Minutes

Health Task Group, Meeting #7

Date: Thursday, July 24, 2014
Time: 10:00 am – 3:30 pm
Place: CASA office, 10035 108 Street, Edmonton, Alberta

In attendance:

Name	**Stakeholder group**
Laurie Cheperdak	Alberta Environment and Sustainable Resource Development
Dr. Rocky Feroe	Alberta Environmental Network
Dr. Alvaro Osornio-Vargas	University of Alberta/The Lung Association
Cindy Quintero	Hinton Pulp
Brendan Schiewe	Alberta Health
Opel Vuzi	Health Canada
Kaitlyn Wall	Alberta Environment and Sustainable Resource Development
Celeste Dempster	CASA

Action Items:

Action Items	Who	Due
7.1: Alvaro will provide wording that speaks to odour as a property of a substance.	Alvaro	25 July 2014
7.2: Rocky will provide additional references for section 7 material once the document has been edited by Scott.	Rocky	As appropriate.
7.3: Brendan will update the tool with the changes from meeting #7.	Brendan	Meeting #8.
7.4: Brendan will ask the legal department to look at the tool's disclaimer to check for liability issues.	Brendan	Meeting #8.
7.5: Laurie will determine if an ESRD survey designer is available to assist with question design and advice on gathering demographic information.	Laurie	Meeting #8.
7.6: Celeste will poll for dates for meeting #8 for the end of August.	Celeste	ASAP.

1. Administrative Items

Laurie chaired the meeting which began at 10:05am. Participants introduced themselves and were welcomed to the meeting. Quorum was achieved.

The minutes from meeting #6 were reviewed and approved. The action items from meeting #6 were updated as follows:

Action Items	Who	Status
4.10: Cindy will see if Health Link Alberta will share their scripts relating to odour.	Cindy	Complete.
5.3: After tool design is complete, the task group will seek a legal opinion for how the information might be used for research.	All	Complete.

6.1: Since quorum was not achieved Celeste will follow-up with industry representative, Cindy Quintero, after meeting #6.	Celeste	Complete.
6.2: Laurie will draft the 'Monitoring Challenges' section of the backgrounder.	Laurie	Complete.
6.3: Members will update referencing in their section of the backgrounder using the original source rather than citing the Alberta Health literature review on odour and health.	All	Complete.
6.4: Celeste will contact Scott Rollans to determine his availability to edit the backgrounder and to discuss a quote.	Celeste	Complete.
6.5: Celeste will share Scott Rollans' website with the task group.	Celeste	Complete.
6.6: Celeste will solicit feedback from the OMT with regards to writing and referencing style for the Good Practice Guide.	Celeste	Complete.
6.7: Celeste will distribute the Nottingham document to the task group.	Celeste	Complete.
6.8: Brendan will draft a 1-page form based on the tool design from meeting #6.	Brendan	Complete.
6.9: Celeste will poll for dates for meeting #7 for the end of July/beginning of August.	Celeste	Complete.

Additional Information:
Action Item 4:10: The scripts are confidential and cannot be shared.
Action Item 5.3: The task group noted that this item does not need to be completed at this time as the tool will not be used for research and is only for individuals.
Action Item 6.4: Scott is available to do the work at a reasonable rate. The OMT has approved contracting Scott to do this work.
Action Item 6.6: The OMT provided the following advice that the task group will pass on to Scott:

- Writing style:
  - Written for professionals but not experts
  - Simple, direct, not flowery
  - Easy, short, succinct
  - Readable but covers technical points
  - Practical
  - Manual portions written 'recipe style'
  - Similar to 2003 Electricity Framework report
- Referencing style:
  - Use in-text referencing with author's name and date
  - Include a bibliography list
  - This will allow the OMT to easily compile references when it is compiling the Good Practice Guide

2. CASA Update

Celeste provided an update on the Odour Management Team:

- The team has scoped the remaining areas of work from their project charter. They presented this information to the CASA Board on June 5th and outlined three possible scenarios for how the work will be completed, depending on what additional funding is available. The Board agreed that, subject to funding being made available, Scenario #3 where consultants are used to complete the work is the best path forward.

- Since the Board meeting, the Secretariat and the CASA Executive Committee have located sufficient funds to move forward with Scenario #3.
- The team will meet next on August 28th. This is an opportunity for the task group to potentially review products with the OMT and receive feedback.

Celeste also provided an update on the work of the task groups:
Complaints Task Group:
- The task group prepared a background report outlining the current odour complaint landscape in Alberta and used this document to frame a discussion about strengths and gaps. The task group used this discussion to refine the categories of tools they will be developing.
- The task group will use a consultant to assist with some tool development and has prepared an RFP with responses due on August 11th. The remaining tools will be developed by the task group.

Odour Assessment Task Group:
- The task group is working with a consultant to prepare an inventory and analysis of odour assessment tools. They recently provided comments on a draft report and will provide an overview of the report to the Odour Management Team on August 28th.

Prevention/Mitigation:
- This work was kicked off on June 18th and the Odour Assessment Task Group (who are taking on this piece) have prepared an RFP for an inventory and analysis of odour prevention and mitigation tools. Responses to the RFP are due on August 11th.

Enforcement/Role of Regulation Task Group:
- The task group kicked off this work on June 23rd and prepared an RFP to collate and review regulatory approaches. Responses to the RFP are due on August 11th.

Celeste provided an update on CASA activities:
- The next Board meeting will be on September 18th in Edmonton.
- The Board has asked the Secretariat to form a working group to scope work under non-point source air emissions and to develop a project charter for the Board's consideration at their September meeting.

3. Review Odour and Health Backgrounder

The task group reviewed draft 8 of the backgrounder on odour and health – this draft contains all sections from the table of contents as well as updated referencing. Members also had the opportunity to provide comments in advance of the meeting which were compiled into draft 8. The task group reviewed and updated the draft in track changes focusing on ensuring the backgrounder contained the appropriate content (see Appendix A).

Additional highlights from task group's discussion:
- The introduction should include a definition of odour. The task group decide to include both the perception based definition from the draft odour assessment report as well as a definition that speaks to odour as a property of a substance.
- Section 7 requires additional references.

- The group discussed section 6 (odour monitoring challenges) and whether more specific information about odour assessment tool needs to be included. The task group thought that the odour assessment report will speak to limitations of specific tools. When the task group reviews the edited version, they may wish to discuss if some high level information should be added.

Action Item 7.1: Alvaro will provide wording that speaks to odour as a property of a substance.

Action Item 7.2: Rocky will provide additional references for section 7 material once the document has been edited by Scott.

4. Design the Tool for Individuals

The task group reviewed the draft tool for individuals to track symptoms. The task group noted that the tool is progressing well and aligns with the vision for the tool. The task group noted the following changes to the tool:

- Under the odour section, it should read "Did the odour come and go during the day?".
- The user should be able to print a summary table. Is this technically feasible?
- Currently you can't save the form, only print it.
- Before the disclaimer, there should be a sentence that reads "If this is an emergency situation, call 911."

Action Item 7.3: Brendan will update the tool with the changes from meeting #7.

The task group discussed the possibility of individuals using the tool to build a legal case and if CASA could be held liable.

Action Item 7.4: Brendan will ask the legal department to look at the tool's disclaimer to check for liability issues.

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. The task group noted that they would like to include considerations for future versions of the tool in their final report to the team, such as:

- The possibility of developing an app
- Coding symptoms (similar to Nottingham document) so that the information can be used for research
- Engaging a methodologist to help ensure the tool can be used for research
- The need for a legal opinion around gathering health information

The task group discussed pilot testing the next version of the tool. Pilot testing is required to:

- Ensure ease of use, comprehensiveness and comprehensibility.
- Test aesthetics and format.
- Test wording of symptom intensity scale.

The task group discussed the possibility of testing the validity of the tool. The task group decided that ultimately undertaking this type of testing would not all the task group to meet their timelines, and would be quite complex due to legal, ethical and confidentiality issues. The task group noted that this would be more appropriate to undertake in the next iteration of the tool and will include these considerations in the final report.

Since the tool is for individuals rather than research, the task group decided to take a pragmatic approach to pilot testing focusing on the three objectives described above through existing members' networks. Reviewers should include people from a variety of backgrounds:

- Environmental Health Officers
- University of Alberta students
- Spouses
- Patients
- Environmental public health/ESRD (including Beth Nanni) colleagues
- Hinton pulp employees
- David Spink
- The Lung Association

Reviewers will be asked to look at the tool and fill out a short survey via survey monkey. The questions will focus on:

1. Is it easy to read?/Do you like the format?/Format easy to read and follow?
2. Is the purpose/intent of the tool clear?
3. Are the questions easy to understand?
4. Are there functionality issues?/Does it work?
5. Are the scales useful?/Are there too many/not enough options?
6. Any other comments?

Action Item 7.5: Laurie will determine if an ESRD survey designer is available to assist with question design and advice on gathering demographic information.

The survey monkey link and tool will be emailed with a cover letter (prepared by Celeste) that includes:

- Purpose of the tool
- How the information from the tool will be used
- Why we are doing pilot testing
- What we are asking participants to do
- How information from the survey will be used

5. Budget and Timeline Check-in

The task group reviewed and updated their upcoming timelines:

Date	Task
Post-meeting #7	– Send backgrounder to Scott Rollans for editing – Prepare second draft of the tool – Action Item 7.3 – Action Item 7.4
Meeting #8: week of August 18th	– Review edited version of backgrounder – Discuss the final report – Receive an update on pilot testing
August 28th	– Present the backgrounder to the OMT – Present plan for pilot testing

Early September	– Obtain feedback from the OMT – Pilot testing
Fall	– Prepare final report to the team, including: o Finalize backgrounder o Finalize tool o Prepare advice regarding a distribution plan o Prepare advice for future work

There were no budget updates at this time.

6. Meeting Wrap-up

The team reviewed the action items from today's meeting.

The task group determined that will be ready very soon to begin writing their final report. The task group will discuss the table of contents for the final report at meeting #8.

The objectives for the next meeting are:

- Review edited version of backgrounder
- Discuss the final report
- Receive an update on pilot testing

Action Item 7.6: Celeste will poll for dates for meeting #8 for the end of August.

The meeting adjourned at 3:30pm.

Appendix A: Draft Backgrounder on Odour and Health

1. Introduction

*(*I thought that it would be useful to have a short introduction that outlines what the backgrounder is meant to do i.e. what we hope to achieve. I wrote out a few rough points.)*
This piece is meant to build understanding about odour and health as well as help to clarify what is currently known and not known about the relationship between odour and health.
Maybe the definition of health can go in this section?

2. Why do we have a sense of smell?

Our perception of our surroundings relies on information collect by our senses. Our brains use this information to construct an image of the perceived outside world. This representation of the external world is only a partial picture, which from an evolutionary perspective, is important for survival and reproduction of the species. From this evolutionary perspective, the olfactory sense is one of the oldest senses developed to identify food, reproductive mates, dangers and enemies in organisms with appropriate species-related cell mechanisms to capture ***odours***. Therefore, the part of the external world represented by the chemicals signals present in the environment is the sense of smell.

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~~2.1. The physiology of smell~~ The mechanism of detecting a small

Odours are made up volatile chemicals – called odourants – that can be detected through the ~~physiological function~~ *mechanism* called olfaction. ~~The olfactory system is responsible for the smelling sensation of odorant molecules. Odourants can also interact with the trigeminal nerve system, which is responsible for sensations of pressure, pain, and temperature as well as responses to noxious stimuli. Odourants can interact with both the olfactory and trigeminal systems simultaneously (mixed response), and signals from each system can interact in the brain – in this way a trigeminal response can influence odour perception. Odorants can be classified as pure olfactory, trigeminal, or mixed olfactory/ trigeminal odorants.~~
The essential processes of olfaction include:

- ***the binding of odorants to olfactory receptors based on their specific chemical structure; and***
- ***signaling from olfactory receptors to the brain where associations are made between the odour exposure and past experiences.***

The nose is equipped with two systems to collect sensations:

- Smell neurons (olfactory neurons) located in the lining of the nose bind to specific odorant molecules.
- Another nerve (the trigeminal nerve) gathers information on temperature, pressure, pain is responsible for sensations of pressure, pain, and temperature as well as responses to noxious stimuli.

Odorants can be classified as pure olfactory, trigeminal, or mixed olfactory/ trigeminal odorants.

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~~2.2. Olfactory System~~

~~The essential processes of olfaction include:~~

- ~~***the binding of odorants to olfactory receptors based on their specific chemical structure; and***~~

- *signaling from olfactory receptors to the brain where associations are made between the odour exposure and past experiences.*

2.2.2. Chemical Binding of Odourants

Olfactory receptors located on olfactory receptor neurons in the mucosa of the olfactory epitheliumin the lining of the nose bind to specific odorant molecules. There are several million receptor neurons in the human olfactory epithelium and ~350 receptor types, with each receptor neuron containing only one type of receptor (Malnic et al., 1999). The binding of an odorant to a receptor induces a conformation change, which initiates a sequence of events that converts the chemical signal into a neuronal signal.

Due to the large number of receptor neurons dispersed throughout the olfactory epithelium, the olfactory system is able to differentiate between an endless number of odours, odorants of similar structure, and varying concentrations of a single odorant.

In addition to olfactory neurons, the olfactory epithelium is innervated by trigeminal neurons. The trigeminal system is responsible for sensations of pressure, pain, and temperature as well as responses to noxious stimuli. Odorants can be classified as pure olfactory, trigeminal, or mixed olfactory/ trigeminal odorants. Pure olfactory odorants (eg. hydrogen sulfide, phenylethyl alcohol, vanillin) stimulate only the olfactory neurons, and pure trigeminal odorants (primarily carbon dioxide) stimulate trigeminal neurons; odorants activating only one system are referred to as unimodal.

Mixed olfactory/trigeminal odorants (or bimodal odorants) 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). Olfactory/trigeminal mixtures have been found to produce activations in more brain regions than the sum of its components, including areas involved in cross-modal integration (Boyle et al., 2007a).

2.2.3. Processing of Olfactory Signals in The Brain

While the general regions of the brain involved in olfactory processing have been identified, the exact mechanism in which the brain decodes odour information remains poorly understood. Adding further difficulty is the fact that areas of the brain involved may differ depending on odour properties (eg. pleasantness or familiarity) or the task at hand (eg. odour identification or discrimination). The involvement of a large portion of the limbic system (a group of brain structures associated with controlling emotion (the limbic system)) reflects the high interconnectedness between smell and emotion, memory, and behavior (Gottfried, 2010; Wilson and Rennaker, 2010; Savic, 2005). This helps to explain why responses to odours are largely dependent on the perceived intensity, pleasantness, and familiarity of the odour as well as past experiences with the odour.

Structures in the brain associated with olfaction can be grouped into the primary olfactory cortex (POC) and the secondary olfactory cortex (SOC). The piriform cortex (in the POC) and the orbitofrontal cortex (in the SOC) are the primary areas of the brain responsible for odour processing.

Primary Olfactory Cortex

Regions of the brain that receive direct input from the mitral cell axons (which are linked to the olfactory receptor neurons) make up the POC. The POC includes the piriform cortex, anterior olfactory cortex, olfactory tubercle, amygdala, and rostral portions of the entorhinal cortex according to most sources (Wilson and Rennaker, 2010; Menini et al., 2004; Savic, 2001).

2.2.3.1. Secondary Olfactory Cortex

The SOC receives neuronal input from the POC and consists primarily of the orbitofrontal cortex, lateral entorhinal cortex, and insular cortex. The orbitofrontal cortex receives sensory input from the piriform cortex, thalamus, amygdala, entorhinal cortex, and hippocampus to formulate the behavioral response to

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2.3. Trigeminal System

In addition to olfactory neurons, the olfactory epithelium is innervated by trigeminal neurons. The trigeminal system is responsible for sensations of pressure, pain, and temperature as well as responses to noxious stimuli. Odorants can be classified as pure olfactory, trigeminal, or mixed olfactory/ trigeminal odorants. Pure olfactory odorants (eg. hydrogen sulfide, phenylethyl alcohol, vanillin) stimulate only the olfactory neurons, and pure trigeminal odorants (primarily carbon dioxide) stimulate trigeminal neurons; odorants activating only one system are referred to as unimodal.

2.3.1. Mixed Response

Mixed olfactory/trigeminal odorants (or bimodal odorants) 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). Olfactory/trigeminal mixtures have been found to produce activations in more brain regions than the sum of its components, including areas involved in cross-modal integration (Boyle et al., 2007a).

2.4.2.3. Factors Influencing Olfaction *the sense of smell*

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Olfactory function and olfactory sensitivity can vary greatly between individuals. Factors such as age, gender, disease status, and culture can contribute to significant differences in odour perception. For example:

- loss of olfactory function is typically associated with aging, and elderly subjects show decreased odour sensitivity and poorer odour identification than younger adults (Murphy et al., 1994; Doty et al., 1984);
- women have generally been found to perform better than men on tests of olfactory threshold sensitivity, odour discrimination, and odour identification (Ferdenzi et al., 2011; Doty and Cameron, 2009; Doty et al., 1985); and
- Odour perception can also be influenced by certain diseases; for example, Parkinson's disease, Alzheimer's disease, and multiple sclerosis can all contribute to reduced smell or loss of smell (Bromley, 2000).

- Odour fatigue, which is the loss the ability to smell due to consistent exposure, has been documented in exposed individuals (Sears, 2013).

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2.4.1. FIDOL

The main factors used to describe human exposure to odours are typically referred to as FIDOL: Frequency, Intensity, Duration, Offensiveness, and Location (Nicell, 2009).

- **F**requency refers to how often the population is exposed to odour;
- **I**ntensity refers to the strength of the odour;
- **D**uration refers to the length of time of the odour episode;
- **O**ffensiveness/character encompasses the odour quality (type of odour) and hedonic tone; and
- **L**ocation represents the specified land use of the surrounding area and the tolerance of the community (residential/rural location, schools, hospitals).

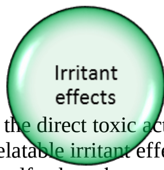
Also, these 5 factors are often used collectively to evaluate the potential impact of odour on a population surrounding an odour source.

3. How do irritant and nuisance effects differ?

~~Odours are detected through the physiological function called olfaction. Olfactory function and olfactory sensitivity can vary greatly between individuals. Thresholds for detection of odours vary widely, with some individuals being very sensitive while others experience anosmia (no sense of smell).[i] Factors such as age, gender, health status, and culture can contribute to significant differences in odour perception.[ii]~~ When considering the potential health effects of odour exposure, there are two types of effects that can be described: irritant effects, and nuisance effects. Irritant and nuisance effects can occur in isolation or simultaneously.

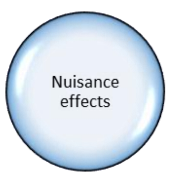
While long term outcomes ~~such as cancer~~ may result from exposure to compounds that have an odour, it is the toxicological properties of the chemical in question – not only the chemical's odour – that causes the outcome. Generally, the only long term outcome that may be associated with odours is sensitization, an effect that is addressed in the section on nuisance effects. ~~Long term health outcomes are not otherwise addressed in this document as they are not related to the odour.~~

3.1. Irritant Effects:



Irritant effects are referred to as the direct toxic action that a chemical (or mixture of chemicals) can have on the human body. An easily relatable irritant effect (although not technically due to the odour) is the effect of chopping an onion – a sulfur-based compound can cause an individual's eyes to water.
People may react differently to the same chemical under the same exposure circumstances based on differences in age, gender, lifestyle, health status and other factors influencing susceptibility. Some individuals will react to a smaller concentration of the chemical than the average person: these people are described as having a low response threshold, and they will be more susceptible to the irritant effects of the chemical than an average person. Conversely, others are described has having a high response threshold. Such individuals are less susceptible to the irritant effects of the chemical than an average person. Infants, young children, the elderly and people with pre-existing medical conditions are generally regarded as being sensitive sub-populations that may show heightened responsiveness to chemical exposures. [iii]
It is important to understand that irritant effects may be observed over a range of concentrations depending on the sensitivity of the individual being exposed to the chemical. Depending on the properties of the chemical, an irritant effect can occur above, at, or below the threshold of odour perception (concentration at which the subject can detect the odour).

3.2. Nuisance Effects:



Nuisance effects are tied to the *perception of odour*. Nuisance effects have been referred to as psychological impacts, or 'odour-worry,'[iv] but the symptoms observed are real. In comparison to an irritant effect where a direct toxic mechanism can be defined, nuisance effects are more complex and poorly understood. To continue the onion analogy, a person with an aversion to onions could become nauseous upon exposure to the smell of onions before they were chopped (i.e., an aversion to the aroma of onions, not the sulfur-based chemical that is released when they are chopped). While there may not be a direct toxicological pathway to describe the effect, the nausea is real nonetheless. There is a wide range of nuisance effects, and it is difficult to predict how individuals will react to given odours.

In the nuisance effect paradigm, health symptoms occur at odorant levels that are detectable but not irritating (odour detection threshold is below the irritant threshold). The mechanisms in which odours induce adverse health effects are not well understood; it is not clear if the odour-induced effects are the result of a direct biological process or an indirect psychological response based on past experiences and expectations. In most cases, the observed health effects of odours cannot be explained by classical toxicological mechanisms (Shusterman, 1992). For example, health complaints are often reported with exposure to hydrogen sulfide at levels above the odour threshold (0.5 to 30 ppb) but well below the irritant threshold (2.5 to 20 ppm) (Schiffman and Williams, 2005).[v]

Possible mechanisms for odour-induced health effects occurring under this paradigm include 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). Increased stress due to odour-worry may have health consequences due to changes hormone levels in the body (by impacting the hypothalamic-pituitary-adrenal axis, which among other functions controls the body's 'fight-or-flight response').

Responses to odours are heavily tied to past experiences, memory, and emotion, causing the physiological and psychological effects to vary greatly between individuals. This complicates any assessment of health effects induced by odours, and is an important caveat to keep in mind when considering the effects of odours.[vi]

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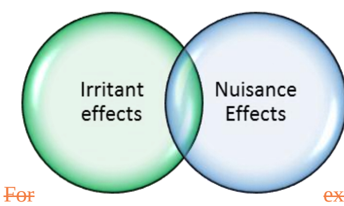
Generally, nuisance effects only occur when the offensive odour can be perceived, but it is important to note that individuals who become sensitized to an odour may perceive it at lower concentrations than the average person. Sensitization to an odour can occur where adverse effects change an individual's perception of an odour, which can be described as an individual's threshold of acceptability being reduced. The reasons why some people become sensitized to odours while others do not is not well understood. Addressing nuisance effects in sensitized individuals must be approached tactfully in order to avoid unwelcome implications of psychological instability (i.e., telling someone that their problems are 'in their head') – the resulting stigmatization can conceivably exacerbate the underlying psychological trauma. Regardless of the level of sensitivity, it is important to remember that nuisance effects cause real health symptoms.

3.3 Combined effects



It is possible that an odorant may be a component of a mixture that contains an irritating co-pollutant. ~~For example, environmental odour mixtures can contain odourless co-pollutants such as carbon dioxide (CO_2) and nitrogen dioxide (NO_2), particulate matter, and endotoxins (Schiffman and Williams, 2005).~~ In cases of health complaints reported by residents living near odour-emitting facilities, it is possible that co-pollutants are responsible for the observed health effects, with odour serving as a marker of exposure, although it may not be clear whether the odours or the co-pollutants (or both) are responsible for the observed health effects.[vii]

4. ~~What physical, psychological, and social impacts have been reported in relation to odour in the scientific literature?~~Reported Health Impacts

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Odours may affect health physically, psychologically, and socially. However, not all individuals experience odour in the same way. Factors such as age, gender, familiarity with the odour, state of awareness, state of health, and sensitivity can all affect the ability to smell odours (Davies, 2013). The differences in the way individuals perceive odours and the challenge of analytically measuring odours creates great uncertainty when assessing the health effect they cause. Due to this, few scientific reports that directly measure the association between odour and health exist. Therefore, both typically-reported symptoms and measured symptoms in scientific studies will be discussed.

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4.1. Physical Impacts

A wide variety of physiological symptoms have been reported by individuals experiencing odour. Nausea, reduced appetite, congestion, sensory and respiratory irritation, headache, dizziness, sleep problems, diarrhea, and a wide array of respiratory effects are some of the symptoms that have been reported from individuals experiencing odour from a wide range of sources (e.g. petroleum operations, agriculture, and 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, nose bleeds, and temper tantrums (Sears, 2013).

Epidemiology studies have measured physiological changes such as differences in heart rate, heart rate variability, blood pressure, skin conductance response, irritant symptoms, and facial musical activity in response to odour. Symptoms differ between studies both in magnitude and tendency depending on the odour characteristics and the individual perceiving them. This indicates that the relationship between odour and physiological response is very complex. Odour fatigue, which is the loss the ability to smell due to consistent exposure, has been documented in exposed individuals (Sears, 2013). The stress that is caused by the odour may contribute to the physiological effects (Laudien et al., 2008; Dalton, 1999; Knasko et al., 1990). Certain studies have indicated that and individual's odour annoyance is a stronger predictor of symptom reporting that 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. Psychological Impacts

Health may also be affected psychologically when odours are present. A wide variety of psychological effects have been reported by individuals experiencing odours. These may include, but are not limited to 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., 1995; Radon et al., 2004). Some of the psychological responses may be caused due to concerns about the health effects of odours (Sears, 2013). Stress and other symptoms may also be caused when individuals do not feel like their concerns regarding odour are not being heard (Davis, Attached page 22, Letter). Studies of odour annoyance (an emotional response to the presence of odour) have shown that it 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).

While psychological effects are themselves cause for concern, they may also lead to physiological effects (Bosma et al., 1997). Stress experienced by workers has been linked to higher blood pressure and other cardiovascular incidences (Bosma et al., 1997).

4.3. Social Impacts

The social and economic environment are very important as they are considered to contribute 50% of the health impact experienced (O'Hara, 2005). Epidemiology studies have suggested 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 assessed quality of life metrics of residents in odour affected areas such as decreased outdoor activities, keeping the windows down, temporarily leave their place of residence when environmental odours are present, and changes in property values (Davies, 2013).Odours may affect how residences interact socially as some have reported feelings of embarrassment over the presence of odours (Davies, 2013)

5. Limitations of Current Knowledge

In the environment, individuals are exposed to mixtures of air pollutants and the co-pollutant in the odorous mixture maybe a toxic (Schiffman and Williams, 2005). Therefore, depending on the constituents of the mixtures, chemical interactions of odourant and non-odourant chemicals can result in reduced or increased adverse health effects [RWDI pg. 26] (Azocar, 2002). Because existing studies on exposures to odorants have been based on single odorant, the research results may not be suitable to explain human exposures to chemical mixtures in the environment (Zou and Buck 2006). In addition, health effects of chemical mixtures cannot be accurately determined because 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 [Sears pg. 21] (Roth and Goodwin, 2003).

Researchers have found strong correlation between self-reported odour exposure frequency and health effects however, due to the subjectivity of the parameters, the results of current studies is difficult to quantify and cannot be interpreted with absolute confidence to evaluate human health effects and exposure to odours (Sucker et al., 2009, 2008; Luginaah et al., 2002a, 2000; Ames and Stratton, 1991; Shusterman et al., 1991).

Variable exposure durations have been used in toxicological studies related to odour and health impacts. Response to odour varies with exposure duration therefore the results of one study cannot be compared with that of another. As well, results of short exposure durations (Cavalini, 1994 and Cavalini et al., 1991) might not be sufficient to evaluate health effects associated with chronic exposures to odorants in the environment.

Epidemiological and toxicological studies on exposures to odours and health effects have not fully evolved. The use of subjective parameters (Laudien et al., 2008; Dalton, 1999; Knasko et al., 1990) and weak exposure assessments (Lowman et al., 2013) are the limiting factors of epidemiological studies while the validity of toxicological studies are limited by lack of standardized exposure methods (Steinheider and Winneke 1993), inability to conduct blinded experiments, the subjects personal bias (Cavalini, 1994; Cavalini et al., 1991; Shusterman et al., 1991) and past experience.

Researchers have not completely determined how exposure to odorants at concentrations lower than the irritant levels induce health effects in humans (Shusterman, 1992).

6. Odour Monitoring Challenges

There is not a standard way to assess odour. The challenges with monitoring odour and its implications on health are complex and diverse. Assessing exposures is a challenge. Several other sections in this background have acknowledged some of the challenges currently being experience in this area such as reporting, sample and selection biases, influence of personal characteristics emotional responses etc. The Odour ~~Monitoring~~ Assessment Task group will address the overall challenges being faced with our current monitoring practices.

One of the direct issues of concern is that typically the data is not collected with the intention to be applied to health. Generally with monitoring short term acute exposure samples are collected, which are then used to approximate long term chronic exposures through an algorithmic equation. The challenge being that epidemiological studies typically examine the effects of chronic odour exposures, with less focus on acute exposures. So there are potential inconsistencies in the data conversions, and applicability of the results.

It should also be noted that typically exposures in the environment are complex mixtures, which contrasts the majority of studies which expose subjects to single odorants at a time. Exposure to single odourants may have a different response than to that of mixtures ~~(AH pg 58)~~.

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Commented [CD10]: Repetition in paragraph 3 of next section *Odour monitoring challanges*

Commented [CD11]: Repetition with 2nd paragraph from section 3.2 (nuisance effects)

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Going forward, the design of monitoring programs, and research studies will need to account for these nuances in order to produce results that will be targeted to health issues.

7. Research Gaps and Limitations of Available Research Tools

Responding to an odour complaint requires critical appraisal. We must acknowledge our information gaps and respond to complaints with an appetite for inquiry as well as with action based on current knowledge. Given the complexity of the topic, what we don't know about odour and health could well be greater than what we know. This section will briefly discuss limits to our current understanding of odours and their links to human health.

Odours travel with other air particles that we breathe. When we think of an odour we need to consider that the smell is just one aspect of the air carrying the odourant compound. We have heard about the intricate mechanisms surrounding odour perception. When we additionally examine the company the odour keeps, we add further complexity. Odour is our perception while "odourant" refers to any chemical in the air that is part of that perception. At the same time an odourant may be stimulating the trigeminal nerve (responsible for sensing smell pungency), associated ultra-fine particles (that we may or may not smell) may be absorbed directly into the blood and circulated throughout the body without first benefitting from detoxification by the liver. Respirable fractions of air (the portion that enters deeply into our lungs) may affect the heart, lungs, and other organs via oxidative stress. There may be multiple routes for odourants to bypass the blood brain barrier, an important line of defence. The olfactory nerve seems to have a uniquely direct route to the brain giving odours the potential to be direct neurotoxins. In animal studies both the olfactory and trigeminal nerve seem to innervate the nasal cavity providing a potential direct connection to the central nervous system.

Clearly the association between odours and health is complex. The olfactory system interprets an odorous mix in a way that does not necessarily correspond to concentration of any single constituent. We detect mixtures which are present in different concentrations. These chemicals can interact in complex ways, sometimes with additive or synergistic effects. Allowances for these interactions are made when emissions standards are set. As our understanding of these interactions evolves, we can evaluate whether the standards are based on appropriate allowances.

Several mechanisms for odour-induced health effects have been proposed such as stress and irritative phenomena, but additional effects could occur that are missed by classic toxicology models. ~~Part of the exercise of evaluating odour complaints is to ensure regulatory limits have not been exceeded and to ensure regulatory limits are appropriate.~~ Some pollutants can have effects at very low doses (endocrine disruptors) that may disappear at higher doses. As adverse effects may not be present at high doses, they are missed by traditional toxicology where 'the dose makes the poison'. In other words some toxics do not follow traditional dose response curves. ~~There is a growing body of evidence that these toxics are increasingly present in the air. In 2009 the American Chemical Society acknowledged that endocrine disruption calls for newer research tools. "Green Chemistry" is now a field where we are learning how to measure potential hormone-like or hormone-inhibiting effects of chemicals. We are learning to evaluate interactions chemicals may have with cell-based receptors. New assays and protocols are designed to identify the presence of endocrine active chemicals. Traditional toxicology would say that the longer the duration, the more severe the response, but some chemicals might show effects only at low concentrations.~~ Additional research is needed to better understand when and why health effects appear at certain concentrations and intensities of odourants and odours.

The epidemiology of odours and health is limited and could improve with standardization and additional use of objective measures (~~Gas Chromatography and~~ electronic noses). There is a need for better assessment of exposures, more long term follow up, and better data assemblage. Better assessment of exposures requires improving the availability of emission and monitoring data. Weak epidemiology may be unable to capture harm and should not be interpreted as proof of no harm. The probability that a study can detect a statistically significant effect is called the power of the study. As the power of a study increases, the likelihood of producing a false-negative decreases. We can reduce false negatives by increasing sample size. We want accurate assessments of who is affected by odours. Odour complaint

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Commented [CD16]: Simplify - We are lacking background information to understand these sentences. E.g. ultra-fine particles have not been introduced at all

Commented [CD17]: This is a repetition of the 1st section. However , this is a nicely worded summary that could be used to augment section 2.2.2.

Commented [CD18]: Needs to be linked with 2nd last paragraph in section 5 processes must be easy to remove barriers but we must also consider that volunteers are known to be problematic for good epidemiology. Multi-center studies could help increase sample size and reduce local bias. A limit of current studies tends to be small sample size, raising the possibility they may lack the power to detect smaller increases in health risk. Monitoring and surveillance could be improved and more robust data collection could increase scientific rigour. Monitoring might include looking for and using biomarkers for exposure when present. It would particularly help to have prospective intervention studies evaluating community health responses before and after introduction of an odour-emitting facility, and especially before and after implementation of an odour reduction plan.

Our understanding of vulnerable populations is evolving. For example some exposures may inhibit our ability to detoxify other exposures. Diet, genetics, age, health co-morbidities, and an individual's medications are just some factors that may have an effect on how an individual handles an odour exposure. We have a growing understanding of sensitive populations and now appreciate the great variability of an individuals ability to handle toxics.

The relatively new field of toxicology is becoming more sophisticated as its limitations are discovered. ~~"Green Chemistry" is growing~~. We must remain humble knowing there are areas for scientific improvement in our understanding or odour, the environment, and health.

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8. Challenges of Linking Odour and Health Impacts

There is existing evidence linking odours with adverse health outcomes. The collected data has faced challenges, mainly because studies have centered on subjective variables, named, odours and symptoms. Humans perceive odours in order to respond to chemicals present in the environment. Responses are meant to attract or repel us, to or from, situations that support or hamper survival, with no expectation of identifying the chemicals involved (e.g. toxic properties). Odours largely represent mixtures of chemicals and identification of different chemicals present in the mixture is difficult. Symptoms, on the other hand, are personal sensations difficult to quantify objectively. Symptoms alert us of possible body malfunctions and move us toward seeking help or medical attention, but they are not necessarily indicative of specific conditions. Since current knowledge on chemical toxicity resides on chemical-by-chemical assessment, perception of chemical mixtures in the form of odours limits our understanding of odour-related health impacts. Further understanding of chemical mixtures impacting human health is necessary before a proper assessment of odour impacts on human health, beyond identified linked-symptoms is possible. In the meantime, odours could be used as a surrogate for chemical exposure that could trigger further evaluation of potential harm to the individual and/or populations complaining of odours.

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~~[i] Sears (spectrum of odour thresholds), p.12 (section 3.4, 1st sentence)~~
~~[ii] Alberta Health 2.2.6~~
[iii] Davies p.5 – *modified.*
[iv] New Zealand good practice guide – *modified.*
[v] Alberta Health 6.2 – *modified.*
[vi] Alberta Health p2 last paragraph (summary sentence that response to odour varies based on a variety of things) – *modified.*
[vii] Alberta Health 6.2 – *modified.*