3.2 Nuisance effects:

Nuisance effects are tied to the *perception of odour*. Some may try to dismiss nuisance effects as 'just' psychological, or as mere 'odour-worry,' but the symptoms are real (Government of New Zealand, 2003). However, compared to irritant effects—where a direct mechanism can be defined—nuisance effects are more complex and more difficult to understand. For example, to continue the onion analogy, a person with an aversion to onions could become nauseated by the smell even before they were chopped. The nausea is real, even if there's no mechanistically understood cause.


There is a wide range of nuisance effects, and once again they can vary greatly from person to person.

With a nuisance effect, health symptoms occur when odours are detectable but not physically irritating (Government of New Zealand, 2003). It's not fully understood why certain odours can cause adverse health effects. Is it because of a direct biological process, or is it caused by an indirect psychological response based on past experiences? In most cases, when an odour causes health problems there's no straightforward toxicological explanation (Shusterman, 1992).

Odour-induced health effects might be traced to physiological changes, mood changes and stress, cognitive bias and expectations, and learned or conditioned associations (Schiffman and Williams, 2005; Schiffman et al., 2000; Shusterman, 1992). For instance, an odour may cause increased stress, leading to hormonal changes that trigger the body's 'fight or flight response.' Like our ancestors, people may perceive a certain smell as a potential threat to their survival.

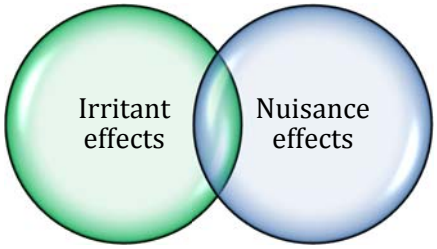
People react to odours very differently, both physiologically and psychologically, because the sense of smell is so heavily connected to past experiences, memories, and emotions. One person's pleasing odour could be another person's perceived health risk.

Generally, nuisance effects only occur when the offensive odour can be perceived. Still, it's once again important to remember that different people have different odour thresholds.

Some people may become sensitized to a specific odour, causing them to suffer adverse effects even when concentrations are so low that others around them can't detect the smell. It's not understood why some people become sensitized to odours while others do not. It's therefore important to remain respectful when dealing with sensitized individuals.

Regardless of people's levels of sensitivity, it is important to remember that nuisance effects cause real health symptoms.

### 3.3 Combined irritant and nuisance effects




It's also possible for an odour to trigger irritant and nuisance effects simultaneously. For example, you might experience watering eyes from irritation as well as nausea caused by an aversion to the smell.

Most odours result from a mixture of chemicals, so combined nuisance and irritant effects may be expected. The effects of mixtures are poorly understood—a challenge we discuss further in section 5.

# 4 Reported health effects

Odours can affect your health physically, psychologically, and socially. As discussed previously, different people experience odours in different ways. Age, gender, familiarity with the odour, state of awareness, health status, and sensitivity can all affect your ability to smell odours (Davies, 2013). These factors, combined with the challenge of measuring odours, makes it very difficult to assess the health effects caused by odours. As a result, there have been few scientific reports directly measuring the association between odour and health. Therefore, this report discusses both typically reported symptoms and symptoms measured in scientific studies.

## 4.1 Effects on physical wellbeing

People complaining about health effects caused by odours report a wide variety of symptoms—nausea, reduced appetite, congestion, sensory and respiratory irritation, headache, dizziness, sleep problems, diarrhea, various respiratory effects, and others. The odours causing these complaints come from a wide range of sources, including petroleum operations, agriculture, hazardous waste sites, landfills, and industrial sites (Dimsdale, 2008; Shusterman, 1992; Shusterman et al., 1991; DeLongis et al., 1988; Davies, 2013; Sears, 2013; Government of Texas, 2007; Government of New Zealand, 2003). In children, odour has been reported to cause language issues, incontinence, eye twitches, nosebleeds, and temper tantrums (Sears, 2013).

The relationship between odour and physiological response is very complex. Epidemiology studies have measured physiological changes in response to odour, including changes in heart rate, heart rate variability, blood pressure, skin conductance response, irritant symptoms, and facial muscle activity. The frequency of symptoms, and their magnitude, differ depending on the characteristics of the odours and the people smelling them. The stress caused by the odour may also contribute to the physiological effects (Laudien et al., 2008; Dalton, 1999; Knasko et al., 1990). And, certain studies indicate that a person's level of annoyance with an odour is a stronger predictor of symptom reporting than proximity to the odour source (Davies, 2013; Claeson et al., 2013; Cavalini, 1994; Cavalini et al., 1991; Lipscomb et al., 1991; Shusterman et al., 1991).

## 4.2 Effects on psychological wellbeing

Smells can also affect people psychologically. People have reported a wide variety of symptoms, including tension, nervousness, anger, frustration, embarrassment, depression, fatigue, confusion, frustration, annoyance, and general stress (Davies, 2013; Government of New Zealand, 2003; Heaney et al., 2011; Horton et al., 2009; Schiffman et al., 2000; Radon et al., 2004).

Some of these psychological responses may be caused by the health worries people have when they smell a bad odour (Sears, 2013). People may also feel stress if they feel their odour concerns are not being heard (Davies, 2013). Studies have shown that odour annoyance (an emotional response to a smell) is correlated with frequency (Aatamila et

al., 2010) and intensity of odour (Luginaah et al., 2000; Taylor et al., 1997; Jonsson et al., 1975; Axelsson et al., 2013; Claeson et al., 2013; De Feo et al., 2013; Aatamila et al., 2010; Steinheider, 1999; Steinheider et al., 1998; Steinheider and Winneke, 1993; Bruvold et al., 1983; Sucker et al., 2008; Both et al., 2004).

Psychological effects can also contribute to physiological effects (Bosma et al., 1997). Stress experienced by workers has been linked to higher blood pressure and other cardiovascular symptoms (Bosma et al., 1997).

### 4.3 Effects on social wellbeing

People's social and economic environment can contribute to 50 percent of the health effects they experience with odour complaints (O'Hara, 2005). Epidemiological studies suggest that odours may decrease quality of life (Heaney et al., 2011; Tajik et al., 2008; Wing et al., 2008; Wing and Wolf, 2000; Miedema and Ham, 1988; Bruvold et al., 1983). These studies looked at different ways odour problems affect people's lives—decreased outdoor activities, having to keep the windows down, being forced to leave home when the smell is bad, and decreased property values (Davies, 2013). Some people report feeling embarrassed about their bad-smelling neighbourhoods, making it harder for them to interact socially (Davies, 2013).

## 5 Limitations and challenges

There are still have gaps in the knowledge and understanding of the relationship between odour and health.

As discussed earlier, researchers haven't been able to fully determine why some people experience health effects from odorants even at concentrations lower than the irritant levels (Shusterman, 1992).

It is recognized that odours are made up of many chemicals that may or may not have specific health effects and risks, but it's not always known what chemicals make up an odour. As a result, odour perception cannot be reliably used as a direct indicator of any other serious health effects. Researchers need to address this limitation of knowledge on a chemical-by-chemical basis.

At the same time, researchers have struggled to arrive at a standard way to assess odour, or to assess the level of people's exposures. Studies in this field have come up against problems in reporting, sample and selection biases, personal influences, emotional responses, etc. The Odour Assessment Task Group must grapple with the overall challenges faced in monitoring practices.

### 5.1 Limitations and research gaps

Research studies on health effects associated with exposure to odorants fall into two main categories: epidemiological and toxicological. Although these two approaches have shed light on many other areas of human health, they have inherent limitations when it comes to building understanding about the effects of exposure to odours.

Epidemiological studies of odour and health are hampered by the application of weak exposure assessments (Lowman et al., 2013), and by the use of subjective measures for exposures and/or outcomes (Sucker et al., 2009, 2008; Luginaah et al., 2002, 2000; Ames and Stratton, 1991; Shusterman et al., 1991, Laudien et al., 2008; Dalton, 1999; Knasko et al., 1990).

On the other hand, toxicological research is limited by the lack of standardized exposure methods (Steinheider and Winneke 1993), difficulty in carrying out blinded studies (Cavalini, 1994; Cavalini et al., 1991; Shusterman et al., 1991), the subjects' personal biases (Cavalini, 1994; Cavalini et al., 1991; Shusterman et al., 1991), and the influence on odour-induced responses caused by personal factors such as predilections and past experiences (Seubert et al., 2009; Inoue et al., 2003; Vernet-Maury et al., 1999; Alaoui-Ismaïli et al., 1997a).

It's also often difficult to compare one study with another. For instance, different studies use different durations of exposure—and people respond differently to odour depending on how long they're exposed. Studies looking at short exposures to odour (Cavalini, 1994 and Cavalini et al., 1991) might not provide meaningful information about how people respond to chronic exposures.

One direct issue of concern is the fact that data is not typically collected with the intention of applying it to questions of health. Most epidemiological studies look for the effect of chronic exposures, rather than acute exposures. Instead, samples are collected from short-term exposures and then an algorithm is used to approximate long-term chronic exposures. The data might not convert as consistently as hoped, in which case the results may not be fully reliable.

Normally, people are exposed to mixtures of odorous air pollutants and non-odorous co-pollutants such as nitrogen dioxide and fine particulate matter respectively. This makes it difficult to know whether the observed health effects are caused by the substances people smell or the ones they don't smell. So far, no toxicological study has been able to separate the health effects of odours from that of the co-pollutants in the mixtures (Schiffman et al, 2005). As well, no toxicological research has been conducted to understand the health effects caused by complex mixtures of environmental odours.

An odorant may be just one component in a mixture of chemicals, and only one of the chemicals may be toxic (Schiffman and Williams, 2005). Depending on the mixture, odorants and non-odorants can interact chemically, either reducing or increasing the adverse health effects (Azocar, 2002; Davies 2013).

Studies based on single odorants might not explain how people react when they're exposed to chemical mixtures in the environment. One chemical in the mixture may prevent the body from eliminating another chemical, or two chemicals in the mixture may affect the same body system but in different ways (Roth and Goodwin, 2003; Sears 2013).

Current research approaches have not determined the mechanisms by which odours adversely affect human health. In general, classic toxicological mechanisms are not helpful in understanding the human health effects associated with exposure to odours (Schiffman et al., 2005), unless the chemical composition is known.

Based on current research, toxicological mechanisms can probably explain the way people respond to odorants above the irritants threshold limits (Schiffman and Williams, 2005; Shusterman, 2001; Schiffman et al., 2000). However, researchers don't completely understand the toxicological mechanisms for exposure to odorants below the irritant threshold levels (Shusterman, 1992).

Likewise, current research hasn't found consistent ways in which the brain responds to odours. Therefore, it is not possible to compare and contrast the studies or confidently make any conclusions on impacts of odours on the brain (Royet and Plailly, 2004; Sobel et al., 2000).

Traditional risk-assessment research looks at human exposures to a single pollutant in a mixture, but this methodology may not adequately protect sensitive or vulnerable individuals. Moreover, combining the risks of all pollutants in a particular mixture in order to estimate an overall risk will end up increasing the level of uncertainty in a study (Lanphear et al., 2005; Ciesielski et al., 2012; Trasande et al., 2005).

Going forward, there is a need to better account for these nuances when designing monitoring programs and research studies.

## 5.2 Challenges of linking odours and health effects

Some of the evidence linking odours with symptoms has been discussed. It is difficult to accurately define and measure those links, because studies focus on subjective variables—namely, odours and symptoms. When something is smelled, most people aren't able to even start identifying or quantifying the chemicals involved. Likewise, different people experience and describe symptoms in different ways—symptoms that don't always point to specific medical conditions.

People who complain about being frequently exposed to bad odours are more likely to report health effects. However, because the parameters are so subjective, it's very difficult to draw confident scientific conclusions about the connection between odours and human health (Sucker et al., 2009, 2008; Luginaah et al., 2000, 2002; Ames and Stratton, 1991; Shusterman et al., 1991).

Current knowledge of chemical toxicity is based on chemical-by-chemical assessment—and, as discussed, the chemicals mixed together in an odour may interact in unexpected ways. Until the ways chemical mixtures affect human health are better understood, it's important to respond to odour complaints by assessing the presence of chemicals in the environment to identify potential health effects.

## 6 Conclusion

The relationship between odour and health remains a major ongoing concern, despite gaps in technical understanding, challenges in collecting standardized data, and shortcomings in research approaches.

Given the unknowns associated with the chemical composition of odours and their interactions within a mixture, one cannot always rely on people's perception of an odour as a direct indicator of other serious health effects.

Professionals dealing with real-life air-quality issues, must continue to do the best work possible with the approaches and knowledge available to them, while at the same time contributing to the data and research needed to improve the overall grasp of the issues.

## Glossary

| | |
|---|---|
| **Irritant effect** | The bodily response to trigeminal nerve stimulation caused by an odorant. |
| **Nuisance effect** | An effect tied to the perception of odour, with no mechanistically understood cause. Sometimes referred to as an annoyance effect. |
| **Odorant** | A volatile chemical in the air that stimulates our sense of smell. |
| **Odour** | An *odour* refers to the sensations people experience when chemical compounds, in the air they breathe, stimulate receptor neurons in their noses. The odour of a substance refers to the specific chemical combination that gives that substance its characteristic scent or smell. |
| **Odour threshold** | The concentration at which one can detect an odour. |
| **Olfaction** | The scientific term for the processes involved in our sense of smell. |
| **Olfactory epithelium** | The nasal lining. |
| **Olfactory neuron** | A specialized receptor neuron in the nasal lining which bonds with a specific type of odorant. |
| **Response threshold** | The concentration at which one experiences an effect. |
| **Trigeminal neuron** | Neurons that transmit information on temperature, pressure, and pain, and also respond to noxious stimuli. |

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## Appendix II: Symptom and Odour Tracking Tool

*(The following is a scanned version of the Symptom Odour Tracking Tool and not the fillable form.)*

# Symptom and Odour Tracking Tool

**If this is an emergency, call 911. This form is for non-emergency situations only.** Use this form to record any symptoms that you think are related to an odour you have noticed. Bring the completed form to appointments with your health care professional to help with the diagnosis and treatment of the symptoms or underlying conditions. Once completed, this form contains personal health information: *it is your responsibility to protect your information appropriately.*

About this form:

**Add a new individual record for each day that you experience an odour event that you associate with a symptom.** Additional symptoms and odours can be added to each individual record if required (e.g. *I smelled manure and rotten eggs in the same day, had a headache followed by trouble sleeping (insomnia)*).



## Individual Record - Symptom & Odour

| Symptom Details | | Symptom Description, other relevant information |
|---|---|---|
| Date | | |
| Time | | |
| Location (home, work, etc) | | |
| Intensity (0-5) | | |
| Did the symptom come and go during the day? | | |

Add Symptoms | Remove Symptoms

| Odour Details | | Odour Description, other relevant information |
|---|---|---|
| Date | | |
| Time | | |
| Location (home, work, etc) | | |
| Intensity (0-5) | | |
| Did the odour come and go during the day? | | |

Add Odours | Remove Odours

Add Records | Remove Record

# Appendix III: Pilot Testing Questions

| | |
|---|---|
| Question 1 | Do you find that the tool prototype clearly outlines the purpose of the tool? |
| Question 2 | Do you find the format of the tool prototype easy to follow? |
| Question 3 | Do you find the language used in the tool prototype easy to understand? |
| Question 4 | Do you find the "Symptom Intensity Scale" used in the tool prototype useful when describing the intensity of your symptom? |
| Question 5 | Did you notice any design issues with the tool prototype? |
| Question 6 | Is there anything else you'd like us to know about your experience with the tool prototype? |
| Question 7 | Are you a health professional? |
| Question 8 | Which of the following best describes the level of school that you have completed? |