Health, Coping Strategies, & Adaptation to Drought-Driven Poor Air Quality in Saskatchewan

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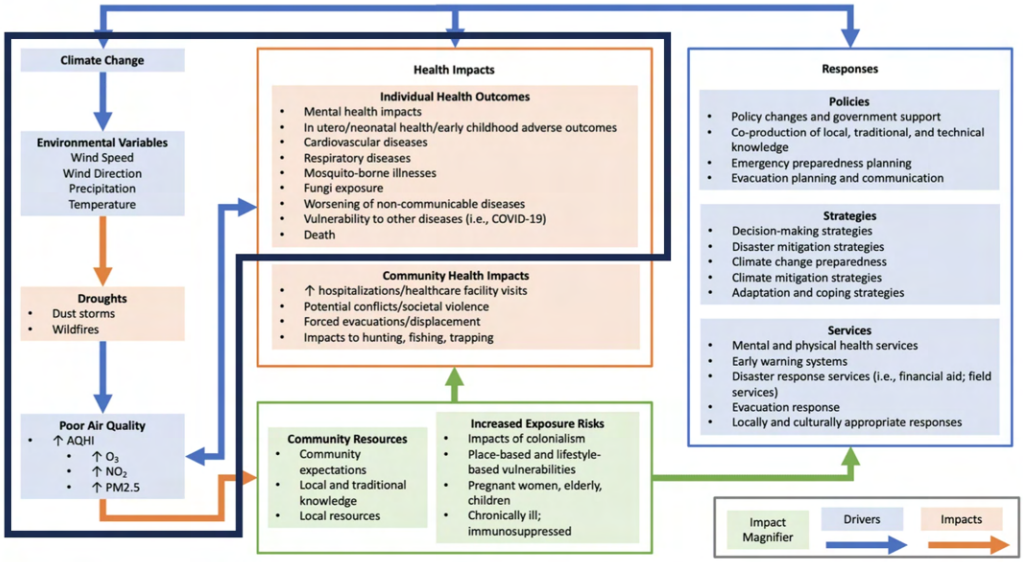
PRESENTED AT:

BACKGROUND

Connecting Drought-Induced Poor Air Quality & Health Impacts



As greenhouse emissions increase worldwide, **drought frequency and events such as dust storms and wildfires are expected to increase** in Saskatchewan, **reducing air quality**.

The predicted increase in drought conditions (dust and wildfire smoke) and exposures to poor air quality are **likely to have impacts on human health**. Exposure to air pollution is responsible for millions of deaths worldwide (Caretta et al., 2022).

This means that **there is an increasing need for research that focuses on regional-scale climate uncertainties and associated impacts on human health, coping, and adaptation strategies.**

This study is part of a larger project that uses a **coupled human and environment approach** to assess meterological drivers of drought-induced poor air quality on health, coping, and adaptation.

<u>This first phase of the study looks to:</u>

- Identify relationships between health impacts and weather conditions associated with droughts in Saskatchewan.

<u>Research Question:</u>

- What are the relationships between health impacts and air quality conditions associated with droughts in Saskatchewan over a 7-year period (2015-2022)?

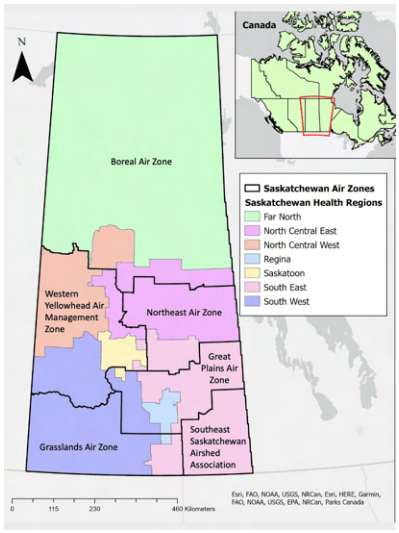
Study Objective:

- ***Understand*** the weather conditions that exacerbate air quality as a result of drought to better inform early warning systems.

Funding for this project was provided by the SSHRC Explore and Exchange Grant, the CIHR Canadian Graduate Scholarships - Masters program, and the University of Saskatchewan CGPS New Faculty Award.

METHODS

Saskatchewan, Canada



Study Location:

Health Region	Air Zone(s) *italicized* = primary air zone*	Major City/Town	Population of Health Region (Male)	Population of Health Region (Female)	Total Population
Far North	***Boreal Air Zone***	Buffalo Narrows	21345	20225	41570
North Central East	***North East Air Zone***	Prince Albert	63300	691146	754446
	Boreal Air Zone				
	Western Yellowhead Air Management Zone				
North Central West	***Western Yellowhead Air Management Zone***	North Battleford, Lloydminster	42510	42431	84941
	Boreal Air Zone				
Regina	***Great Plains Air Zone***	Regina	165636	163217	328853
	Grasslands Air Zone				
Saskatoon	***Western Yellowhead Air Management Zone***	Saskatoon	204421	204643	409064
	Great Plains Air Zone				
South East	***South East Airshed Association***	Estavan, Yorkton, Weyburn	63800	58768	122568
	Western Yellowhead Air Management Zone				
	Boreal Air Zone				
South West	***Grasslands Air Zone***	Swift Current, Moosejaw	75738	74398	150136
	Western Yellowhead Air Management Zone				
	Great Plains Air Zone				

Data & Methods:

To understand the relationships between drought-induced poor air quality and health, this study uses quantitative analysis (time series, case-crossover).

Health Data:

Health data were obtained for each of the Health Regions in Saskatchewan from 2015-2022 in weekly aggregates by sex based on expected health outcomes associated with drought-induced poor air quality (aggregated ICD-10 CA codes). Data were obtained from the Discharge Abstract Database held by the Canadian Institutes for Health Information.

Drought-Induced Poor Air Quality Condition	Health Aggregate	Health Impacts Included	ICD-10 CA Codes Included
Dust Storms	Stress and Mental Health	Depression	F30, F31, F32, F33
		Anxiety	F41
		Post Traumatic Stress Disorder (PTSD)	F43.1, F62.0
		Acute Mental Stress	F43.0
	Toxin Exposure	Assault by other specified chemicals or noxious substances	T60.3, T62.8, X89
	Foodborne Disease	Other bacterial foodborne intoxications	A02, A04.7 A05, A32
	Vectorborne Disease	West Nile	A92.3
		Scabies	B86
		Necrotizing Faciitiis	M72.6
	Infectious Disease	Coccidioidomycosis	B38
	Malnutrition	Malnutrition	E40, E41, E42, E43, E44, E45, E46
	Respiratory Health	Inflammation	J68.2
		Allergies	J30
		Silo-Fillers Disease	J68.8
		Asthma	J45
		Chronic Obstructive Pulmonary Disease (COPD)	J44
		Bronchitis	J68.0, J68.4
		Bacterial Pneumonia	J15
		Hay Fever	J30.1
		Wheezing	R06.2
		Coughing	R04.2, R05
	Gastrointestinal Illness	Diahhroea	A09.0, K59.1
	Organic Dust Toxic Syndrome	Abnormalities of Breathing	R06
		Organic Dust Toxic Syndrome	J67.8

Drought-Induced Poor Air Quality Condition	Health Aggregate	Health Impacts Included	ICD-10 CA Codes Included
Wildfires	Smoke	Toxic Effect of Smoke	T59.8, T59.9
		Scratchy Throat	J02.9, R07.0
	Nose/Sinus	Rhinitis	J00, J30, J30.1
		Sinusitis	J01, J32
		Headaches	G44, R51
	Eyes	Conjuctivitis	H10.0
		Occular Pruritis	L29.8, L29.9
	Respiratory	Cough	R04.2, R05
		Abnormalities of Breathing	R06
		Asthma	J45
		Chronic Obstructive Pulmonary Disease (COPD)	J44
		Bronchitis	J68.0, J68.4
		Pneumonia	J10.0, J11.0, J12, J13, J14, J15, J16, J18
	Cardiovascular	Heart Failure	I50
		Heart Attack	I20
		Stroke	I63, I64
	Stress and Mental Health	Depression	F32, F33
		Anxiety	F41

Air Quality Data:

Air Quality Health Index (AQHI) was selected to represent how air quality has changed over time because it is the most commonly used index for air quality in the Canadian context. AQHI represents the risk of poor air quality on health and is split into the following categories:

- 1-3: Low risk to health
- 4-6: Moderate risk to health
- 7-10: High risk to health
- 10+: Very high risk to health

AQHI was calculated using three variables: nitrogen dioxide (NO_2), ground level ozone (O_3), and fine particulate matter ($PM_{2.5}$). All three of the variables are found in wildfire smoke and dust. The variables were obtained as daily averages from 2015-2022 and were used to calculate daily AQHI using the equation below.

$$AQHI = \frac{1000}{10.4} \times (e^{0.000537 \times O_3} - 1) + (e^{0.000871 \times NO_2} - 1) + (e^{0.000487 \times PM2.5} - 1)$$

AQHI calculations were used to identify weekly maximum values and converted to weekly averages so that it could be compared with the health aggregates.

Air Quality & Health:

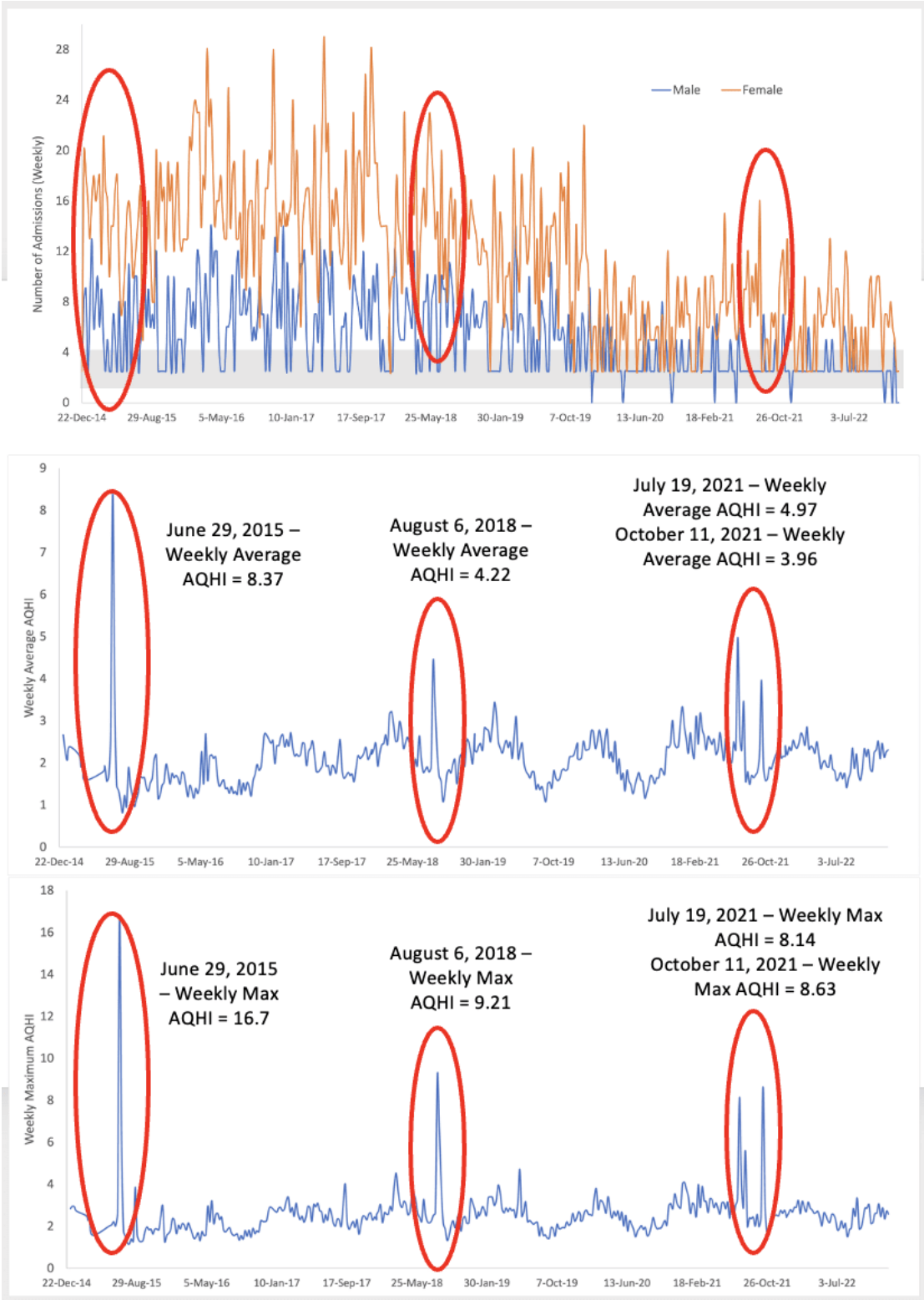
To see if there are relationships between air quality and health, the weekly time series were compared visually and statistically. If weekly adverse health outcomes consistently increase during and/or after periods of poor air quality, we can assume an association between poor air quality and adverse health outcomes.

STRESS & MENTAL HEALTH

Drought-Induced Poor Air Quality and Stress and Mental Health Impacts

In Saskatchewan, one of the main health aggregate impacts that had significant outcomes and was related to the impacts of poor AQHI was *Stress and Mental Health*. In this section, you will find some examples of how health cases related to stress and mental health changed during periods of poor air quality.

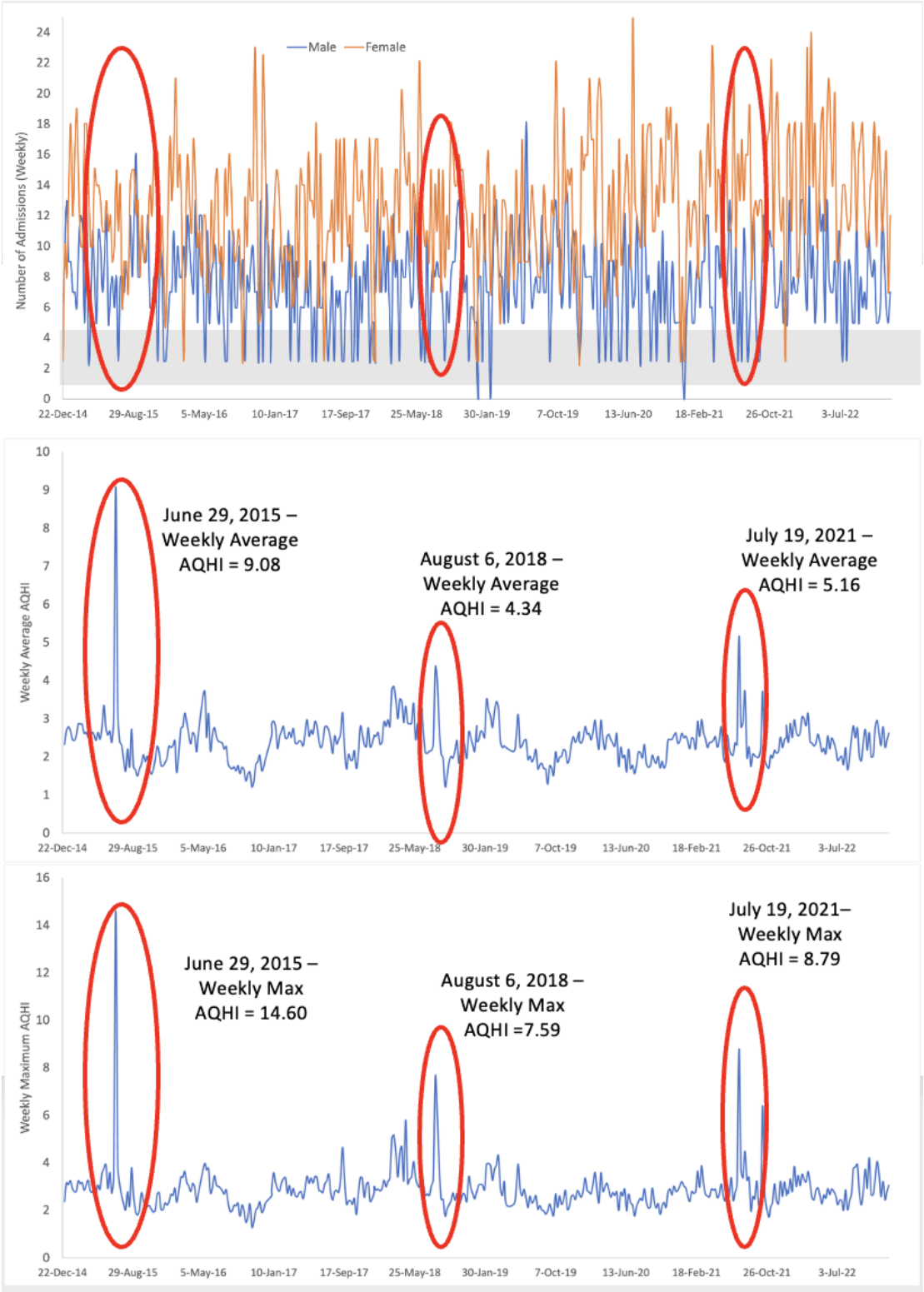
North East Air Zone & North Central East Health Zone



Four poor air quality events are highlighted in the above graphs with the corresponding weekly health admissions for stress and mental health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
June 29 2015	16.7	8.37	Cases increased during the week of the event and the week following the event compared to the week before the event.	Increased during the week of the event and the week following the event compared to the week before the event.
August 6 2018	9.21	4.22	Cases remained consistent with the week before, during, and after the event.	Increased during the week of the event compared to the week before the event.
July 19 2021	8.14	4.97	Cases stayed consistent the week before, during, and the week after the event.	Cases increased slightly during the week of the event and the week after the event compared to the week before the event. There was a larger increase in cases two weeks after the event.
October 11 2021	8.63	3.96	Cases increased during the week of the event compared to the week before the event.	Cases increased slightly during the week of the event comapred to the week before the event.
Overall Trend:			Female cases generally increase during the week of the event or the week after the event when compared to the week before the event.	

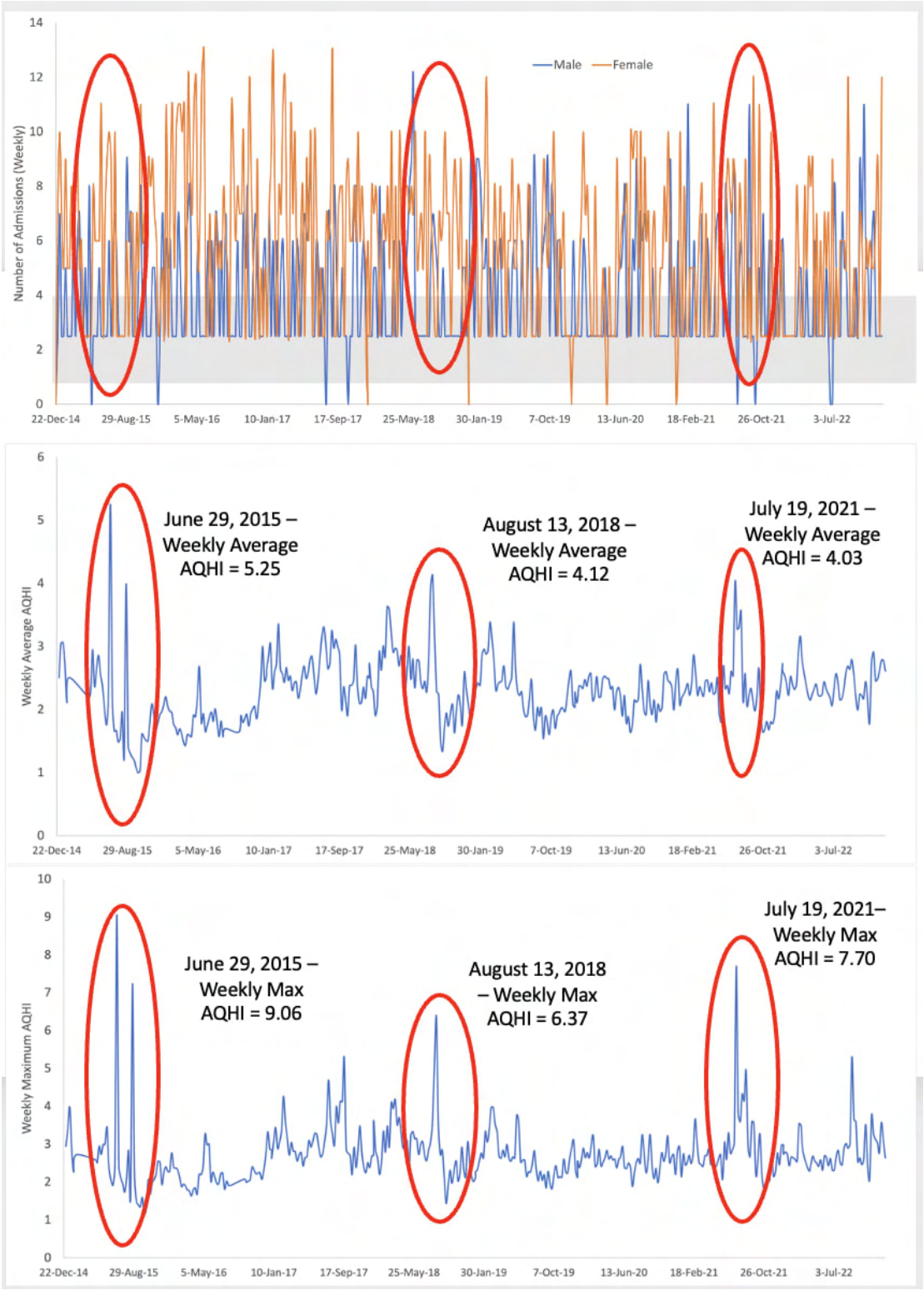
Western Yellowhead Air Management Zone & Saskatoon Health Zone



Three poor air quality events are highlighted in the above graphs, with the corresponding weekly admissions for stress and mental health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
June 29 2015	14.6	9.08	Cases increased during the week of the event when compared with the week before the event.	Cases increased during the week of the event when compared with the week before the event.
August 6 2018	7.59	4.34	Cases increased during the event week compared to the week before the event.	Cases increased the week after the event when compared to the week of the event and the week before the event.
July 19 2021	8.79	5.16	Cases increased two weeks after the event when compared to the week of and before the event.	Cases increased the week following the event when compared to the week of and the week before the event.
Overall Trend:			Male and female cases increased during and after the event when compared with the week before the event.	

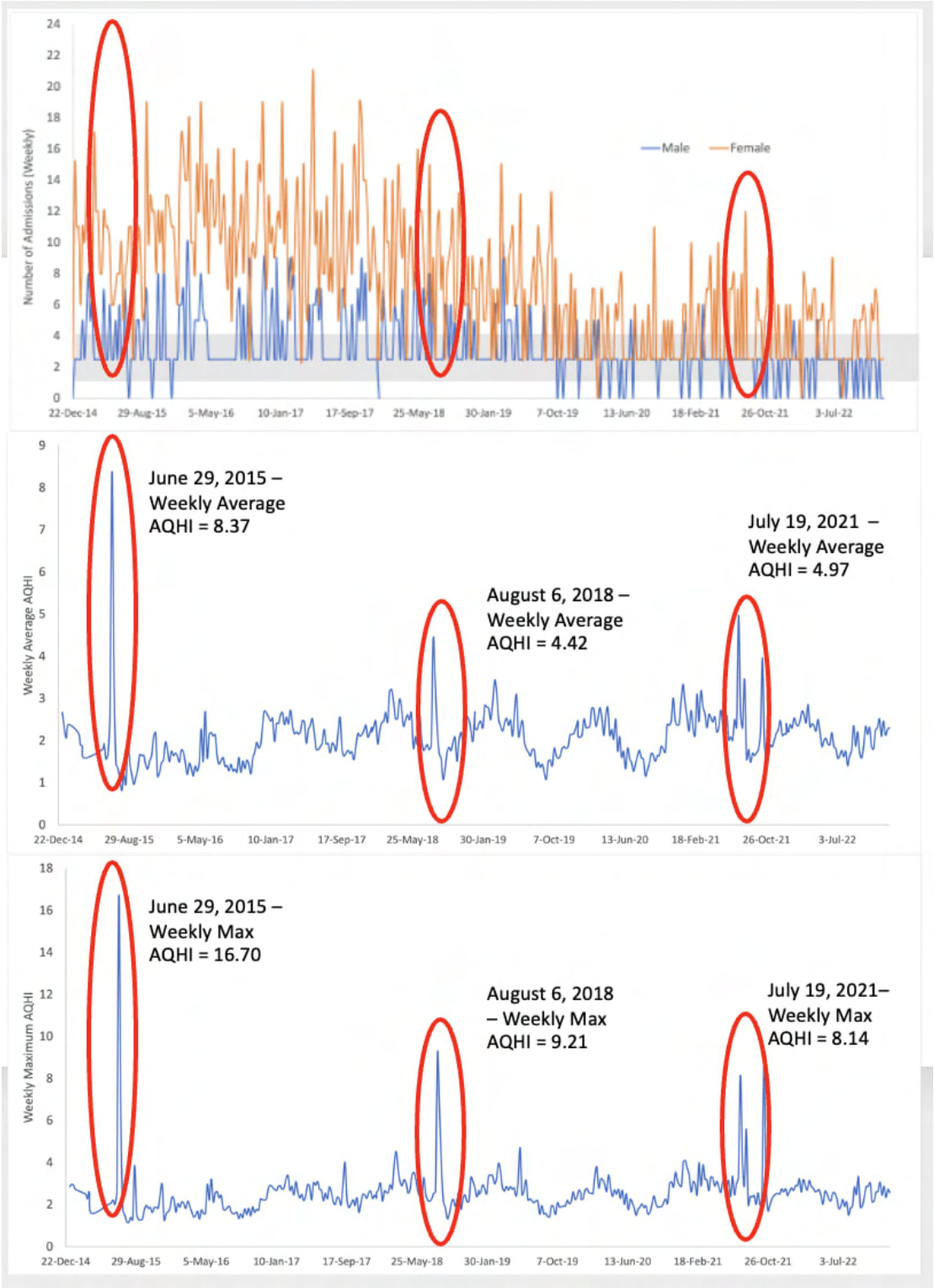
Grasslands Air Zone & South West Health Zone



Three poor air quality events are highlighted on these graphs with the corresponding weekly admissions for stress and mental health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
June 29 2015	9.06	5.25	Cases increased during the week of the event when compared to the week before the event.	Cases increased the week of the event and the week following the event when compared to the week before the event.
August 13 2018	6.37	4.12	Cases increased during the week of the event and the week following the event when compared to the week before the event.	Cases increased during the week of the event when compared with the week before the event.
July 19 2021	7.7	4.03	Cases increased during the week of the event when compared to the week before the event.	Cases increased during the week of the event when compared with the week before the event.
Overall Trend:			Male and female cases increased during the week of the event when compared to the week before the event. Sometimes, male and female cases also increased in the week following the event when comapred with the week before the event.	

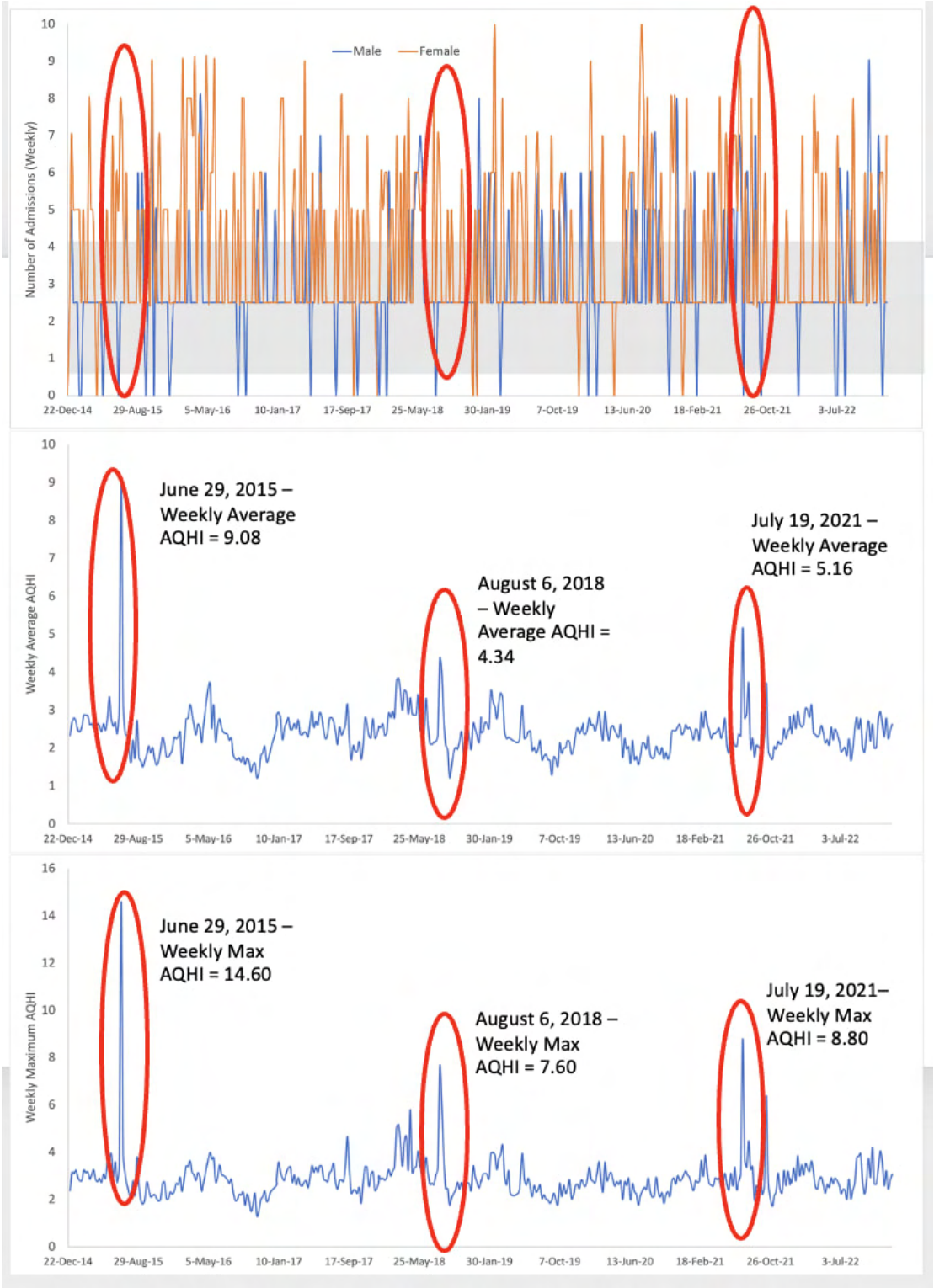
North East Air Zone and North Central East Health Zone



Three poor air quality events are highlighted in the above graphs with the corresponding weekly health admissions for stress and mental health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
June 29 2015	16.7	8.37	Cases increased during the week of the event when compared to the week before the event.	Cases increased during the week of the event and up to three weeks following the event when compared to the week before the event.
August 6 2018	9.21	4.42	Cases increased three and four weeks after the event when compared with the week before the event.	Cases increased during the week of the event when compared with the week before the event.
July 19 2021	8.14	4.97	Cases stayed consistent the week before, during, and the week after the event.	Cases increased during the week of the event and two weeks after the event when compared with the week before the event.
Overall Trend:			Female cases increased during the week of the event compared to the week before the event in all three poor AQHI events.	

Western Yellowhead Air Management Zone & South West Health Zone



Three poor air quality events are highlighted in the above graphs with the corresponding weekly health admissions for stress and mental health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
June 29 2015	14.6	9.08	Cases increased three weeks following the event when compared to the week before the event.	Cases increased the week of and the week following the event when compared with the week before the event.
August 6 2018	7.6	4.34	Cases stayed consistent the week before, during, and the week after the event.	Cases increased during the week of the event when compared with the week before the event.
July 19 2021	8.3	5.16	Cases increased during the week of the event and the week following the event when compared to the week before the event.	Cases increased during the week of the event when compared with the week before the event.
Overall Trend:			Female cases increased during the week of the event compared to the week before the event in all three poor AQHI events.	

Conclusions:

Both male and female outcomes for stress and mental health increase during and after poor air quality events.

Healthcare systems should be prepared for increased cases during and after poor air quality.

Policy and practice around healthcare should keep in mind that cases are likely to increase for both males and females during and after poor air quality events, specifically related to stress and mental health.

note: to protect privacy, case numbers between 1 and 4 are not reported. Values have been replaced with 2.5 and highlighted in grey.

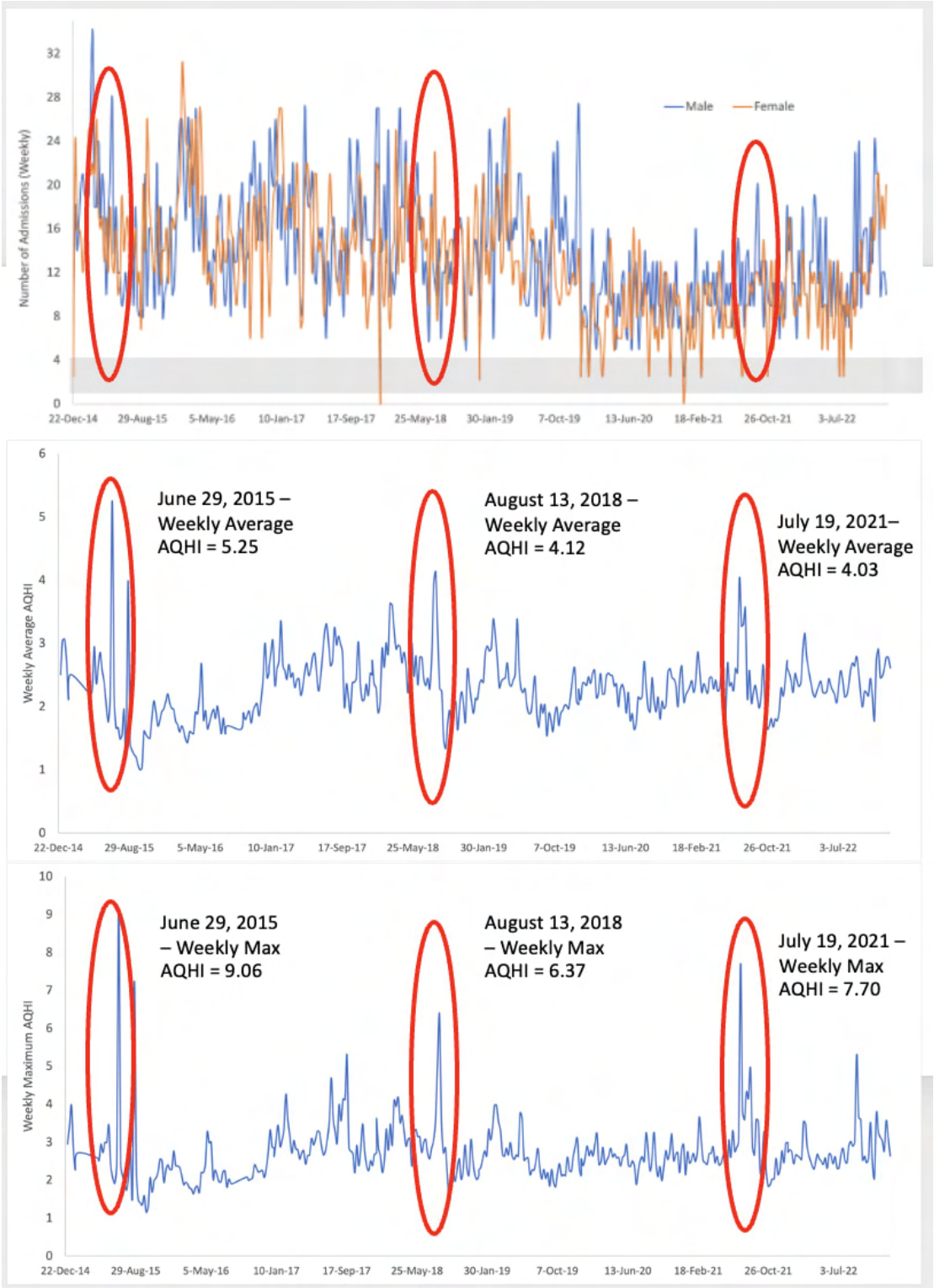
RESPIRATORY & CARDIOVASCULAR HEALTH

Drought-Induced Poor Air Quality and Health Impacts

In Saskatchewan, *Respiratory* and *Cardiovascular Health* had significant outcomes and were related to the impacts of poor AQHI. This section will provide some examples of how health cases related to cardiovascular and respiratory health changed during periods of poor air quality.

Respiratory

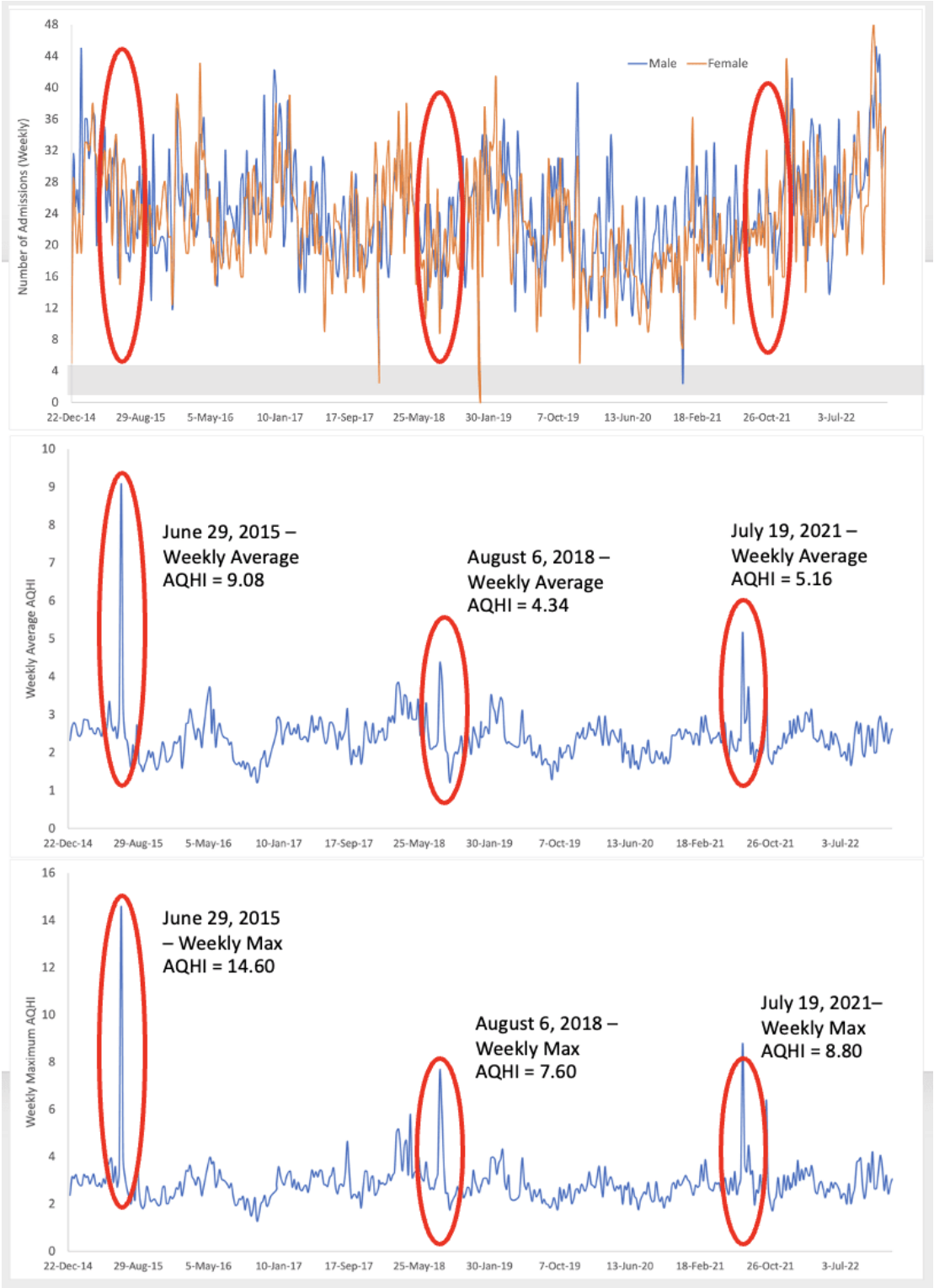
Grasslands Air Zone & South West Health Zone



Three poor air quality events are highlighted in the above graphs with the corresponding weekly health admissions for respiratory health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
June 29 2015	9.06	5.25	Cases increased during the event when compared to the week before the event.	Cases increased during the week of the event and the week following the event when compared to the week before the event.
August 13 2018	6.37	4.12	Cases increased during the event when compared to the week before the event.	Cases increased during the week of the event and the week following the event when compared to the week before the event.
July 19 2021	7.7	4.03	Cases increased the week following the event when compared to the week before the event.	Cases did not increase during the week of the event when compared to the week before the event.
Overall Trend:			Male and female cases increased during the week of the event and the week following the event when compared with the week before the event.	

Western Yellowhead Air Management Zone & Saskatoon Health Zone

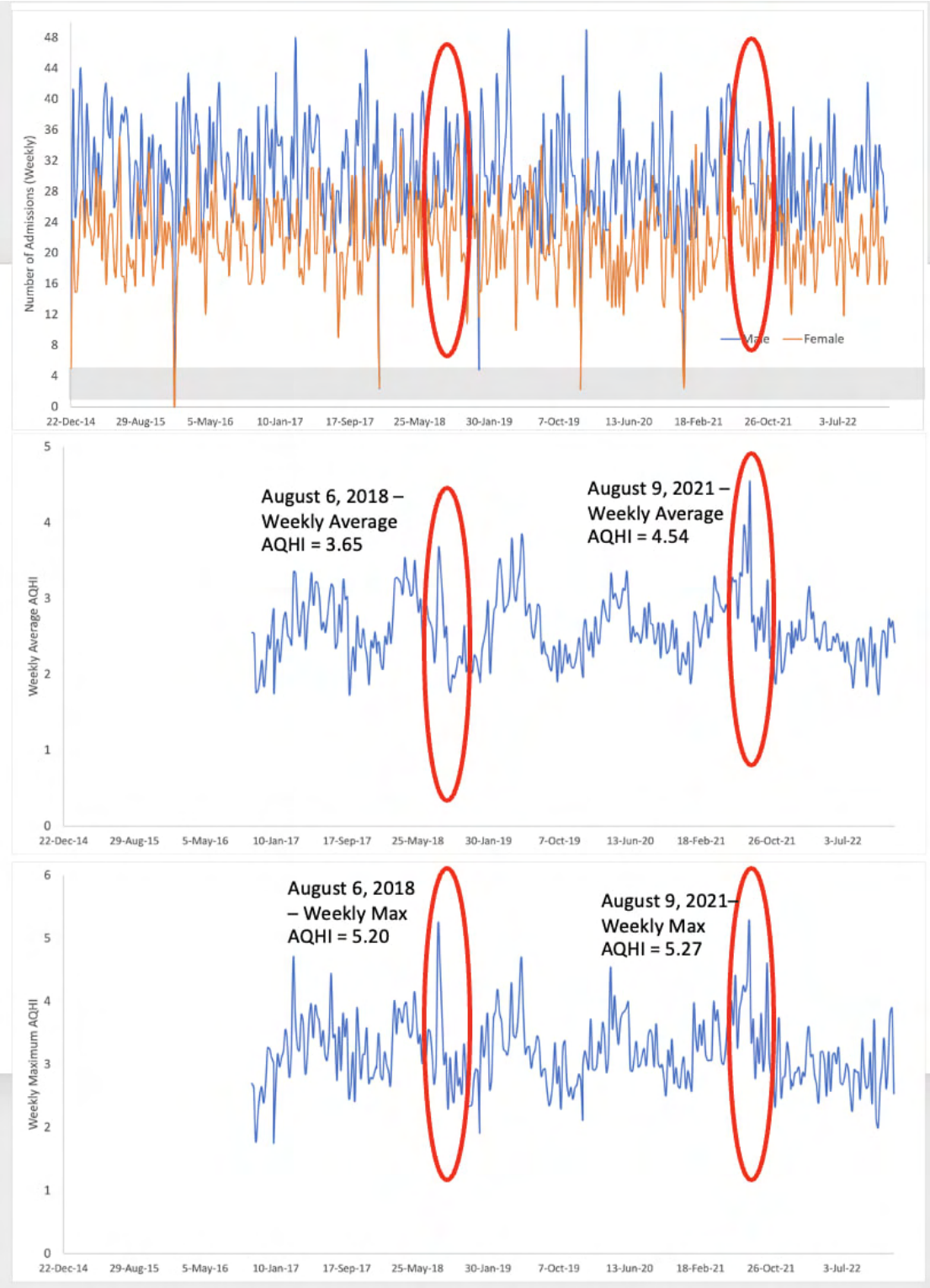


Three poor air quality events are highlighted in the above graphs with the corresponding weekly health admissions for respiratory health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
June 29 2015	14.6	9.08	Cases did not increase during the week of the event when compared to the week before the event.	Cases increased during the week of the event when compared to the week before the event.
August 6 2018	7.6	4.34	Cases increased during the week of the event when compared to the week before the event.	Cases increased the week following the event when compared to the week before the event.
July 19 2021	8.6	5.16	Cases did not increase during the week of the event when compared to the week before the event.	Cases increased the week following the event when compared to the week before the event.
Overall Trend:			Cases sometimes increased during the week of the event and the week following the event for males and females when compared to the week before the event.	

Cardiovascular

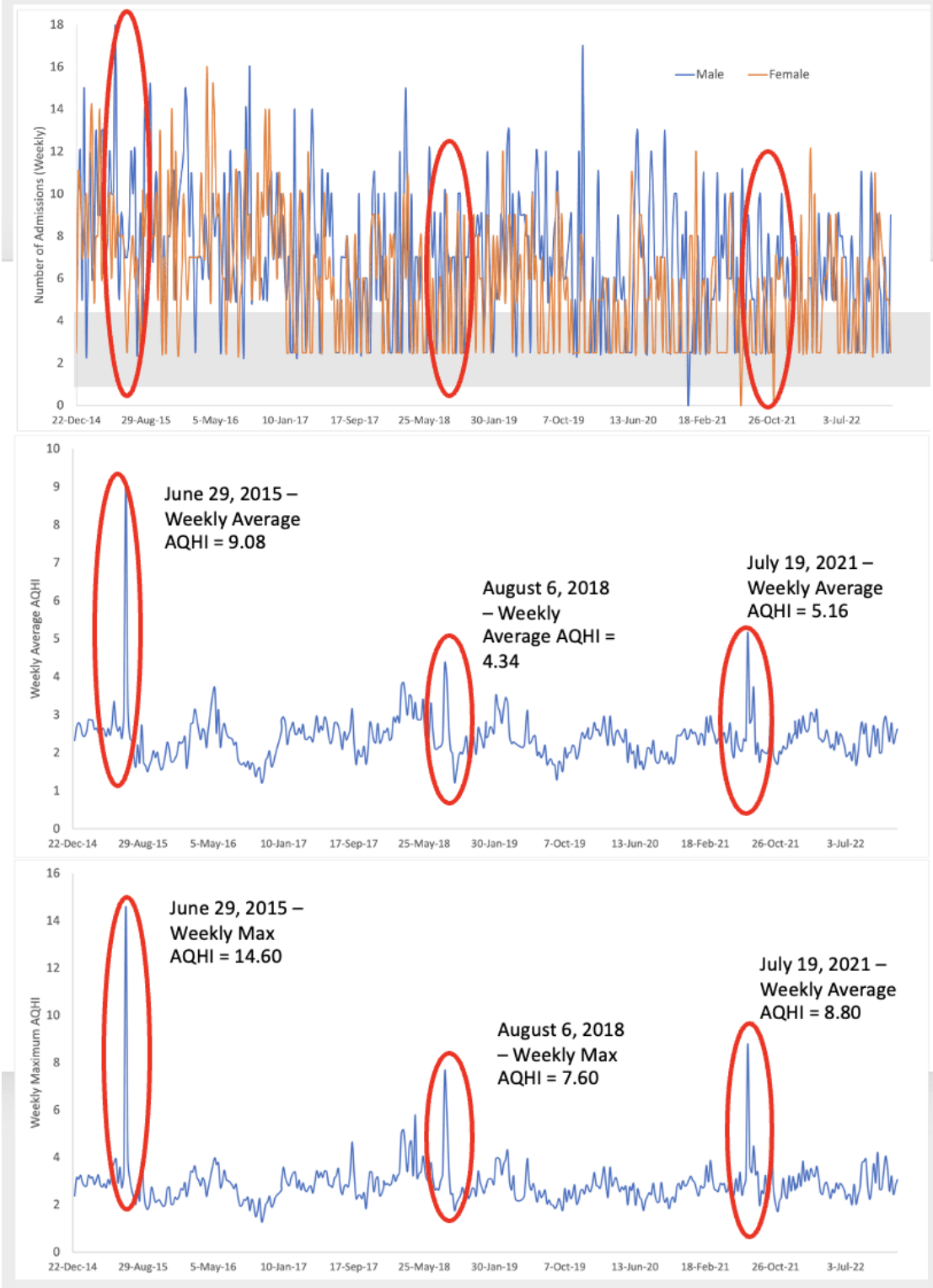
Great Plains Air Zone & Regina Health Zone



Two poor air quality events are highlighted in the above graphs with the corresponding weekly health admissions for cardiovascular health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
August 6 2018	5.2	3.65	Cases increased three weeks following the event when compared to the week before the event.	Cases increased three weeks following the event when compared to the week before the event.
August 9 2021	5.27	4.54	Cases increased during the event and the week following the event when compared to the week before the event.	Cases increased two weeks following the event when compared to the week before the event.
Overall Trend:			Cases increased for both males and females in the weeks following the event when compared to the week before the event.	

Western Yellowhead Air Management Zone & North Central West Health Zone



Three poor air quality events are highlighted in the above graphs with the corresponding weekly health admissions for cardiovascular health.

Date (Week)	Weekly Maximum AQHI	Weekly Average AQHI	Impacts to Males	Impacts to Females
June 29 2015	14.6	9.08	Cases increased during the week of the event, the week following the event, and three weeks following the event when compared to the week before the event.	Cases increased during the week of the event and two weeks after the event when compared with the week before the event.
August 6 2018	7.6	4.34	Cases increased during the week of the event when compared with the week before the event.	Cases increased the week following the event when compared with the week before the event.
July 19 2021	8.8	5.16	Cases increased two weeks after the event when compared with the week before the event.	Cases increased during the event when compared to the week before the event.
Overall Trend:			Cases for both males and females increased during and the week after the event when compared to the week before the event.	

Conclusions:

Male and female cases for respiratory health and cardiovascular health occured during and after the poor air quality event in a number of circumstances.

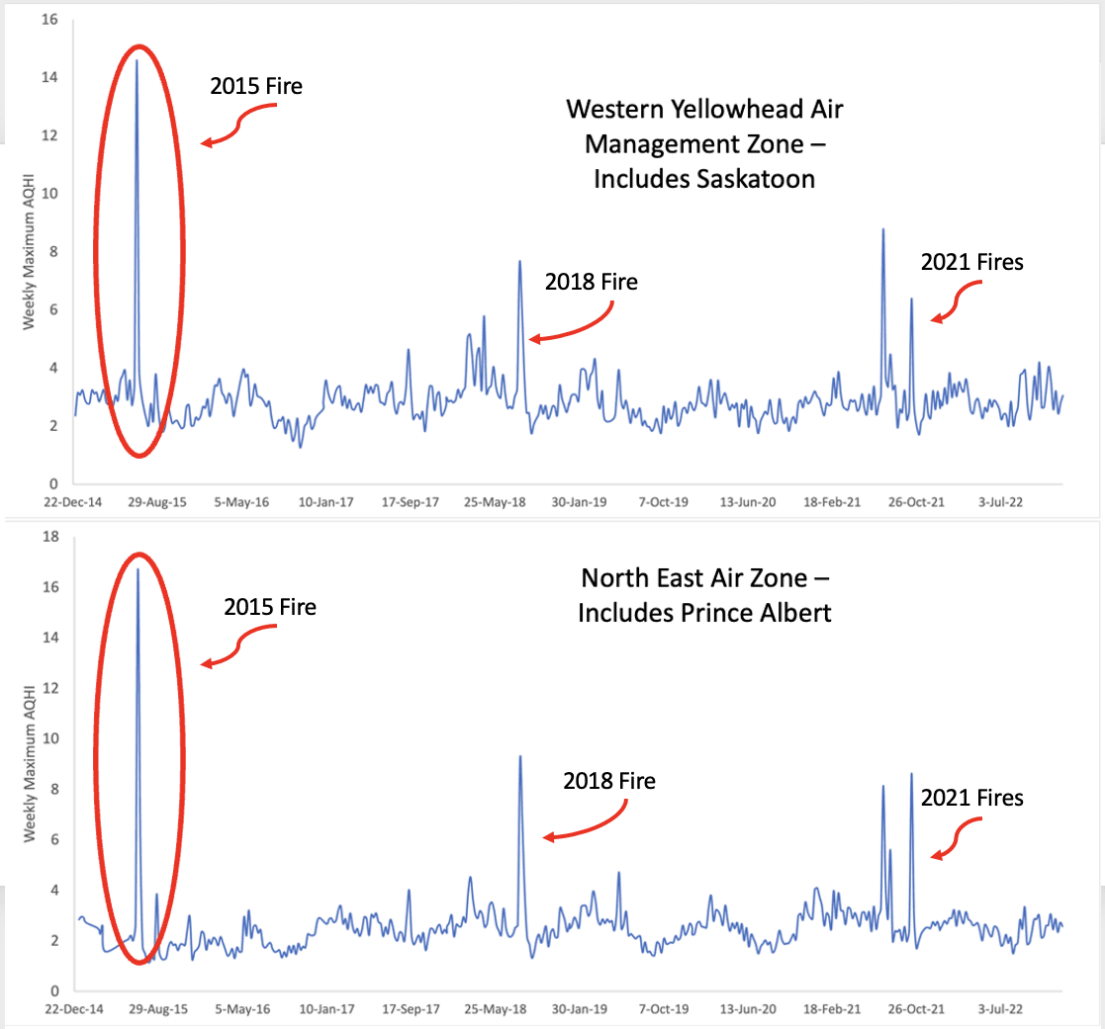
Healthcare systems need to be prepared for weeks with poor air quality and the weeks following for increases in cases related to respiratory health and cardiovascular health.

Future policy and practice should anticipate these increases during periods of drought-induced poor air quality so that individuals can recieve adequate care and so that the system is not overwhelmed.

note: to protect privacy, case numbers between 1 and 4 are not reported. Values have been replaced with 2.5 and highlighted in grey.

CASE STUDY

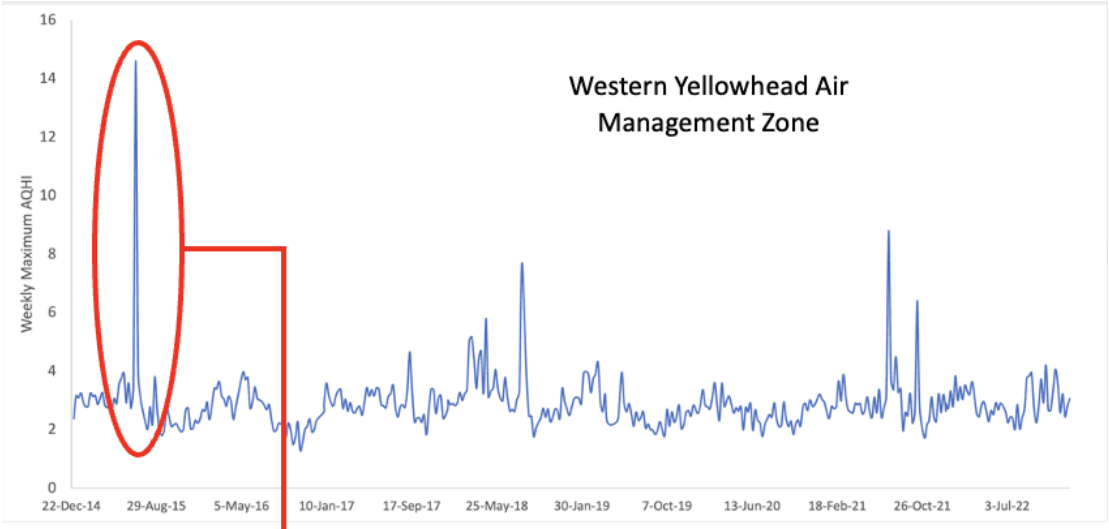
June 2015 - Drought & Wildfires in Western Canada

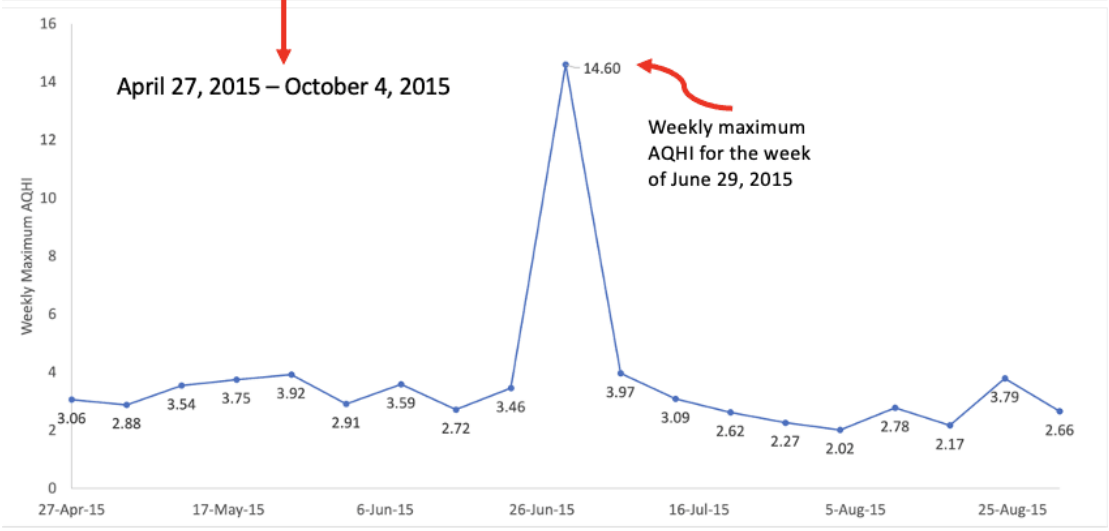


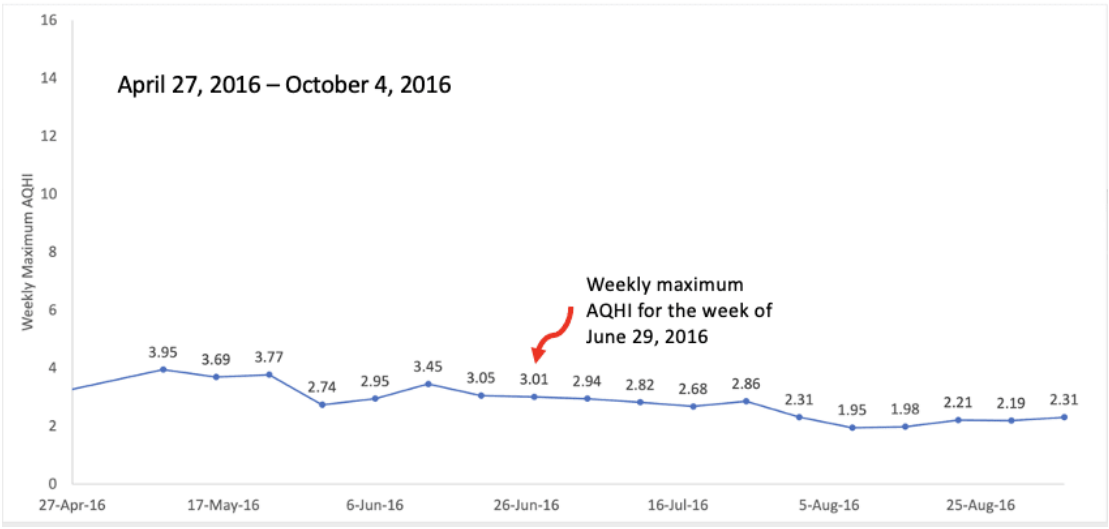
In the summer of 2015, Western Canada (British Columbia, Alberta, and Saskatchewan) was experiencing **extreme drought and major fires.** The graph above shows the period in 2015 that saw abnormally high weekly maximum AQHI values in two Saskatchewan Air Zones. While later air quality events are also associated with wildfire activity, 2015 still stands out.

A comparison between the same week in 2015 (June 29) and 2016 (where there was very little fire activity) highlights how extreme the AQHI was (see graphs below).

Western Yellowhead Air Management Zone:

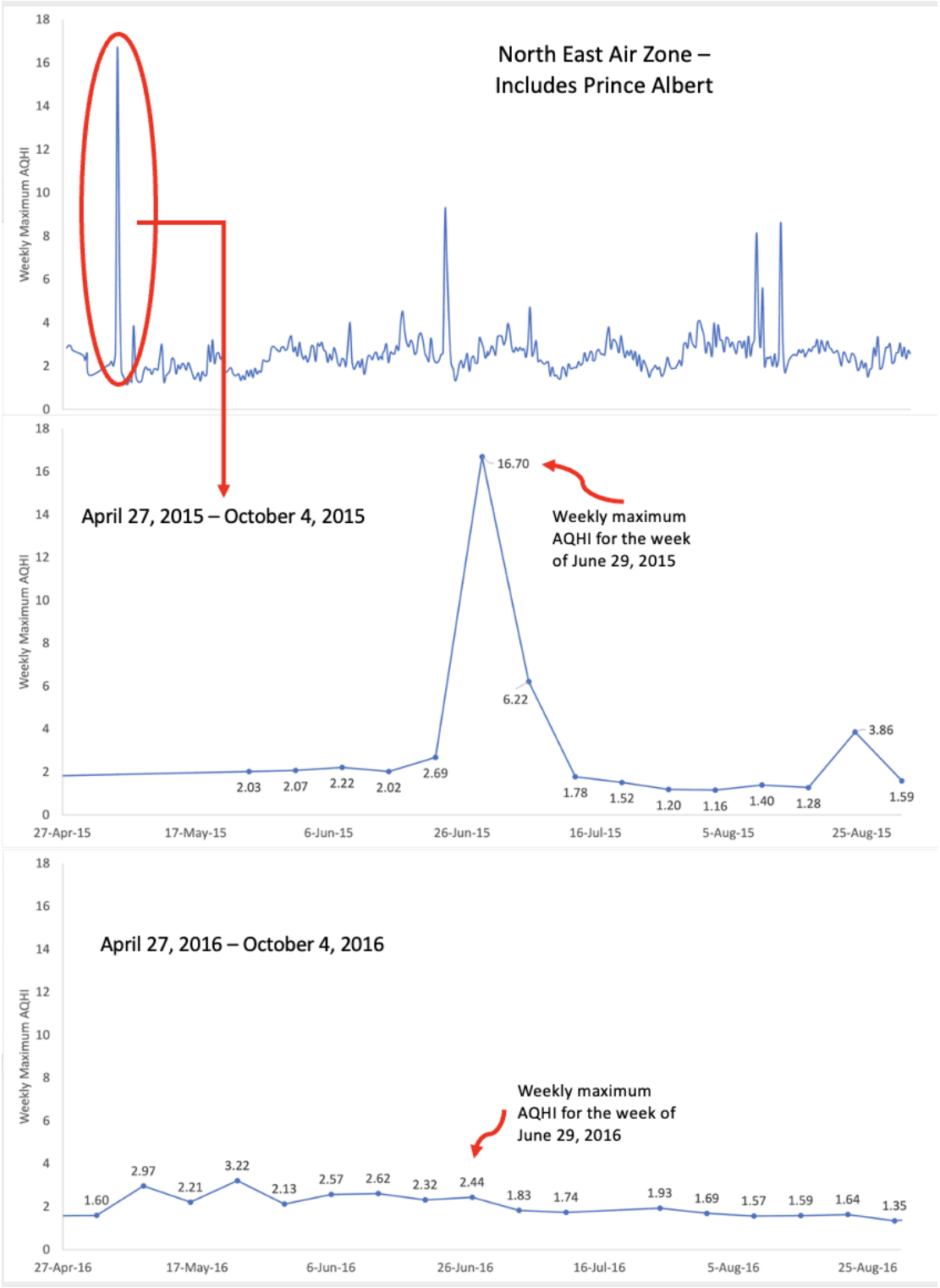






The most noticeble difference between the 2015 and 2016 graphs is the **abnormally high weekly maximum AQHI value** (AQHI = 14.60) that occured during the week of June 29, 2015. This value is drastically higher than the same week in 2016 (AQHI = 3.01).

North East Air Zone:

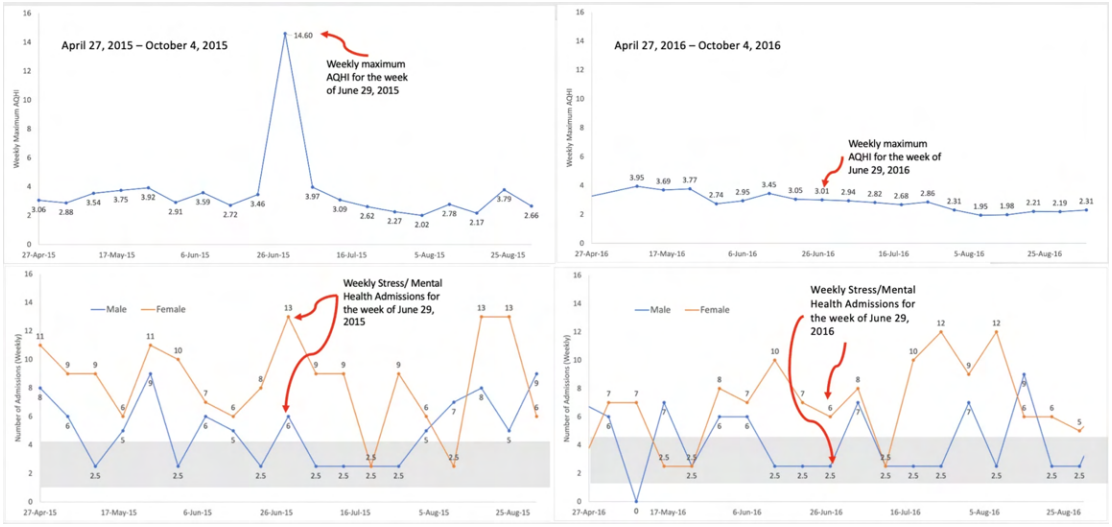


Weekly maximum AQHI peaked during the week of June 29, 2015 at 16.70, which is **drastically higher** than the same week in 2016, where maximum weekly AQHI was only 2.44.

These AQHI values represent very high risk to health (10+). Two of the largest cities in Saskatchewan are located in these air sheds. Saskatoon is located in the Western Yellowhead Air Management Zone (Saskatoon Health Region) and Prince Albert is located in the North East Air Zone (North Central East Health Region).

During the week of June 29, 2015, Saskatoon saw an increase in hospital cases for **stress and mental health** for both males and females.

- This was an increase in cases over the previous week (June 15, 2015).
- In the same week in 2016, cases were also lower for both males and females.
- When compared to the same week in 2016 (no wildfire event), male cases were above the 50th percentile and female cases were at the 90th percentile.



Similarly in Prince Albert, there were elevated cases for **stress and mental health** during the week of June 29, 2015.

- The opposite trend was observed in Prince Albert when compared to the same week in 2016 (no wildfire event). Male cases were at the 90th percentile and female cases were above the 50th percentile.

Stress and mental health cases for both males and females increased over the previous week in both Saskatoon and Prince Albert.

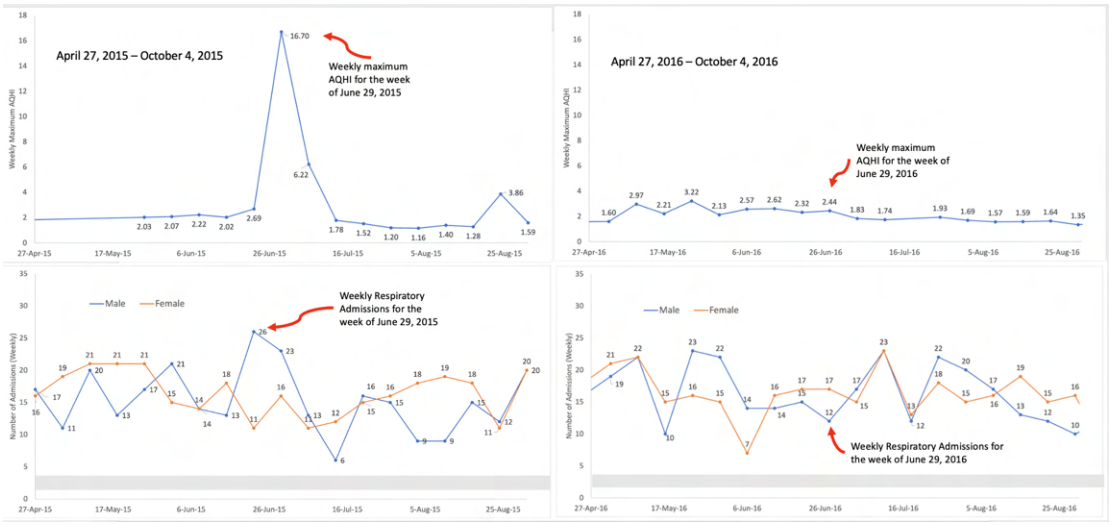
In addition to demonstrating an association between air quality and mental health, **evacuations from other heath regions to Saskatoon and Prince Albert during that time may have contributed to the elevated stress and mental health cases** that occurred during the week of June 29, 2015.

Respiratory health also showed an association with the high AQHI of the week of June 29, 2015 for both Saskatoon and Prince Albert. However, this association was only seen for males.

During the week of June 29, 2015, Prince Albert saw an increase in cases for **respiratory health** in males.

- There was an increase in male respiratory cases over the previous week (June 15, 2015).

- In the same week in 2016, Price Albert saw less than half of the male respiratory hospital cases.
- When compared with the same week in 2016 (no wildfire event), male cases were elevated (above the 90th percentile).



Saskatoon also saw elevated cases for males during the week of June 29, 2015 for **respiratory health**.

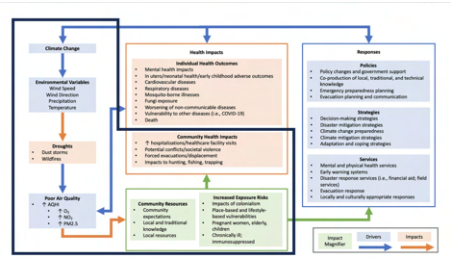
- Male cases were higher than average and when compared to the same week in 2016 (no fire event) and were above the 50th percentile.

Respiratory health cases for males during the week of June 29, 2015 were higher in both Saskatoon (above 50th percentile) and Prince Albert (above 90th percentile) when compared with the same week in 2016.

note: to protect privacy, case numbers between 1 and 4 are not reported. Values have been replaced with 2.5 and highlighted in grey.

NEXT STEPS

Coping with and Adapting to Drought-Induced Poor Air Quality



The next part of this study is to understand coping strategies and adaptation methods that are employed by two First Nations communities in Saskatchewan as a result of drought-induced poor air quality.

The second part of this study will be in collaboration and partnership with Okanese First Nation and Mistawasis Nêhiyawak and will be used to understand how each community copes with and adapts to poor air quality situations caused by drought.

This part of the study will be qualitative and will ask questions about self-reported health impacts, coping strategies, and adaptation methods that community members use in poor air quality periods. The self-reported health impacts from this portion of the study will be compared with the province-wide health impacts to see if they are consistent with or unique to the communities. Gender differences and differences in day-to-day activities will also be asked to understand who in the communities are likely to be at a greater risk to poor air quality.

Results from this study could be used by the partnering communities and/or the Provinical and Federal governments to better inform early warning systems, policy, and practice and to enhance knowledge in a First Nations context for evidence-informed policies, education, and awareness about drought-induced poor air quality and its impacts on health, coping, and adaptation.

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TRANSCRIPT

Hello! We appreciate your interest in our iPoster presentation "Health, Coping Strategies, and Adaptation to Drought-Driven Poor Air Quality in Saskatchewan." My name is Krishna and I am a Masters student at the University of Saskatchewan in the Department of Geography and Planning. I am working with Dr. Corinne Schuster Wallace and Dr. Krystopher Chutko on this project. This iPoster presentation represents the first part of a two part project related to drought-induced poor air quality and its impacts on health, coping, and adaptation in the province of Saskatchewan Canada. The study uses a coupled-human and environment approach of assessing the meteorological drivers of drought-induced poor air quality on health, coping, and adaptation in Saskatchewan communities. The first part of the study, which is presented on this poster, looks to identify relationships between health impacts and weather conditions associated with droughts in Saskatchewan, specifically related to dust storms and wildfire smoke.

Please take some time to read through our poster. If you have any questions or comments, you can reach out to any of us by email or you can add me on LinkedIn. Our contact information can be found in the "Author Information" tab at the bottom of the iPoster.

Thank you.

TRANSCRIPT

ABSTRACT

As greenhouse gas emissions increase worldwide, the planet is continuing to warm, changing water amounts and timing. Drought frequency in Canada is expected to increase due to glacier retreat, decreased duration of seasonal snow cover, earlier snow melt, and changing precipitation, along with resulting conditions such as dust storms and wildfires. The predicted increase in drought conditions and resulting exposures to poor air quality demonstrates the importance of researching the impacts of drought conditions on human health, coping methods, and adaptation strategies in the Canadian context due to the relatively few existing studies.

This study will look at the wider impacts of drought on the health of Saskatchewan populations as well as coping strategies and adaptation methods of Indigenous groups in Saskatchewan in the face of drought conditions. Studying marginalized communities, such as Indigenous communities who face specific exposures due to their ties to the land, is essential because these communities are likely to experience significant structural barriers and limits to their adaptation given drought impacts. It is important to work with Indigenous communities to understand place-based impacts and culturally appropriate adaptation strategies to inform policy and practice. This project aims to answer the following questions using a coupled human and environment approach of assessing meteorological drivers of drought-induced poor air quality on health:

1. What are the relationships between health impacts and air quality conditions associated with droughts in Saskatchewan over a 12-year period (2010-2022)? and;
2. How have individuals in Indigenous communities in Saskatchewan experienced and been impacted by drought conditions, including coping and adaptation responses implemented by these communities resulting from adverse air quality?

The outcomes of this project are to understand the weather conditions that exacerbate air quality as a result of drought to better inform early warning systems and to enhance knowledge, particularly in a Saskatchewan First Nations context, for evidence informed policies, education, and awareness.

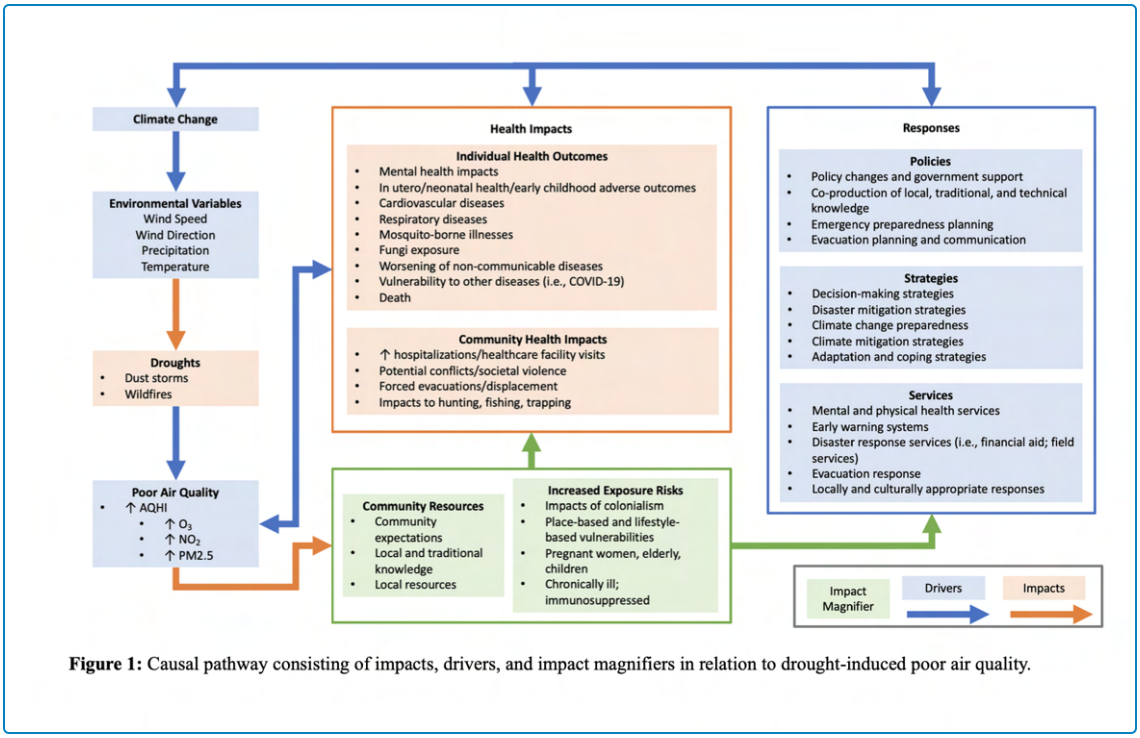

Figure 1: Causal pathway consisting of impacts, drivers, and impact magnifiers in relation to drought-induced poor air quality.

(https://agu.confex.com/data/abstract/agu/fm23/5/2/Paper_1324125_abstract_1155558_0.png)

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