Understanding and responding to the potential health and wellbeing risks associated with unconventional gas mining in Australia

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and
Honorary Member of the
Doctors for the Environment Australia
We acknowledge the Traditional Custodians of the Land on which we meet, and pay respects to Elders past and present...

... and reflect that for some 40-60,000+ years these custodians sustained health and life all over this continent of extremes through intimate knowledge of the Australian environment...

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The Environmental Determinants of Health ---

Good health depends on a working and living environment conducive to both physical & mental wellbeing, including:

- **Clean air, protected from harmful pollutants**
- **Secure supply of safe and sufficient water**
- **Secure supply of nutritious, safe & affordable food**
- **Stable and safe climate**
- **Meaningful livelihood/activities contributing to positive futures**
- **Resilient and cohesive communities**

http://www.local.gov.uk/web/guest/health/-/journal_content/56/10180/3511260/ARTICLE
This Presentation

- Provide a brief overview of environmental health studies on unconventional gas mining (mostly from the United States to date)

- Add some key findings of some qualitative research conducted in a rural NSW community

- Ways forward – the precautionary principle?
What is unconventional gas mining?
Rapid rise in peer reviewed research publications on health and unconventional gas (>685 papers)

Figure taken from Hays & Shenkoff (2016), Towards an understanding of the environmental and public health impacts of unconventional gas development: a categorical assessment of the peer-reviewed scientific literature, 2009-2015. PLOS One
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164
Why is evidence from the US particularly important to understanding health impacts?

• Australia’s unconventional gas industry is in its infancy. Very little research has been done (no pre, post measurements, small sample sizes, etc.) to understand the impacts on health and wellbeing of affected communities.
• In contrast, an estimated 15.3 million Americans live within a mile of one or more unconventional gas or oil wells (fracked since 2000).
• This has occurred in many states, with varying regulatory regimes and physical and social conditions.
• Research is now building rapidly. This represents an invaluable resource that was not available to many US authorities when the industry began.
### Unconventional gas mining in Australia: situation in 2013 and potential growth

<table>
<thead>
<tr>
<th>State or territory</th>
<th>Production</th>
<th>Proved reserves</th>
<th>Contingent resources</th>
<th>Prospective resources</th>
<th>Wells drilled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland</td>
<td>264</td>
<td>41 124</td>
<td>Not available</td>
<td>164 000</td>
<td>1 000</td>
</tr>
<tr>
<td>NSW</td>
<td>3</td>
<td>284–3 919</td>
<td>527–3 757</td>
<td>14 401</td>
<td>10</td>
</tr>
<tr>
<td>Western Australia</td>
<td>none</td>
<td>none</td>
<td>3 275 to 5 898</td>
<td>427 000</td>
<td>15(^{(b)})</td>
</tr>
<tr>
<td>South Australia</td>
<td>none</td>
<td>none</td>
<td>1 725 to 6 807</td>
<td>45 000 to 268 000</td>
<td>13</td>
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<tr>
<td>Northern Territory</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>257 276</td>
<td>10</td>
</tr>
<tr>
<td>Victoria</td>
<td>none</td>
<td>none</td>
<td>403–1 212</td>
<td>452</td>
<td>none</td>
</tr>
<tr>
<td>Tasmania</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

(a) Gas potential specified in peta joules.

(b) Data were not available for 2013 alone for Western Australia—the 15 wells were drilled between 2005 and 2013.

**Note:** Where available, the range in the estimates of resources/reserves has been included.

Fracking is **only one** part of the process that carries health concerns.
A risk comparison between shale gas and coal seam gas activities, with and without fracking.

### Figure 2A
Potential risks of unconventional gas activities

<table>
<thead>
<tr>
<th>Risk</th>
<th>Type of gas</th>
<th></th>
<th></th>
<th>Potential impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Shale/tight</td>
<td>Hydraulic fracturing</td>
<td>No fracturing</td>
</tr>
<tr>
<td>Water resource risks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Water usage</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>Decreased groundwater quantity available for other uses</td>
</tr>
<tr>
<td>• Produced water</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>Pollute surface waters, groundwater, soils, food and livestock</td>
</tr>
<tr>
<td>• Flowback water</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>Pollute surface waters, soils, food and livestock</td>
</tr>
<tr>
<td>• Disposal of produced solids</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>Pollute soils, surface water and groundwater</td>
</tr>
<tr>
<td>Groundwater contamination from fracking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Fracking fluid leakage from poor well design, construction and integrity</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>Pollute groundwater—impact irrigation, stock and drinking water quantity and quality</td>
</tr>
<tr>
<td>• Chemical contamination from poor storage and surface spills of fracking chemicals</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>Pollute groundwater—impact irrigation, stock and drinking water quantity and quality</td>
</tr>
<tr>
<td>• Chemical contamination through leakage of fracking chemicals and flowback water into fracking cracks</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>Pollute groundwater—impact irrigation, stock and drinking water quantity and quality</td>
</tr>
<tr>
<td>• Natural gas released or disturbed by fracturing might seep into groundwater aquifers and other wells</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Pollute groundwater—impact irrigation, stock and drinking water quality and quality</td>
</tr>
<tr>
<td>• Disposal of used fracturing fluid, produced water or waste products</td>
<td>✓</td>
<td>✓</td>
<td>×</td>
<td>Pollute groundwater, surface water and other wells.</td>
</tr>
<tr>
<td>Risk</td>
<td>Type of gas</td>
<td>Shale/tight</td>
<td>Hyraulic fracturing</td>
<td>No fracturing</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>---------------------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>Air contamination from wells and infrastructure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Point source methane released from a well, leak in a pipeline or plant equipment</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Fugitive emissions from fractures and cracks in the ground</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Fracturing fluid can contain volatile organic compounds (VOCs) which can be released into the atmosphere</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>• Naturally occurring contaminants and radioactive materials in groundwater can be brought to the surface through drilling</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Drilling equipment and trucks produce emissions</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Landscape impacts from surface infrastructure or seismic surveys</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Scale of footprint on landscape</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Vegetation removal</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Seismic activity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Seismic activity from aquifer injection</td>
<td>N/A</td>
<td>✓</td>
<td>✓/N/A</td>
<td></td>
</tr>
<tr>
<td>• Seismic activity from hydraulic fracturing</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td><strong>Operational activities</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Noise</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Dust</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Increased infrastructure</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Increased traffic and population</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Well integrity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Well leakage</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Well blowouts</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Abandoned wells</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Depressurisation of the coal seam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Changes in pressures of adjacent aquifers</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Reductions in surface water flows in connected systems</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>• Land subsidence over large areas</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Victorian Auditor-General’s Office.*
Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development

Concerns for Workers Health

John L. Adgate *,†, Bernard D. Goldstein ‡, and Lisa M. McKenzie †
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Six main areas of unresolved concerns to public health

1. Water concerns
2. Air pollution concerns
3. Psychological and social wellbeing, land competition
4. Negative health outcomes associated with living close to wells
5. Uncertainty about protective regulation
6. Methane emissions and climate change
1. Water pollution concerns, no proven long-term solution to the massive waste disposal challenge.
Waste Water Concerns

Millions of litres of produced water containing a wide range of naturally occurring and introduced chemicals that may be harmful to human health are brought to surface from shale and coal beds through unconventional gas operations.

Methods for handling and disposal of huge volumes of contaminated water remain problematic. Adequacy of water treatment processes in removing all potential toxins is unclear.

Evaporation ponds are vulnerable to spills and leaks and there is no long-term solution for disposing the resulting highly concentrated chemical mixtures.

Uncertainty surrounds health risks associated with added chemicals and substances in drilling and fracking fluids, as well as naturally occurring substances due to lack of assessment and problematic disclosure.

Naturally occurring chemicals of concern include heavy metals, volatile organic compounds, polyaromatic hydrocarbons, radioactive materials (NORMs), endocrine disrupting chemicals

Surface water and aquifer contamination from accidents and faulty equipment have already occurred in Australia.

Summary of the literature on Water Quality

Of 58 original research studies on shale gas operations and water quality, “40 (69%) have findings that indicate potential, positive association or actual incidence of water contamination..., while 18 studies (31%) have findings that indicate minimal potential, no association, or rare incidence of water contamination”.

2. Air pollution is an under-recognised but important potential health risk

- Methane
- BTEX chemicals/Volatile organic compounds
- NOx, Hydrogen Sulfide, Formaldehyde
- Diesel fumes, Particulate Matter, fine silica
- Ground level Ozone
Recent and projected growth in the oil and gas production sector has underscored the need for EPA to gain a better understanding of emissions and potential risks from this industry sector. Harmful pollutants emitted from this industry include air toxics such as benzene, toluene, ethylbenzene, and xylene; criteria pollutants and ozone precursors such as NO$_x$ and VOCs; and greenhouse gases such as methane. These pollutants can result in serious health impacts such as cancer, respiratory disease, aggravation of respiratory illnesses, and premature death. However, EPA has limited directly-measured air emissions data on criteria and toxic air pollutants for several important oil and gas production processes. [These] limited data, coupled with poor quality and insufficient emission factors and incomplete NEI data, hamper EPA’s ability to assess air quality impacts from selected oil and gas production activities.

— US Environmental Protection Agency (EPA) Office of Inspector General (1)
Summary of the literature on Air Pollution

A literature analysis conducted by Hays & Shonkoff found that, “of 46 peer-reviewed publications arising from original research, 40 (87%) reported that unconventional gas developments increased air pollution emissions and/or atmospheric concentrations”, while 6 (12%) reported no such indications.

3. Evidence-based Concerns
Psycho-social and economic impacts

• Distress and division within and between families and communities through polarising into for and against/ winners and losers.
• Solastalgia from industrialisation of landscapes.
• Disturbances from lights, noise, traffic, reduced property values, fear, etc. for those living nearby.
• Local, regional and broader unfavourable economic changes

All these factors can contribute to reduced mental health, and increase the risk of depression and anxiety, that can also contribute to other physical health problems.
CSIRO survey of Community Wellbeing and responding to change: Western Downs region in Queensland
Andrea Walton, Rod McCrea and Rosemary Leonard September 2014
Community response
In response to questions around how residents felt their community was dealing with CSG development in their region, about 48.5% felt that their community was struggling with the changes - either “resisting”, “not coping”, or “only just coping”. While 45.6% indicated their community was adapting, less than 10% in every community felt that the changes were to something different but better. Those who moved away from the area are not included.

Psychosocial experiences associated with preparations for CSG mining in a rural NSW community

• Melissa Haswell, Anna Bethmont, Steve Robinson and Jan Ritchie

• The team was invited by members of the community and the study was approved by Council because of concerns about people’s mental health and wellbeing.

• Qualitative study using maximum variation sampling to explore range of experiences across the community.
Quick Summary of experience: two multigenerational farmers, who consented to have exploration wells drilled on their property

Farmer One –

- [The company] approached us to put a well on our property. They spent an enormous amount of money on the roads, where we wanted them. They drilled and fracked the wells and paid us extremely well for that. It's only a small area, 80x80 metre pad. Normally they remove them after drilling and fracking, but we asked them to keep it there to stack silage on it.
- We protested one well too close to the house, they said no problem, sited the road exactly where I wanted it, no questions asked.
- [The disturbance] was no worse than a major railway event… they tell you well in advance… water cart on the road all the time so there's no dust. It was a 24 hour operation but we knew it was happening. The road was very close to our home, so they had a 10km/hr speed limit.

Second Farmer –

- Very similar. Massive traffic for the first pad, cars and trucks with the fracking, but only for about one week, worth it for the thousands of dollars I was paid. Such a short period of time, then its pulled back to about two car spaces. They left the pad there - $50,000 worth of gravel for hay and fertiliser.
Strong confidence that farmers can say no

- And that’s the way it’s gotta be for the simple reason, [the company]’s got it in their things, that if I own a farm and they want to put a gas well on it and I say no, you’re not gonna put it on my place – they don’t come.

- You can’t get much fairer than that – if I don’t want it on my place, I can say no and you can’t come.
Experience of a farm family who did not consent for activities on their property

Slow recognition of what living close to gas fields means

- They started to drill a few wells - we didn't really concern ourselves too much about it because we really didn't know too much about what was going on. They drilled a few wells, they weren't up here... we figured it probably wasn't going to affect us really... when AGL bought it and then they suddenly - then they started talking about, "Well, the gas field's going to go from ** through to ** Road. We thought, "Well, we're all in this now”.

Panic sets in

- And then when the maps came out, you'd see your square of property and there'd be all these grid lines on it and all these dots, and you'd think, "They're all the - they're going to be all the wells", and I suppose that's when panic started to set in when you see how many wells there are and you see the actual dots, even though they say they were ‘indicative dots’. And to this day they've never actually told us where the wells are going to go.
Angry at the ‘power over’ attitude, inability to say no
The battle existed because I said to them, "Look as far as I'm concerned your surveying my land. I'm not giving you permission... If you want permission then we need to organise a whole agreement to do that", and their attitude is, "We're flying over it. We can do what we like. You don't count".

Anger that rural protocols on the farm were not respected
There were steel pegs on the ground... they would shut and open the gates, but... this car comes in behind and sees the gate open, so the gate never gets shut... So they said they won't - cattle won't get mixed up, it'll be fine... we had cattle in different paddocks all the time from them, and... there'd be lolly paper and orange skins left where the car was left, and they would just drive off

The lights
Because we're angry and a bit anxious, you wake up in the night, look out my bathroom window to go to the toilet and you could see these lights shining in your face, so how can you go back to sleep after you've seen all these lights when you don't want them there to begin with? And then we'd get, this local lady that worked for them come and tell us, you know, that, "They'll move - they'll put barriers up and they'll do this, and there's no need to worry", yet she goes home to her house on the other side of town and I'm stuck here in this house looking at them drilling these three wells.
Feeling Attacked and Overwhelmed

“The impact is becoming aware of the reality of what's going on around you. That takes a huge emotional and physical toll because you suddenly realise that, you know you don't just have to go to work and earn a dollar to feed your family. You've actually got a fight on your hands as well, this other really big fight that's threatening the way you live, an asset that you've worked all your life to save up for, and it's a direct attack on your, sometimes it's your values but it's certainly your lifestyle.”
Turning the conflict inward

• In lots of ways it’s torn the community into two camps.

• You keep telling people, it’s a great community, but it no longer is... everybody knows you, everybody talks to you, smiles, you know? And it’s no longer like that.

• I hate to see [the community] go through what it’s going through. I moved here because initially just before coal got here it was a wonderful place to raise your kids and now it’s being divided, it’s been split, it’s got anger and it’s got abuse and all sorts of things going on that’s scaring a lot of people.

• I think it's a really significant issue that's impacting on lots of people's lives. It's not tearing us in half. It's just a really significant thing we've got to deal with and some people have been more affected than others and it's not going to rip [the community] in half, but it's certainly having an impact and a major impact on some people's lives more than others.
This study questions the long term economic benefits of CSG and co-existence over agriculture alone.

Note:
Health and social costs are not considered in this analysis.

The Economic Contest Between Coal Seam Gas Mining and Agriculture on Prime Farmland: It May Be Closer than We Thought

Cindy Chen
University of Sydney

Alan Randall
University of Sydney

Abstract
There is substantial market impetus behind the expansion of coal seam gas (CSG) in Australia, driven by buoyant international demand for liquefied natural gas. The benefits of CSG development come in the first few decades, followed by a potentially long period in which the agricultural and environmental costs dominate. We identify the key drivers influencing the economic contest of CSG versus agriculture on prime farmland, and undertake a Darling Downs case study using evidence from primary and secondary sources. Despite the momentum driving CSG development, under some plausible scenarios, the long-term economic net benefits from agriculture-only exceed those from CSG-only and CSG-agriculture coexistence.
4. Studies reporting associations between unconventional gas developments and negative human health impacts
Three published studies reporting negative birth outcomes linked to well proximity and/or density

Lower mean birth weight and higher frequency of small for gestational age (OR 1.34 (95% CL 1.10-1.63))


Preterm birth (OR 1.4 (95% CL 1.0-1.9)) & high risk pregnancy (OR 1.3 (95% CL 1.1-1.7))


Birth defects (congenital heart defects (OR 1.3 (95%CL 1.2-1.5)), neural tube defects (OR 2.0, (95% CL 1.0-3.9)) but slightly higher birth weight nearer wells

Research Presented by Dr Elaine Hill
Reduced birthweights associated with closeness to wells (avg reduction of 48.5g) (increased % of low birth weight)

Results from a local polynomial regressions (bandwidth=0.1 km) of low birth weight on distance from closest well’s future/current location. Source: Author calculations from Pennsylvania Department of Health Vital Statistics.

Increased hospitalisation rates in postcodes associated with density of wells

Cardiology inpatient prevalence rates were significantly associated with number of wells per zip code ($p < 0.00096$) and wells per $km^2$ ($p < 0.00096$) while neurology inpatient prevalence rates were significantly associated with wells per $km^2$ ($p < 0.00096$). Furthermore, evidence also supported an association between well density and inpatient prevalence rates for the medical categories of dermatology, neurology, oncology, and urology. (Abstract)

Newest study in JAMA: exacerbation of asthma attacks assoc with well activity

Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations.

Rasmussen SG1, Ogburn EL2, McCormack M3, Casey JA4, Bandeen-Roche K2, Mercer DG5, Schwartz BS6.

Key Points

**Question** Is there an association between unconventional natural gas development (UNGD) and asthma exacerbations?

**Findings** In this nested case-control study of 35,508 patients with asthma, those in the highest quartile of residential UNGD activity had significantly higher odds of 3 types of asthma exacerbations (new oral corticosteroid medication orders, emergency department visits, and hospitalizations) than those in the lowest quartile.

**Meaning** UNGD activity near patient residences was associated with increased odds of mild, moderate, and severe asthma exacerbations.
Table 2. Associations of Unconventional Natural Gas Development Activity Metrics and Asthma Outcomes

<table>
<thead>
<tr>
<th>Activity Metric</th>
<th>Odds Ratio (95% CI)</th>
<th>Asthma Hospitalizations</th>
<th>Asthma Emergency Department Visits</th>
<th>OCS Orders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pad</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.26 (1.06-1.50)</td>
<td>1.53 (1.06-2.23)</td>
<td>1.54 (1.37-1.74)</td>
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</tr>
<tr>
<td>Medium</td>
<td>1.37 (1.15-1.64)</td>
<td>1.77 (1.2-2.6)</td>
<td>1.66 (1.47-1.87)</td>
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</tr>
<tr>
<td>High</td>
<td>1.45 (1.21-1.73)</td>
<td>1.37 (0.94-1.99)</td>
<td>1.59 (1.41-1.81)</td>
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</tr>
<tr>
<td>Spud</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.16 (0.98-1.37)</td>
<td>1.53 (1.06-2.21)</td>
<td>1.45 (1.29-1.63)</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>1.26 (1.05-1.50)</td>
<td>1.54 (1.04-2.27)</td>
<td>1.98 (1.75-2.24)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>1.64 (1.38-1.97)</td>
<td>1.57 (1.08-2.29)</td>
<td>1.99 (1.75-2.26)</td>
<td></td>
</tr>
<tr>
<td>Stimulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.13 (0.96-1.33)</td>
<td>1.51 (1.05-2.19)</td>
<td>1.23 (1.09-1.39)</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>1.31 (1.10-1.57)</td>
<td>1.74 (1.17-2.61)</td>
<td>2.22 (1.95-2.53)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>1.66 (1.38-1.98)</td>
<td>1.71 (1.16-2.52)</td>
<td>3.00 (2.60-3.45)</td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.10 (0.92-1.30)</td>
<td>1.47 (1.01-2.14)</td>
<td>1.28 (1.13-1.46)</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>1.16 (0.97-1.38)</td>
<td>1.10 (0.74-1.65)</td>
<td>2.15 (1.87-2.47)</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>1.74 (1.45-2.09)</td>
<td>2.19 (1.47-3.25)</td>
<td>4.43 (3.75-5.22)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: OCS, oral corticosteroid.

Multilevel models with a random intercept for patient and community were adjusted for age category (5-12, 13-18, 19-44, 45-61, 62-74, ≥75 years), sex (male or female), race/ethnicity (white, black, Hispanic, or other), family history of asthma (yes vs no), smoking status (never, former, current, or missing), season (spring, March 22-June 21; summer, June 22-September 21; fall, September 22-December 21; winter, December 22-March 21), Medical Assistance (yes vs no), overweight/obesity status (normal, body mass index [BMI], <85th percentile for children or <25 for adults; overweight, BMI, 85th to <95th percentile for children or 25 to <30 for adults; obese, BMI, ≥95th percentile for children or ≥30 for adults; or BMI missing), type 2 diabetes (yes vs no), community socioeconomic deprivation (across quartiles), distance to nearest major and minor arterial road (truncated at the 98th percentile, measured in meters, z transformed), squared distance to nearest major and minor arterial road (truncated at the 98th percentile, measured in meters, z transformed), maximum temperature on the day prior to event (measured in degrees Celsius), and squared maximum temperature on the day prior to event (measured in degrees Celsius).

For all activity metrics, very low activity was the reference group.
Of 31 studies, 26 (84%) reported negative public health impacts associated with living closer to unconventional gas developments

http://journals.plos.org/plosone/article?id=info:doi/10.1371/journal.pone.0154164

For example,

• Higher frequencies of skin and upper respiratory symptoms
• More hospital admissions per population for heart and nerve problems
• Decreased average birth weight and increase proportion of small for gestational age infants
• Higher incidence of heart defects at birth
5. Evidence-based Concerns
Methane emissions, carbon footprint and climate change

Concerns about high levels and underestimated potency of fugitive methane emissions during drilling, production and transportation adding to, not protecting against, climate change and its health consequences

– acknowledging the importance of the 20 year climate forcing impact (80 times higher than CO$_2$) as opposed to the 100 year timeframe

**Slide from presentation by Howarth, Ithaca NY**

### Methane and the greenhouse-gas footprint of natural gas from shale formations

**Abstract** We evaluate the greenhouse gas footprint of natural gas obtained by high-volume hydraulic fracturing from shale formations, focusing on methane emissions. Natural gas is composed largely of methane, and 3.6% to 7.9% of the methane from shale-gas production escapes to the atmosphere in venting and leaks over the lifetime of a well. These methane emissions are at least 30% more than and perhaps more than twice as great as those from conventional gas. The higher emissions from shale gas occur at the time wells are hydraulically fractured—as methane escapes from flow-back return fluids—and during drill out following the fracturing. Methane is a powerful greenhouse gas, with a global warming potential that is far greater than that of carbon dioxide, particularly over the time horizon of the first few decades following emission. Methane contributes substantially to the greenhouse gas footprint of shale gas on shorter time scales, dominating it on a 20-year time horizon. The footprint for shale gas is greater than that for conventional gas or oil when viewed on any time horizon, but particularly so over 20 years. Compared to coal, the footprint of shale gas is at least 20% greater and perhaps more than twice as great on the 20-year horizon and is comparable when compared over 100 years.

**Keywords** Methane · Greenhouse gases · Global warming · Natural gas · Shale gas · Methane

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**Graphs**

#### 20-year time frame

- **Shale Gas**
  - Low methane: 15 Grams Carbon per MJ
  - High methane: 45 Grams Carbon per MJ

- **Conventional Natural Gas**
  - Low methane: 15 Grams Carbon per MJ
  - High methane: 45 Grams Carbon per MJ

- **Coal**
  - Surface: 10 Grams Carbon per MJ
  - Deep: 20 Grams Carbon per MJ

- **Oil**
  - Low methane: 15 Grams Carbon per MJ
  - High methane: 45 Grams Carbon per MJ

#### 100-year time frame

- **Shale Gas**
  - Low methane: 20 Grams Carbon per MJ
  - High methane: 40 Grams Carbon per MJ

- **Conventional Natural Gas**
  - Low methane: 20 Grams Carbon per MJ
  - High methane: 40 Grams Carbon per MJ

- **Coal**
  - Surface: 20 Grams Carbon per MJ
  - Deep: 30 Grams Carbon per MJ

- **Oil**
  - Low methane: 20 Grams Carbon per MJ
  - High methane: 40 Grams Carbon per MJ
Responding to climate change is the biggest health challenge of our time.
Compounding stress and impacts on mental health, especially on farmers

Mental health vulnerability is a major health concern.
6. Evidence-based Concerns
Questions about the ability of regulation to eliminate these potential risks and harms

Uncertainty about the effectiveness and feasibility of regulations to provide comprehensive, long term protection against the full range of health risks and concerns and cumulative environmental impacts.
Distress, division, conflict in communities and disturbing interactions with police
High paying, but insecure employment, risk of serious debt stress at young age
Depression and anxiety among mining workforce and risk for affected communities, may also heighten suicide risk
Widespread experience of solastalgia: sorrow and yearning for cherished places destroyed or pocked with wells
No time to lose – fossil fuel mining keeps us tracking worst climate trajectory (>2°C rise) and life, health and economic loss
Carbon advantage questioned – drilling, infrastructure and fugitive methane emissions may be worse than oil and coal
Air pollution risks, e.g.: Volatile organic compounds, poly aromatic compounds, diesel fumes, ozone, methane, CO₂
Soil and water pollution risks: Carcinogens, mutagens, endocrine disruptors, irritants, sensitisers, organ-damaging substances, excessive salt
Water scarcity risks – depletion of a potential future resource to deal with climate stress
Risk of structural damage to shallow aquifers leading to loss of accessible water to deeper aquifers
Threat to property values, high rents but unsellable, serious concerns in small towns
Profits going overseas: Problems stay here
Skills depletion to high salaries crippling other industries
Environmental impact on landscape harming tourism and public use
Growing evidence and experience of seismic activity linked to some aspects of unconventional gas mining
Carbon emissions enhancing global warming and increasing extreme climatic events: droughts, floods, cyclones, heatwaves & catastrophic fires
Growing evidence of seepage of fugitive emissions enhancing risk and intensities of fires especially in dry bush land
Risks of spills, accidents in transport, waste water overflow & human error
Heightened risk of traffic accidents, wear and tear on roads
Grief and loss among Aboriginal people witnessing fragmentation, destruction, locked out of traditional lands & disconnected from country, further disempowerment
Fragmentation, road kills, weeds, toxic and saline spills, air/water pollution
Smells, lights and noises associated with drilling, fracking; major increase in heavy transport
Loss of landscape values as pristine wilderness is increasingly fragmented with drill pads and connecting roads expanding over large areas
Wildlife disturbed, corridors restricted, affecting our threatened biodiversity
Massive port expansions for gas export impacting our coastline

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Massive port expansions for gas export impacting our coastline

Melissa Haswell and Marcia Grand Ortega
Many health organisations have expressed serious concern about the health uncertainties linked to unconventional gas and call for precautionary principle – i.e. ‘if in doubt, turn it off’ until safety is proven. These include:

In Australia:
• Doctors for the Environment Australia
• Australian Medical Association (CSG)
• Public Health Association of Australia
• Climate and Health Alliance (which itself has numerous health organisations members)

In the United States:
• American Academy of Paediatrics
• American Public Health Association
• Physicians for Social Responsibility
• Many other health and medical groups….

TACKLING CLIMATE CHANGE COULD BE THE GREATEST GLOBAL HEALTH OPPORTUNITY OF THE 21ST CENTURY

The Lancet, June 2015
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