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ARC Centre of Excellence for Children and Families over the Life Course

Exposure to Trihalomethanes in Drinking Water and Birth Outcomes Study in Queensland

Professor Abdullah Mamun

Dr. Edmund Kanmiki

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Acknowledgement of Country

The University of Queensland (UQ) acknowledges the Traditional Owners and their custodianship of the lands on which we meet.

We pay our respects to their Ancestors and their descendants, who continue cultural and spiritual connections to Country.

We recognise their valuable contributions to Australian and global society.

Funding: National Health and Medical Research Council

Partners: Water Unit (QLD Health), Royal Brisbane and Women's Hospital (RBWH), Metro North Public Health Unit, and Queensland Alliance for Environmental Health Sciences (QAEHS)

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Outline of Webinar

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- Project background and aims
- Overview of project activities
- Key findings from three studies
- Summary of project findings
- Overall conclusions and recommendations
- Next Steps/Way forward

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Project Background

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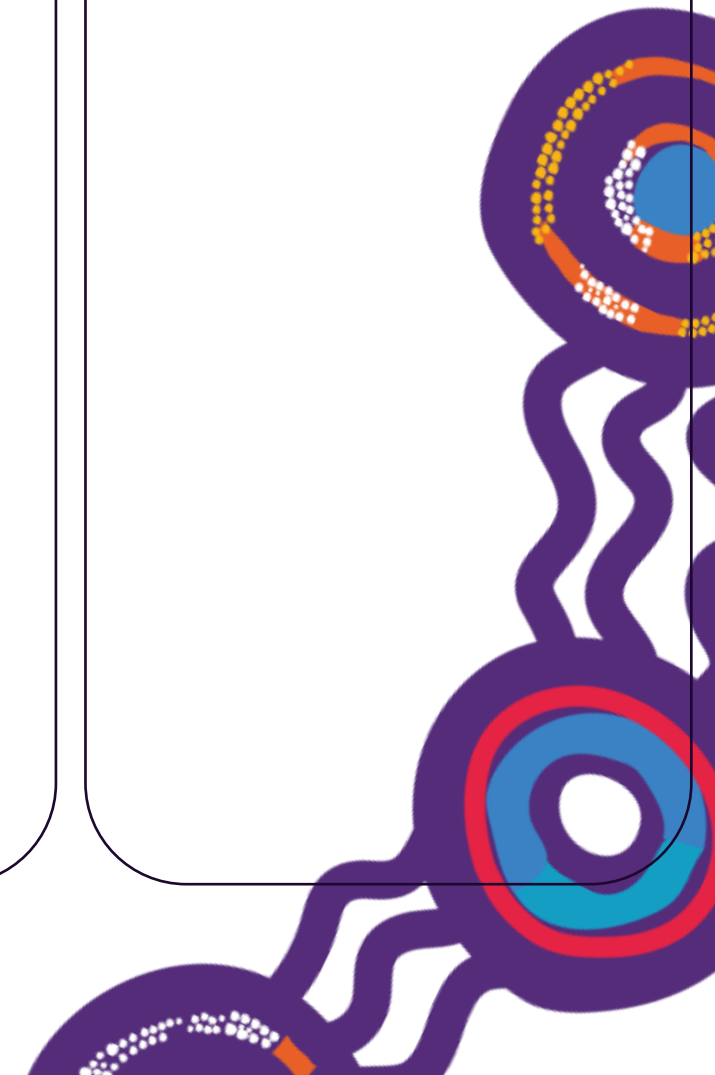
In response to growing evidence on the health effects of water disinfection by-products such as trihalomethanes (THMs), regulatory authorities across the globe have revised guidelines and implemented processes to control THMs levels in treated water



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In response to growing evidence on the health effects of water disinfection by-products such as trihalomethanes (THMs), regulatory authorities across the globe have revised guidelines and implemented processes to control THMs levels in treated water

BACKGROUND

Australia's guideline value for THMs (250 µg/L) is about *three times* higher than in the USA (80 µg/L), and 2.5 *times* higher than other developed countries such as Canada (100 µg/L) and European countries (100 µg/L)

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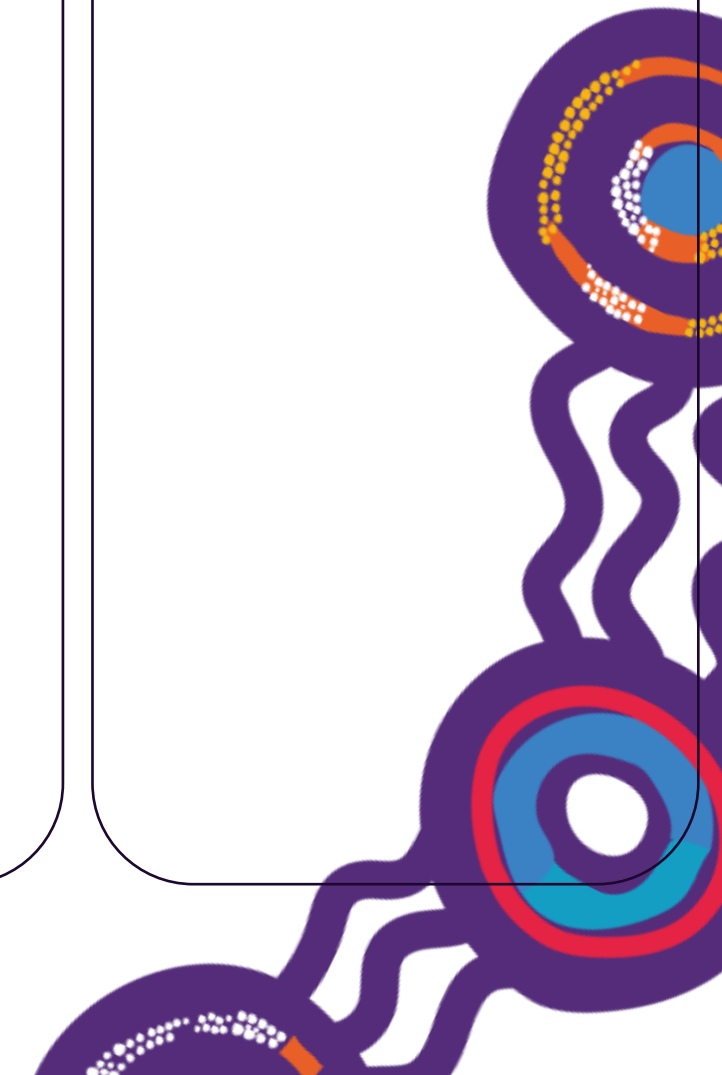

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BACKGROUND

Although the Australian Drinking Water Guidelines (ADWG) have been revised multiple times, the THM value (250 µg/L) remains the same

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BACKGROUND

Although the Australian Drinking Water Guidelines (ADWG) have been revised multiple times, the THM value (250 µg/L) remains the same

BACKGROUND

The latest revision of national guidelines (2018) encouraged action to reduce THMs, yet did not revise its 1996 position, citing a lack of sufficient data

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Project Aims

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Aim 1

Aim 2

Aim 3

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Project Aims

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Study noncompliance with national guidelines, patterns and predictors of THM exceedance in Queensland over a decade (2009-2020)

Aim 1

Aim 2

Aim 3

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Project Aims

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Study noncompliance with national guidelines, patterns and predictors of THM exceedance in Queensland over a decade (2009-2020)

Aim 1

Identify appropriate strategies for THMs risk management and incident resolution, particularly in the context of high-risk areas in Queensland

Aim 2

Aim 3

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Project Aims

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Study noncompliance with national guidelines, patterns and predictors of THM exceedance in Queensland over a decade (2009-2020)

Aim 1

Identify appropriate strategies for THMs risk management and incident resolution, particularly in the context of high-risk areas in Queensland

Aim 2

Investigate the nature and extent of the association between maternal exposure to elevated THMs concentrations and adverse birth outcomes

Aim 3

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Overview of Project Activities

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- Obtained water quality monitoring data, weather & environmental data (rainfall, temperature and NDVI data) covering 27 LGAs, and analysed the prevalence, trends and factors associated with THM exceedance in Queensland.
- Conducted qualitative in-depth interviews with drinking water supply agencies to understand:
  - Policies and practices guiding water treatment
  - Strategies for THM risk management
  - Enablers and barriers to THM exposure minimisation and incident resolution
- Obtained birth outcome data from Queensland Perinatal Data Collection (QPDC) and analysed the association of THMs exceedance with adverse birth outcomes – preterm birth, periviable birth, low birth weight and small-for-gestational age.

Study 1: THM Exceedance in Public Drinking Water Supplies in Queensland

Prevalence, Trends and Factors Associated with THM Exceedance

Objectives:

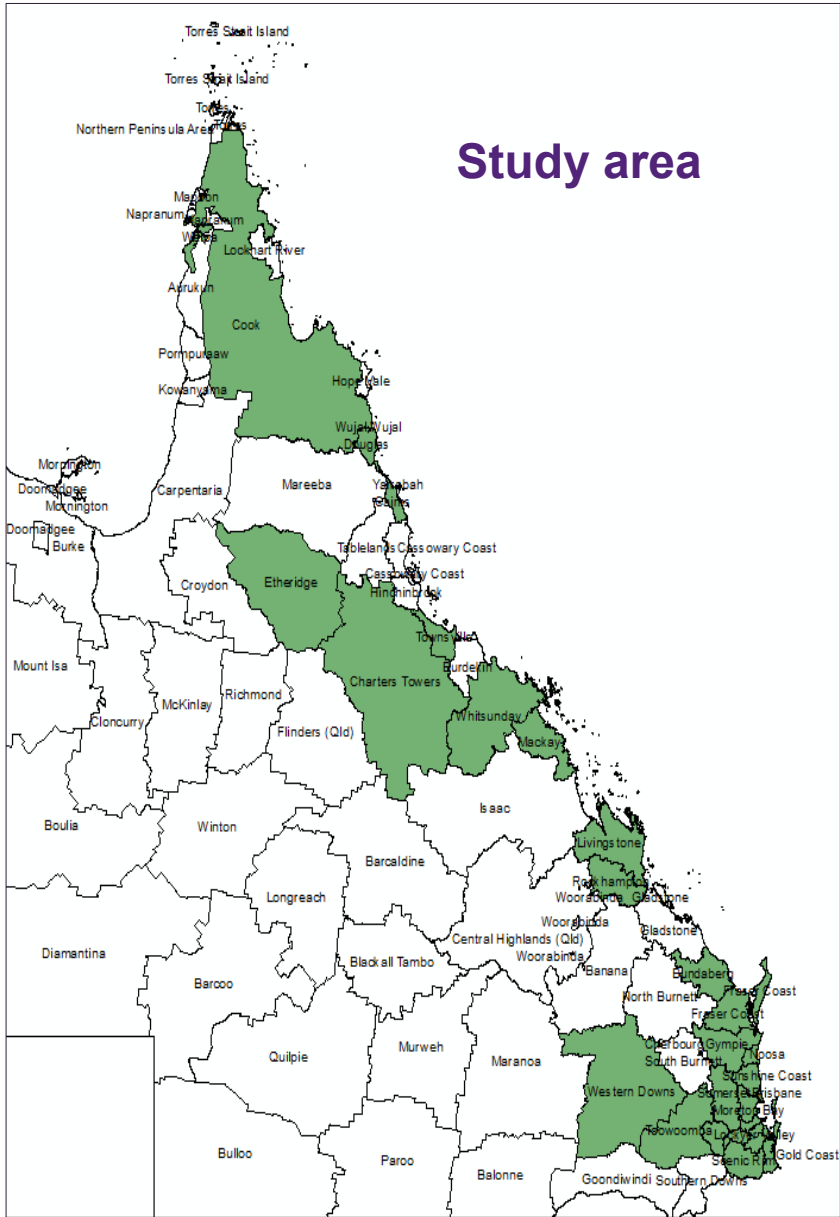
- Examine the prevalence and trends in THMs exceedance (250+µg/L) spanning 2009-2020
- Factors associated with THMs exceedance of guidelines values in Queensland

Data used:

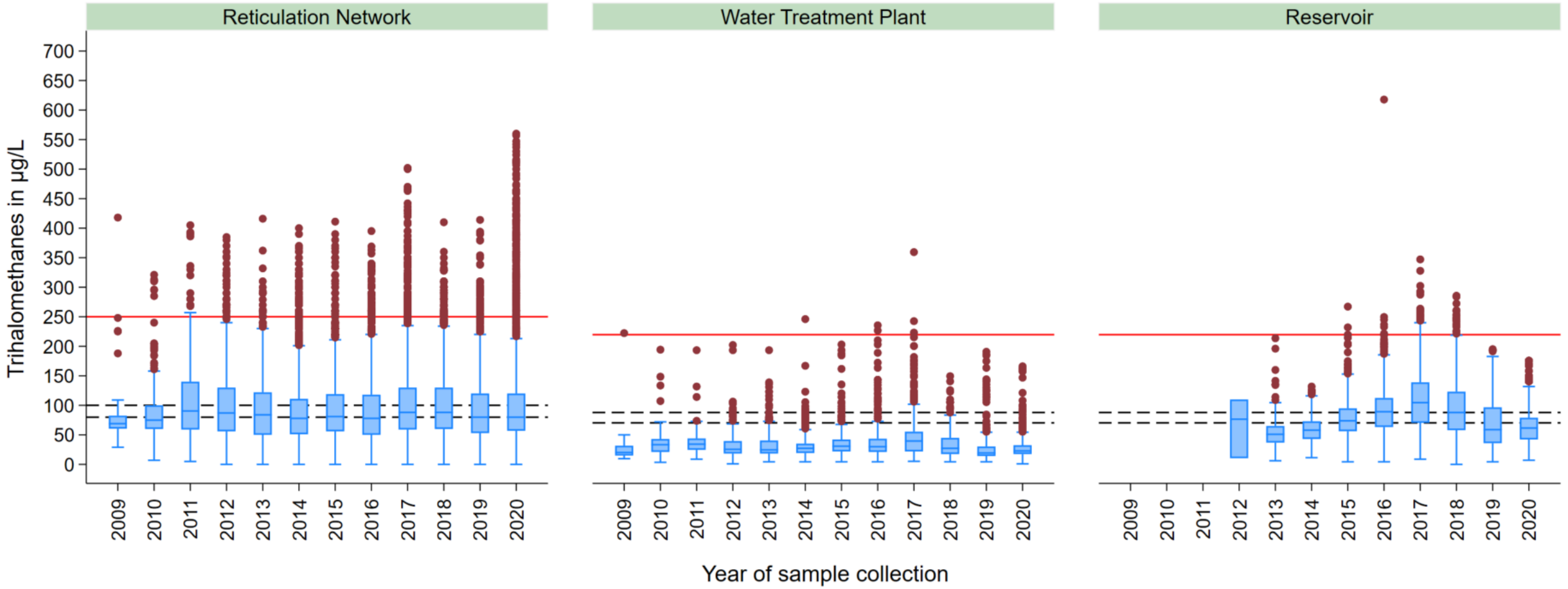
- Water quality monitoring data (2009-2020) from 27 Local government councils.
- Environment and weather data for same period (temperature, rainfall, NDVI)

Analysis:

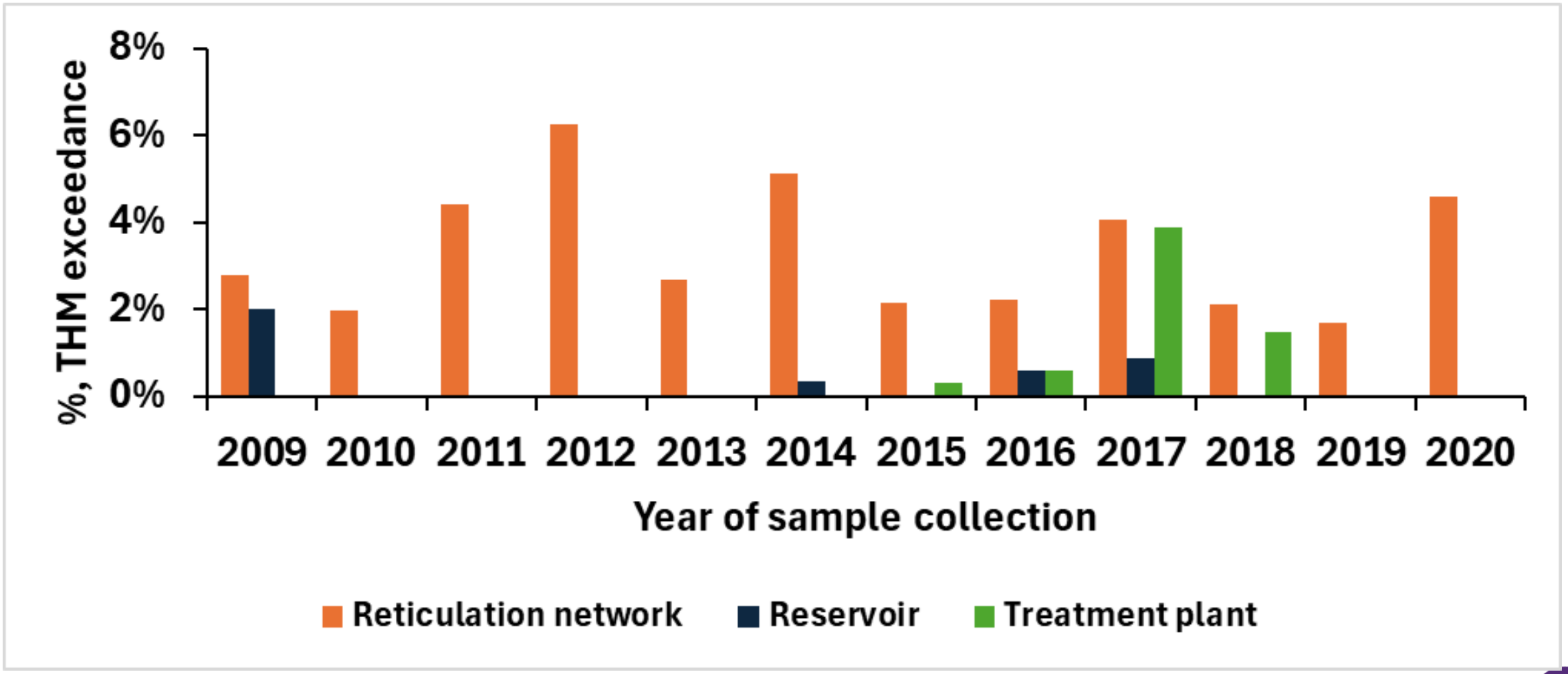
- Descriptive statistics
- Bivariate analysis
- Multivariate regression analysis



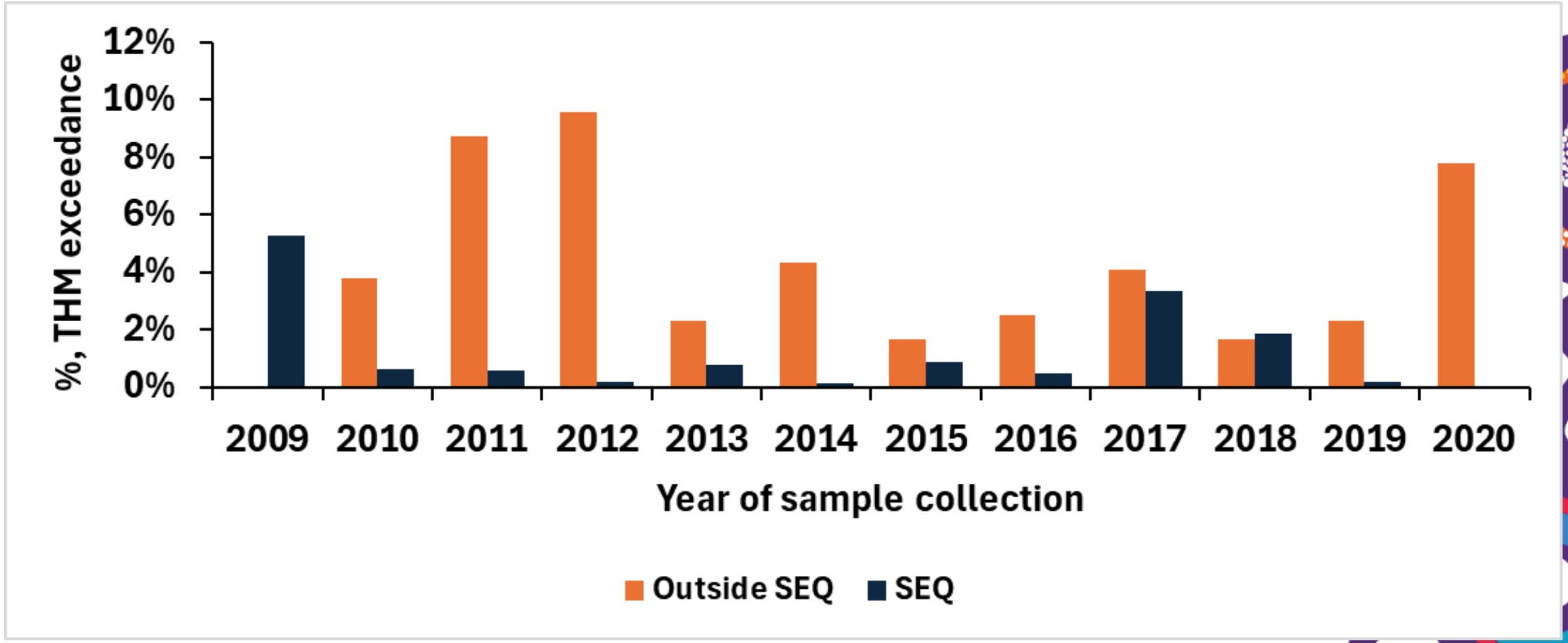
Level of THM Concentrations in Queensland, 2009-2020



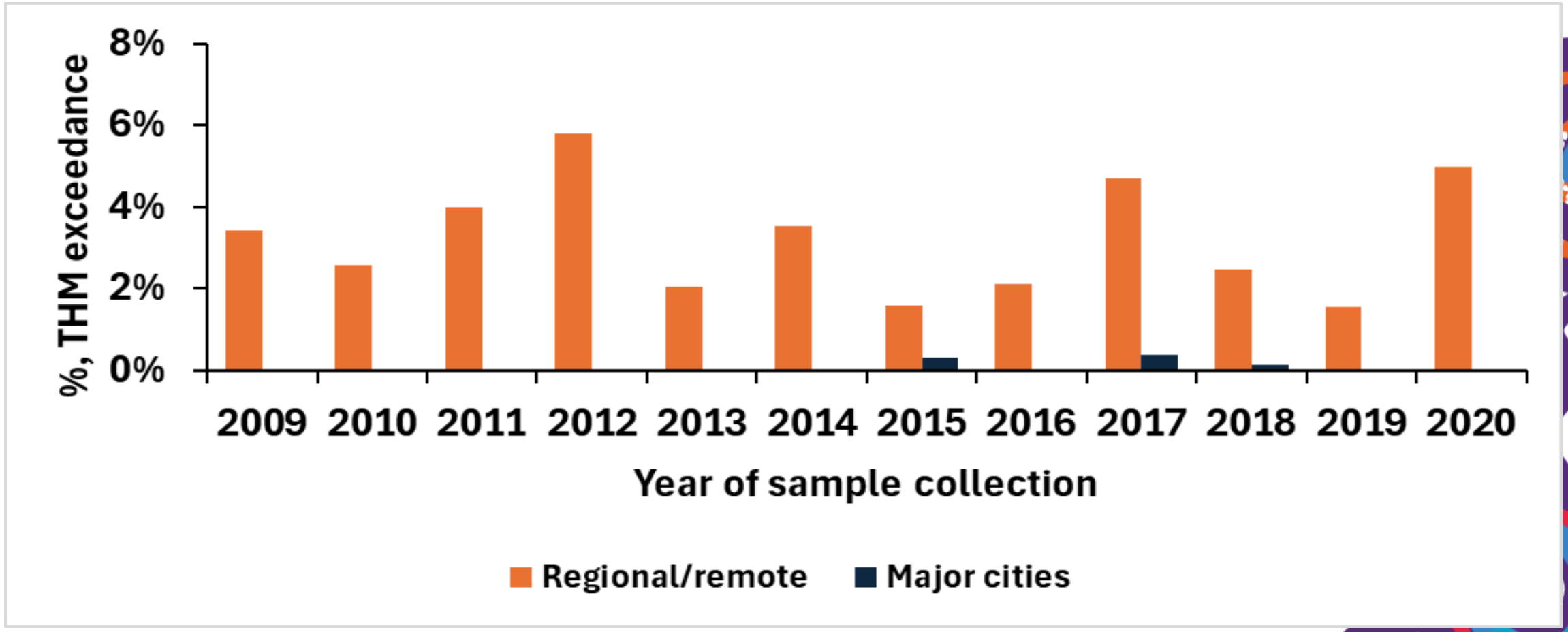
THMs Exceedance by Source of Water Sample in Queensland, 2009-2020



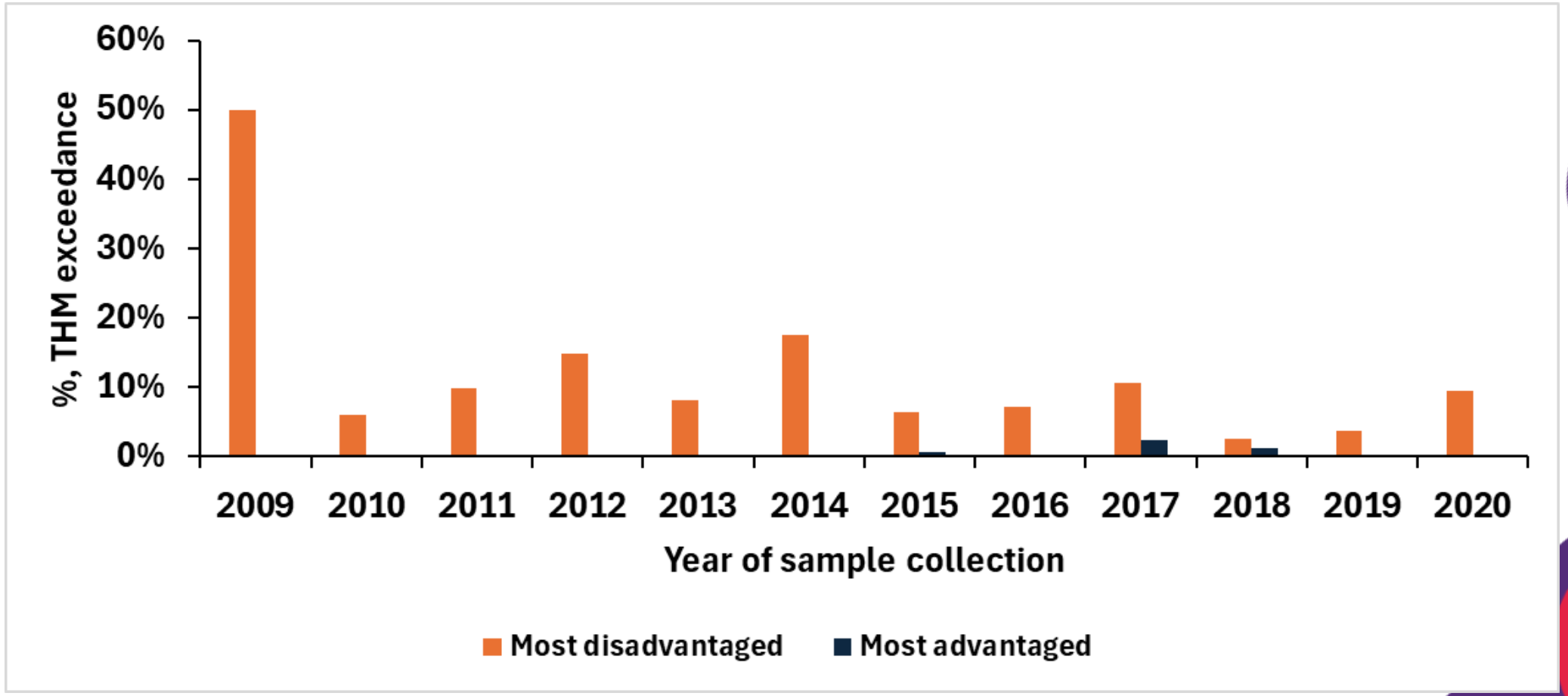
THMs Exceedance by Location in Queensland, 2009-2020



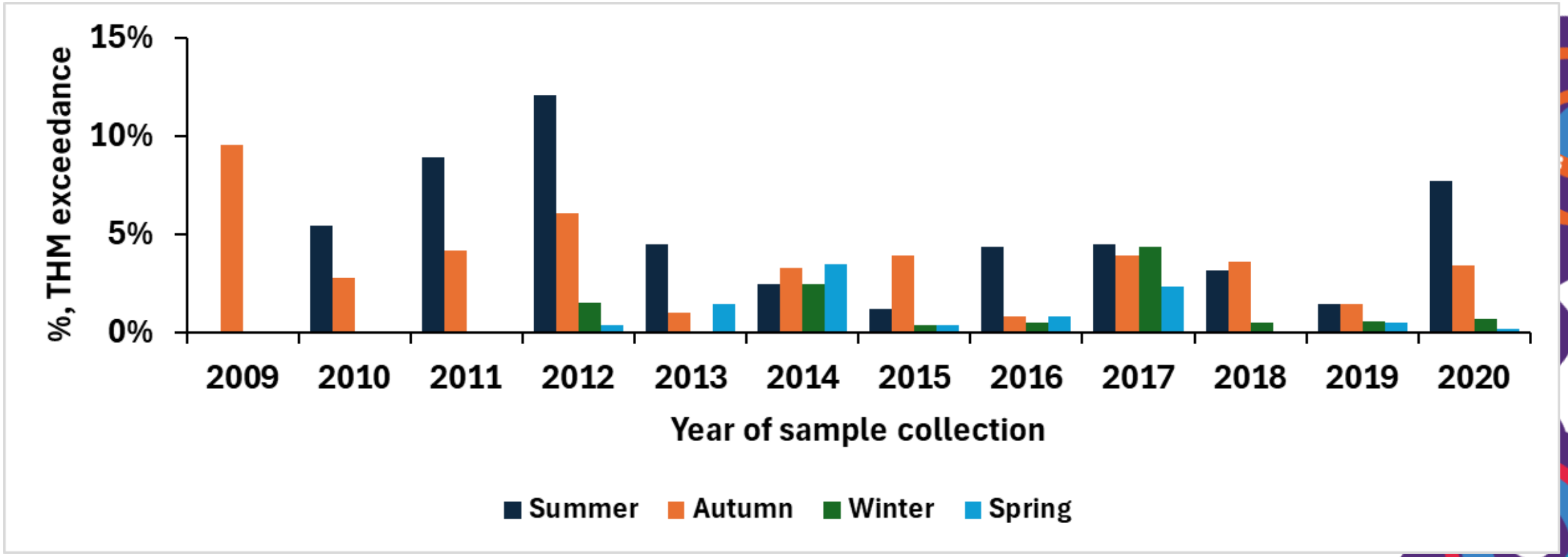
THMs Exceedance by Geographic Remoteness in Queensland, 2009-2020



THMs Exceedance by Geographic Remoteness in Queensland, 2009-2020



THMs Exceedance by Season in Queensland, 2009-2020



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Summary of Water Quality Study

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- THMs exceedance increased from 2.3% to 3.0% between 2009-2020
- Samples from the treatment plant and reservoir have lower rates of THM exceedance compared with samples from the reticulation network
- Generally, lower exceedance in LGAs within SEQ compared to outside SEQ
- Geographic disparities in THM exceedance, with urban regions at low risk compared to rural and disadvantaged areas.
- There is seasonal variation in THM exceedance: more in summer and lower exceedances in the spring season
- Climate events and weather variables (rainfall and NDVI) were not significantly associated with exceedances in the multivariate analysis

Study 2: Challenges and Opportunities for Effective THMs Management in Queensland

Challenges and Opportunities for Effective THMs Management in Queensland

Objectives:

- To understand the policies, practices, and procedures involved in water treatment, disinfection and delivery
- To identify appropriate strategies for THM risk management and incident resolution
- To understand stakeholders' views on the enablers and barriers to:
  - Effective risk management
  - THM exposure minimisation
  - Incident resolution

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Qualitative Methods

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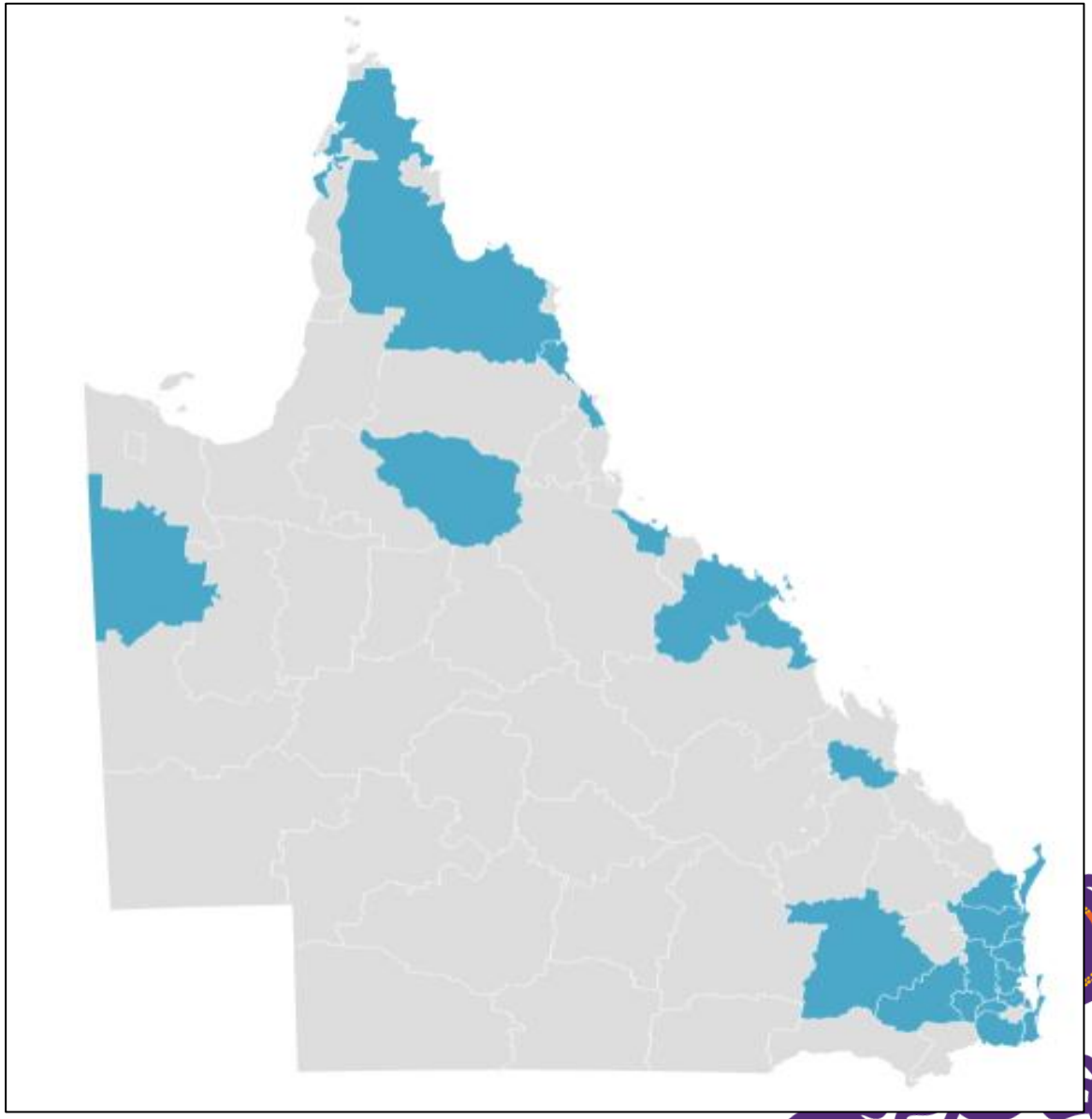
Qualitative In-depth Interviews of Water Utilities Covering 22 Local Government Areas in Queensland

- 15 Local Government Councils
- Two Utility companies
  - Urban Utilities (serving 5 LGAs)
  - Unity Water (serving 3 LGAs)

Data collation

- Semi-structured interview guides developed and tested with inputs and support from Queensland Health
- Interviews done through online (zoom and teams)
- Audio recorded and transcript verbatim



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Qualitative Methods (cont.)

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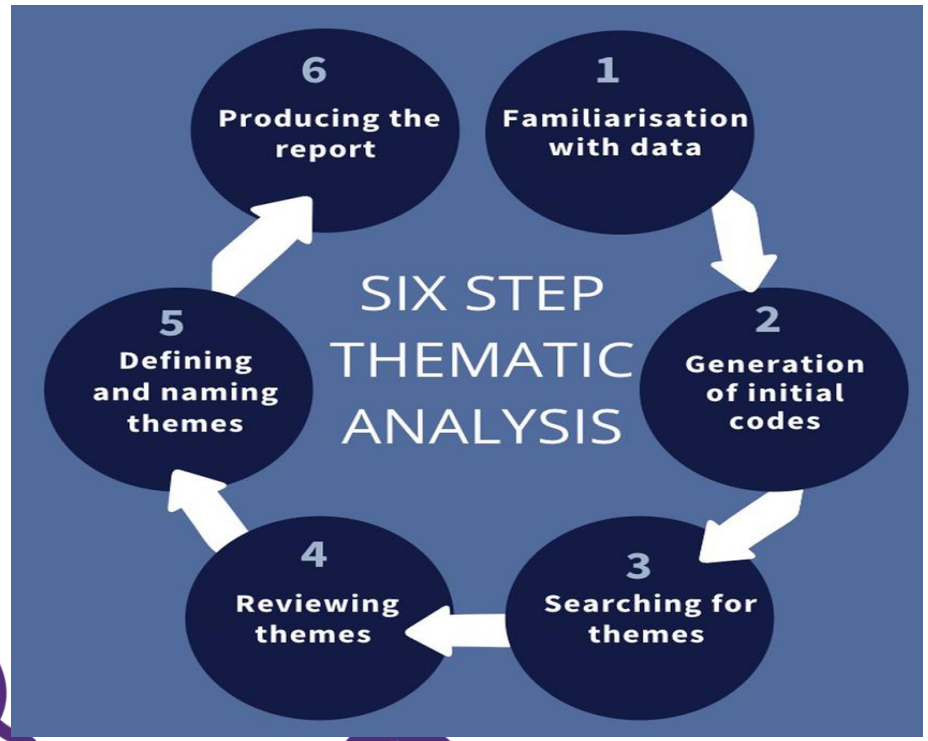
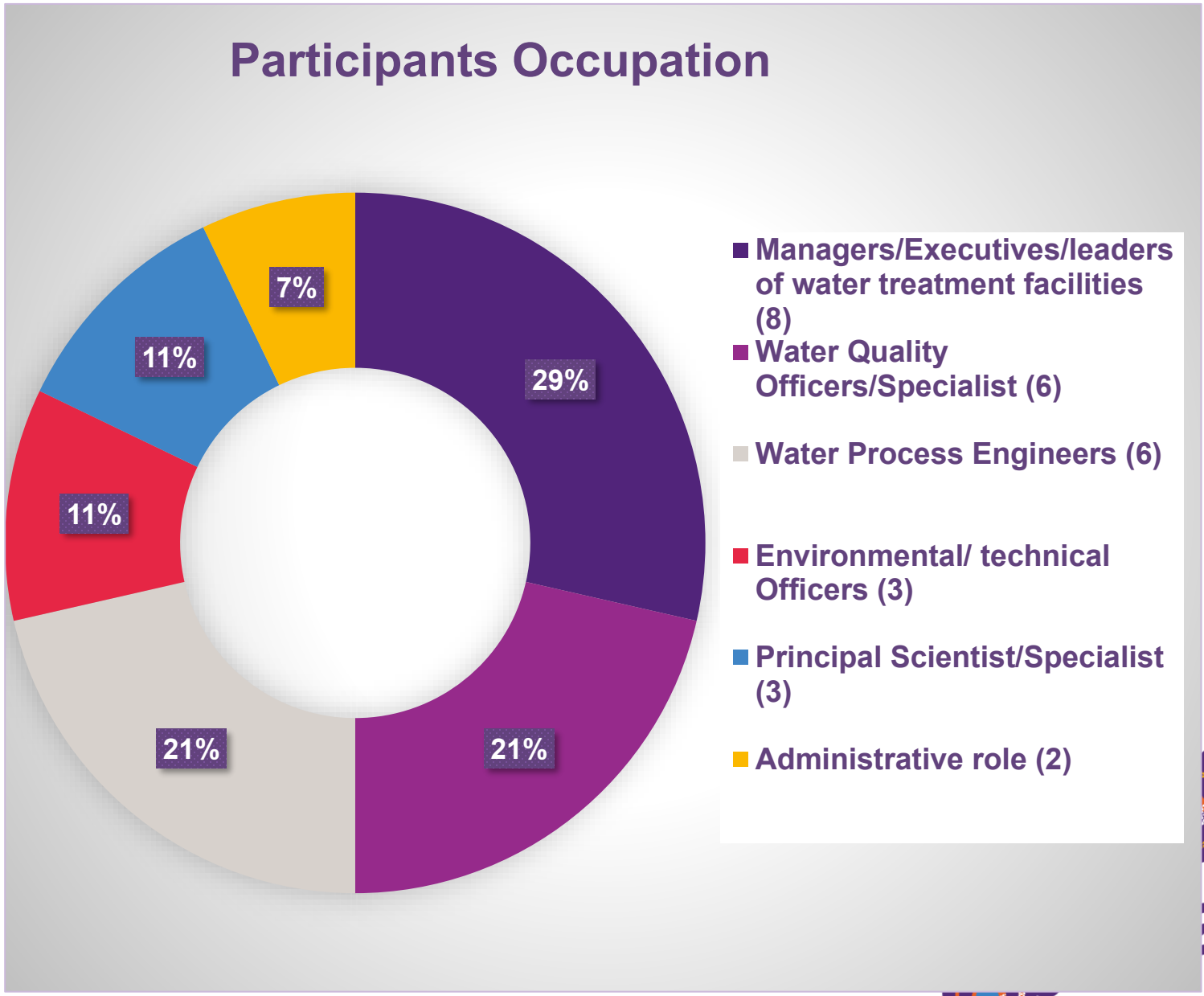
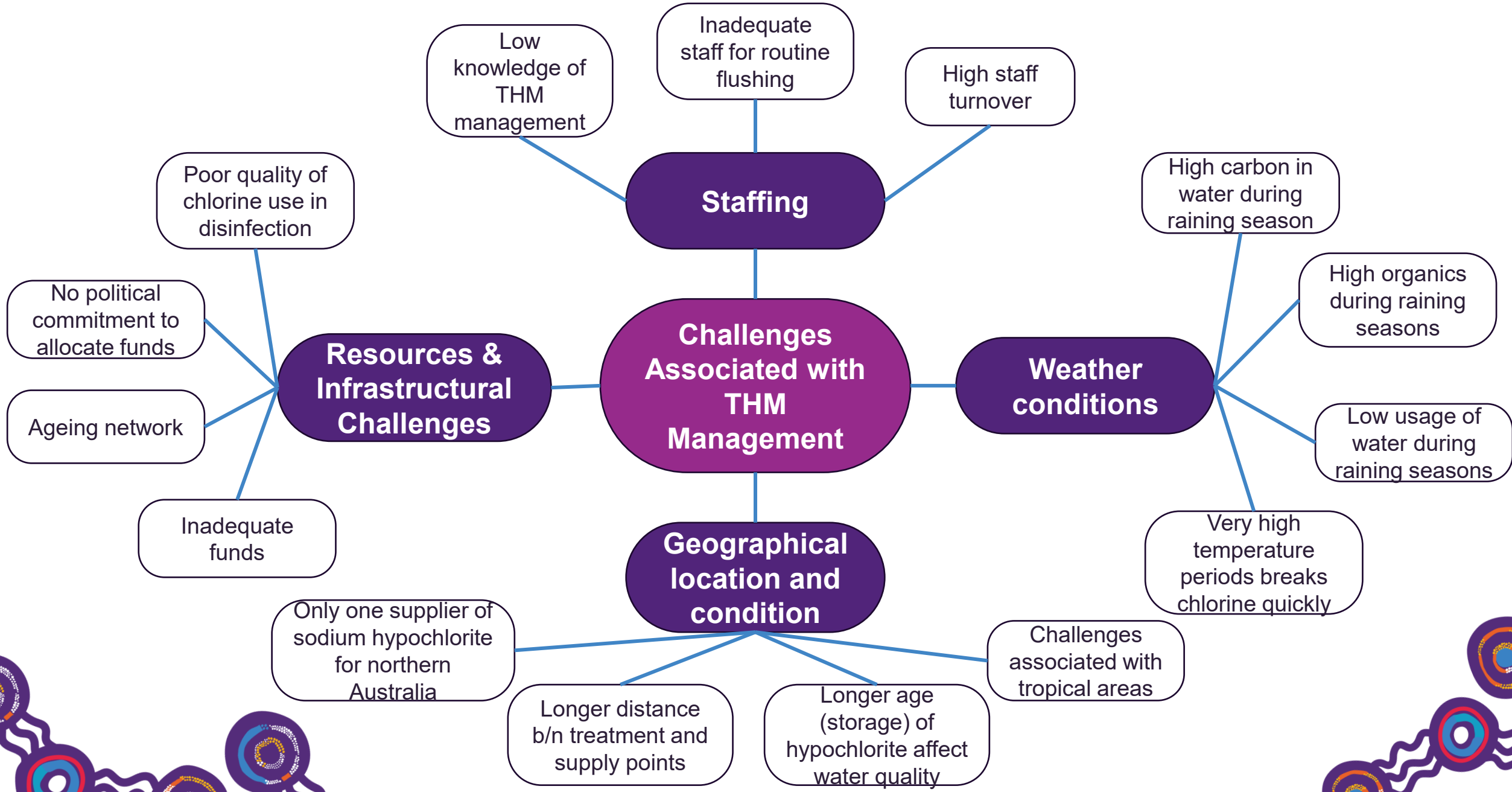
- **Data analysis**
  - Guided by thematic analysis and situational analytical framework:





Challenges Associated with THM Management



Stakeholder’s voices for Improving THM Management

Optimized the network to reduce water age within the network by reducing stagnant water

Find a way to put somewhere in the network a treatment process to take THM out.

Aeration

Changing source of raw water when THMs are high (source blending)

Optimizing chlorine, no excessive secondary dosing (reduce multiple secondary dosing sites),

Need some additional type of filtration: that is adding things to settle out carbon, using UV ,

Need to sample more frequently and everything, it would be good to get more information from across Queensland and try and act as

Stakeholder’s voices for Improving THM Management

Getting together and collaborating, understanding each other's challenges, sharing data and coming up with what's the best cost solution for everybody

Getting more information about newer technologies

Need more suppliers of hypo chloride for the northern councils of QLD

Improve relationship with SEQ Wate Unity water and LGA councils

Form THM management groups

Study 3: THMs exposure and birth outcomes

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Objectives

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Objective 1

Objective 2

Objective 3

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Objectives

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To assess the burden of maternal exposure to trihalomethanes and adverse birth outcomes

Objective 1

Objective 2

Objective 3

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Objectives

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To assess the burden of maternal exposure to trihalomethanes and adverse birth outcomes

Objective 1

To examine the spatiotemporal patterns of maternal exposure to trihalomethanes and adverse birth outcomes

Objective 2

Objective 3

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Objectives

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To assess the burden of maternal exposure to trihalomethanes and adverse birth outcomes

Objective 1

To examine the spatiotemporal patterns of maternal exposure to trihalomethanes and adverse birth outcomes

Objective 2

To investigate the nature and extent of the association between maternal exposure to trihalomethanes and adverse birth outcomes

Objective 3

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Methodology

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Data

- Queensland Perinatal Data Collection
- Water Quality Monitoring Data
- Weather Station Data
- Normalized Difference Vegetation Index (NDVI)

Study period

- 2009-2020

Study setting

- 25 Local Government Areas with reticulation network for household water supplies (covering 87% of total birth)

Sample size

- 134,966 singleton livebirths

Statistical analysis

- Descriptive analysis
- Bivariate analysis
- Multivariable Generalized Estimating Equation Modelling

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Data linkage framework

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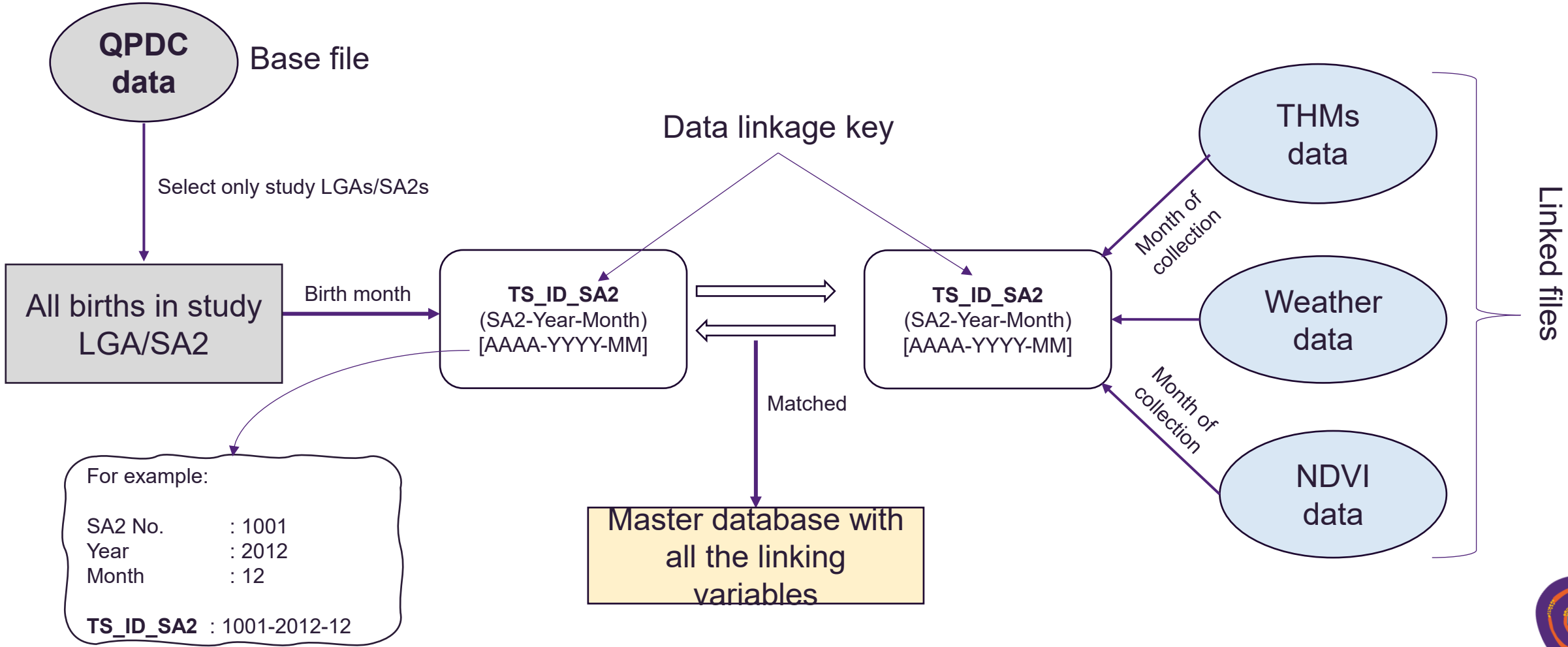

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Outcome variables

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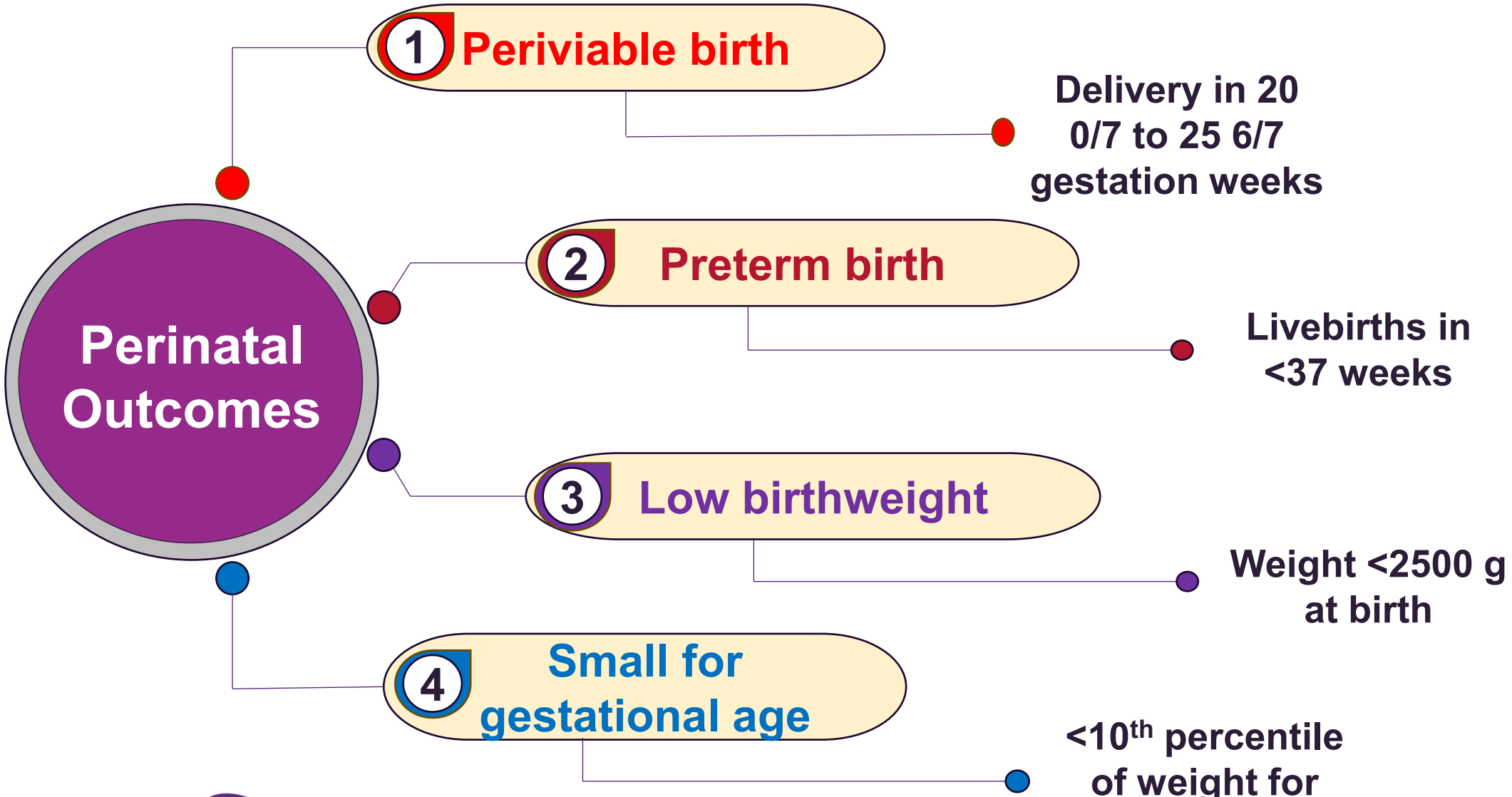

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Exposure variable

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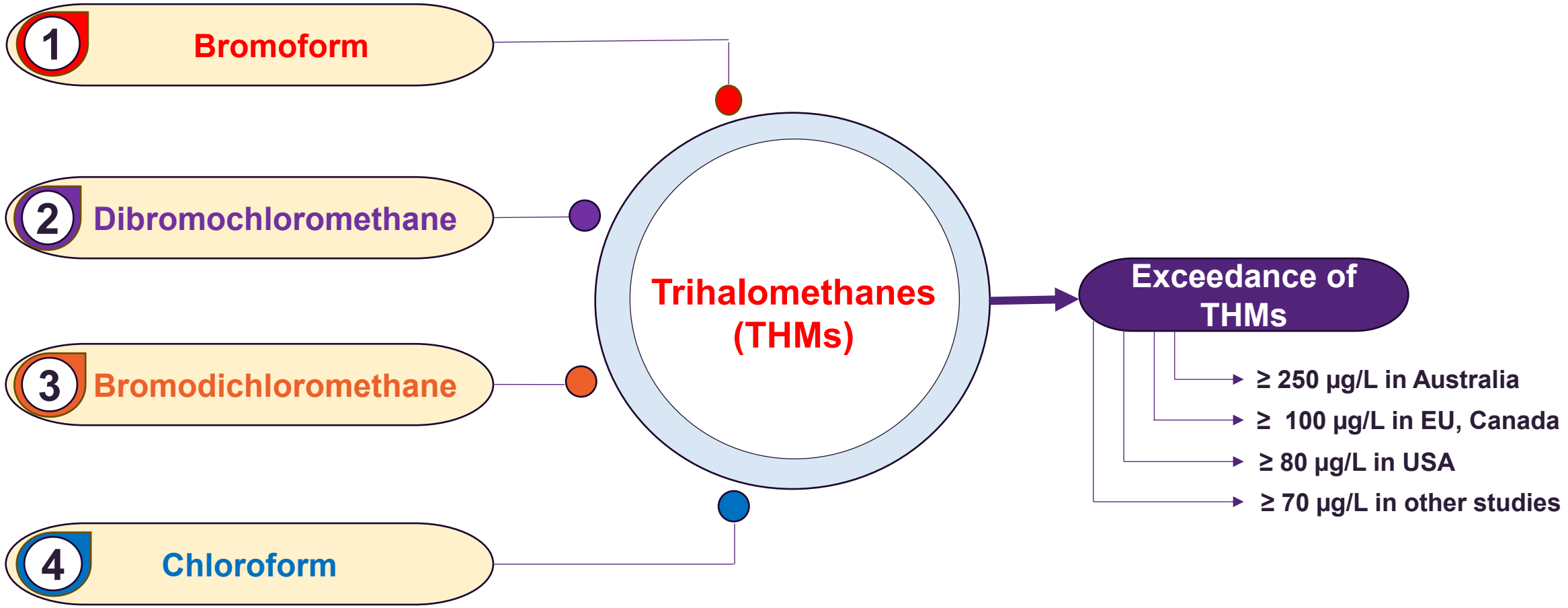

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Covariates

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Covariates	Measurement
Underlying factors	
Maternal age (in years)	<20, 20-24, 25-29, 30-34, 35-39, 40+
Indigenous status	Indigenous vs Non-Indigenous
Birth country	Australia vs Overseas
Geographical location	Major cities vs Regional/remote
Area of sample collection	SEQ vs Non-SEQ
Area-level socioeconomic status	Q1 (Most disadvantaged) to Q5 (Least disadvantaged)
Proximate factors	
Body Mass Index (kg/m2)	Underweight (BMI<18.5), Normal (18.5-24.9), Overweight (25-29.9), Obese (30+)
Smoking status	Smoker vs Non-smoker
Antenatal care visits	<4 visits, 4-7 visits and 8+ visits
Place of delivery	Home, Public Facility and Private Facility
Environmental factors	
Total rainfall	Mean of monthly total rainfall
Max temperature	Mean of monthly maximum temperature
NDVI	Mean monthly NDVI
Season	Summer (Dec-Feb), Autumn (Mar-May), Winter (Jun-Aug), Spring (Sep-Nov)

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Results- Prevalence of maternal exposure to trihalomethanes and adverse birth outcomes

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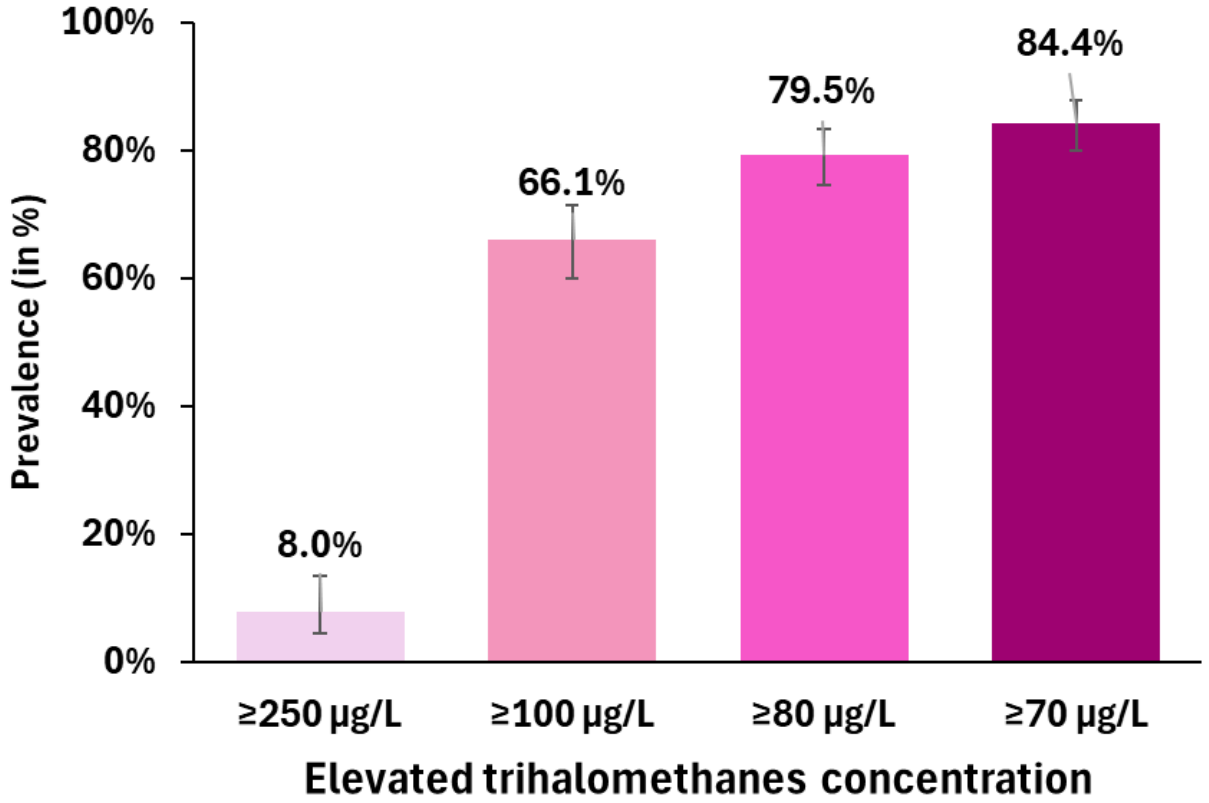

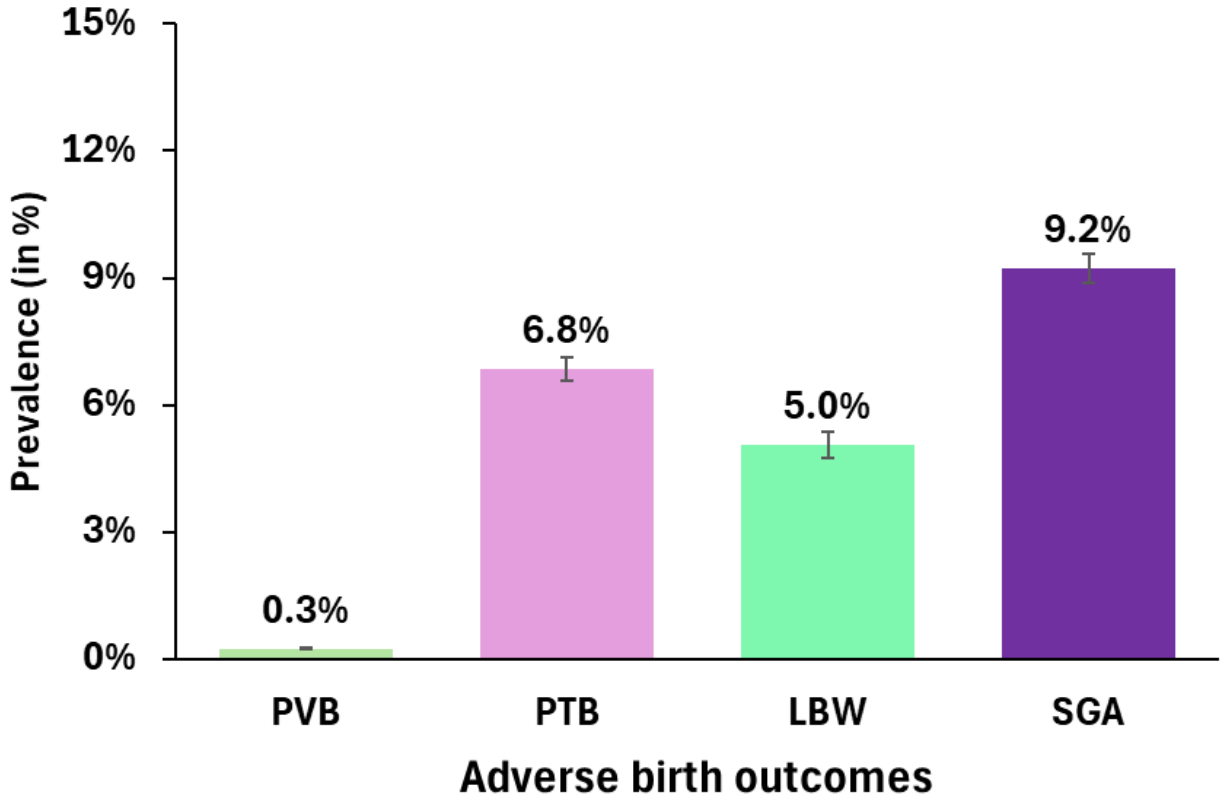

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Results- Temporal patterns of maternal exposure to trihalomethanes at ≥250 µg/L

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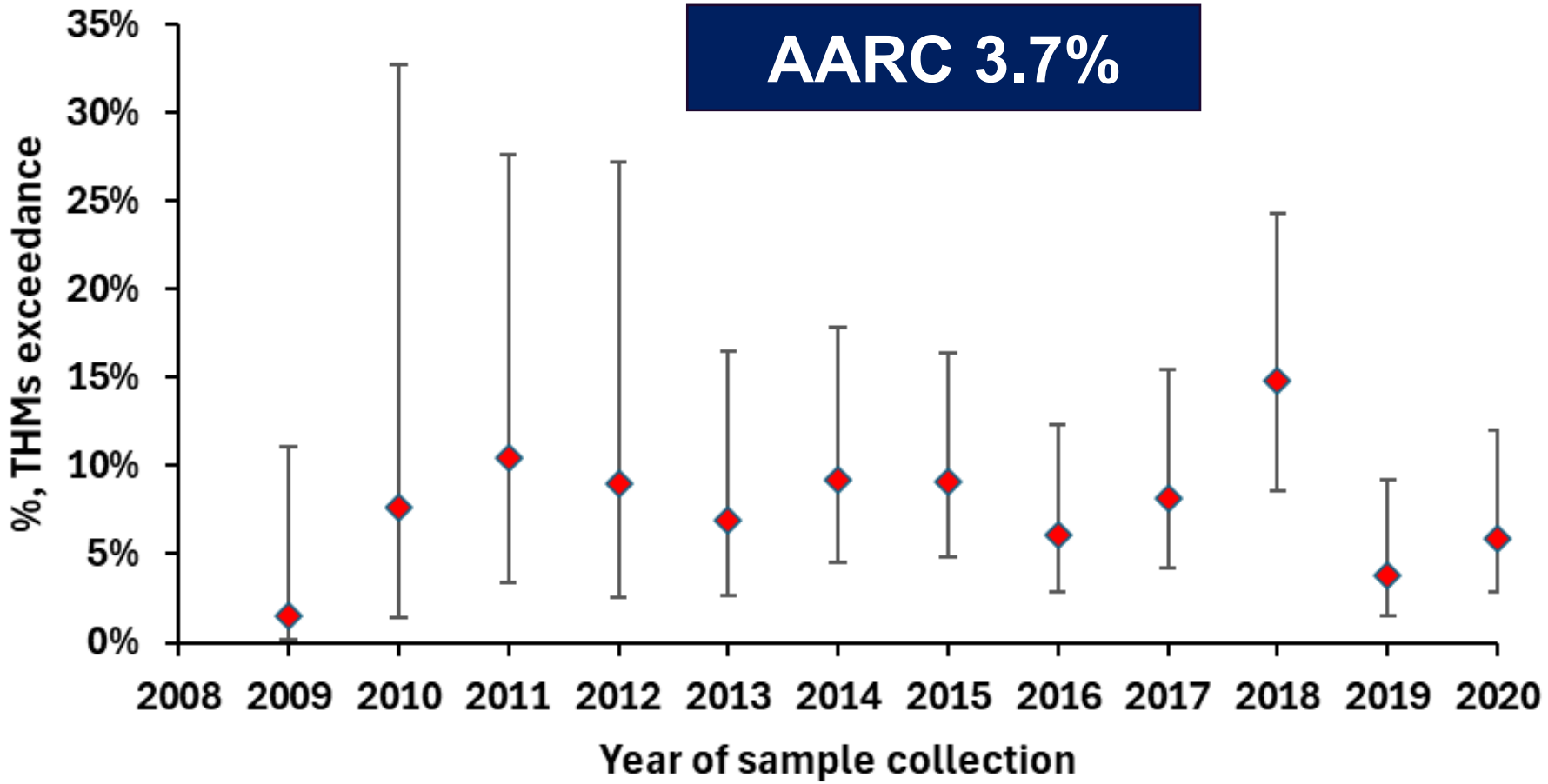

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Results- Temporal patterns of periviable birth

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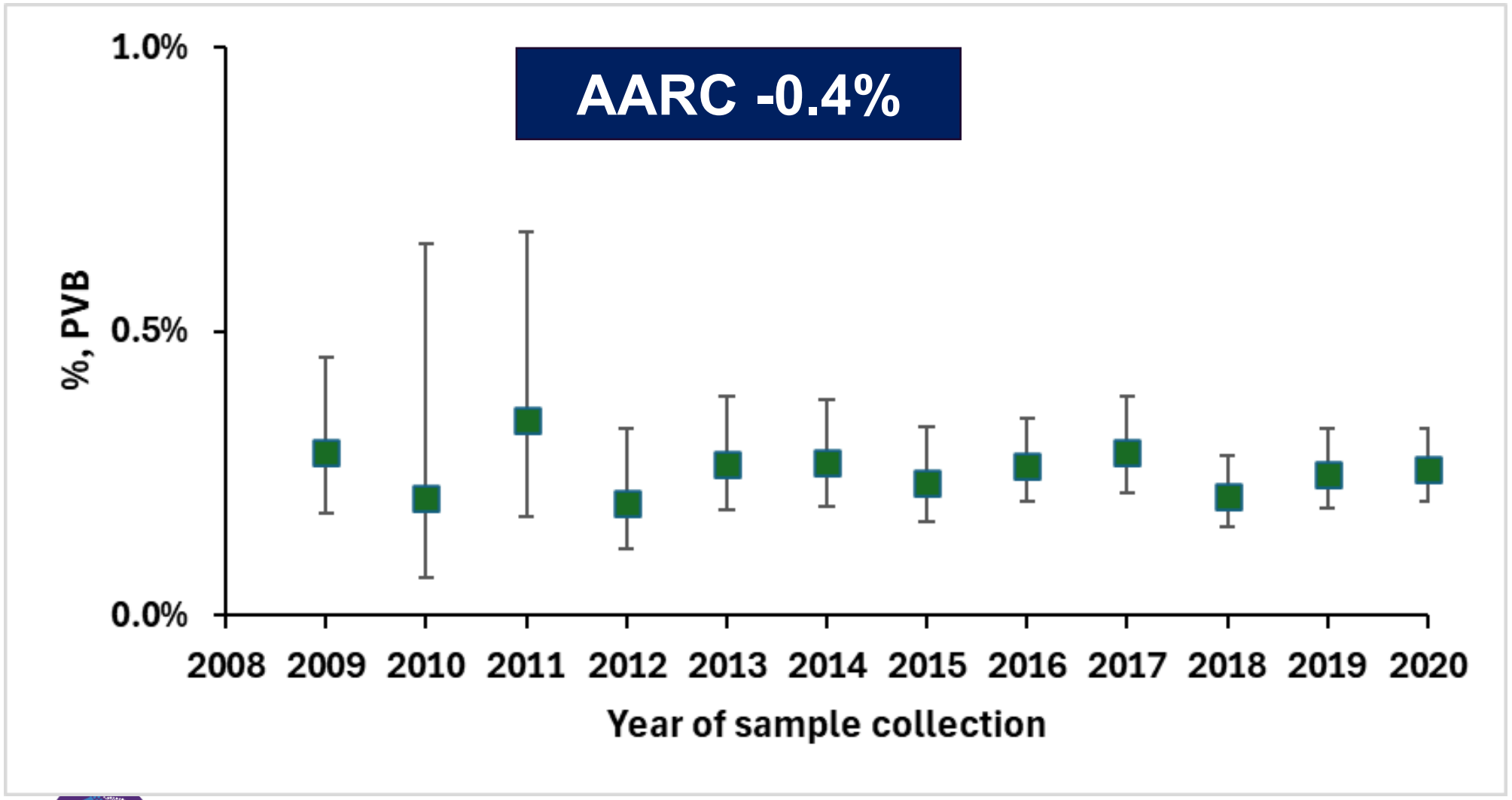

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Results- Temporal patterns of preterm birth

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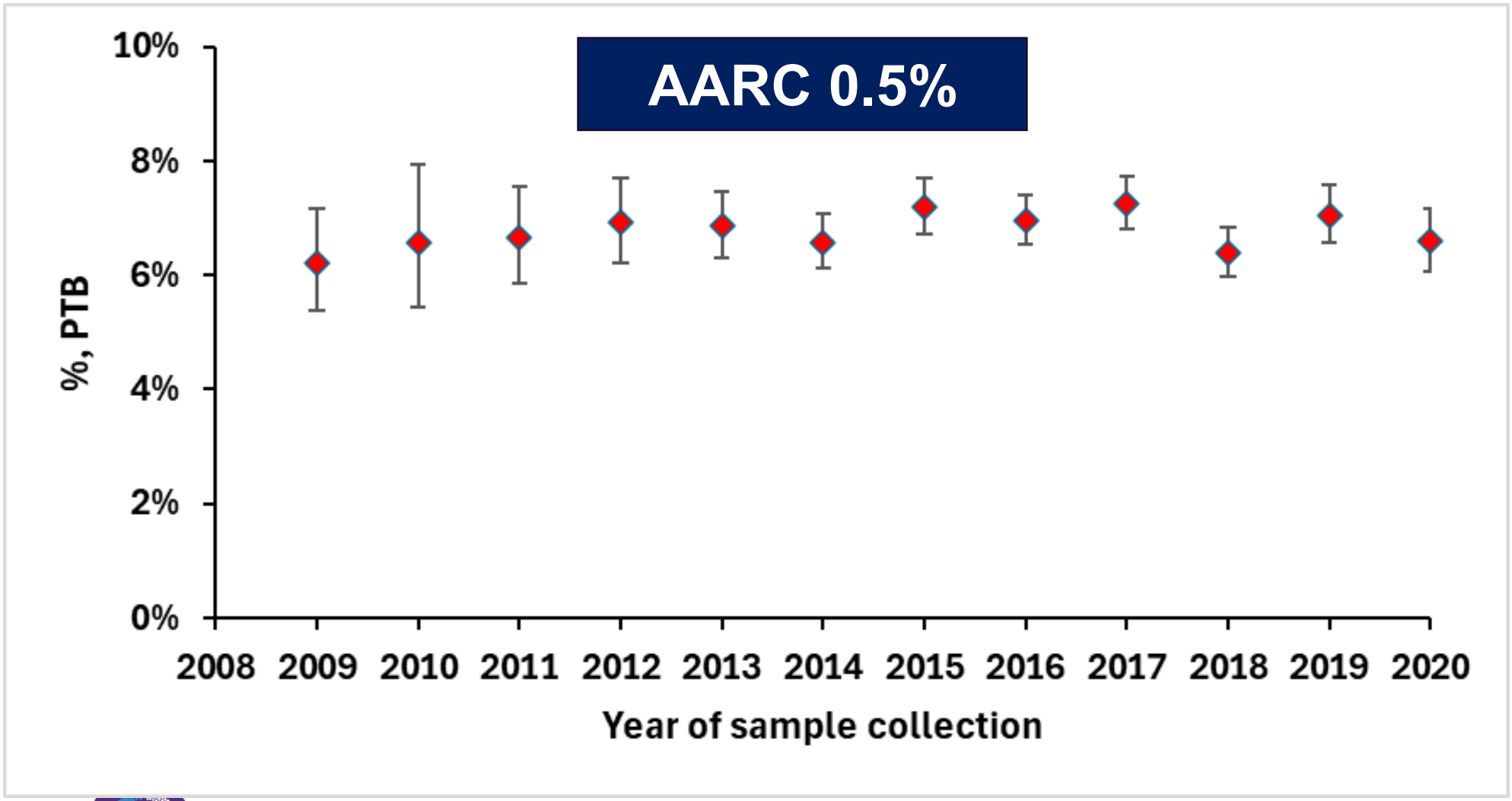

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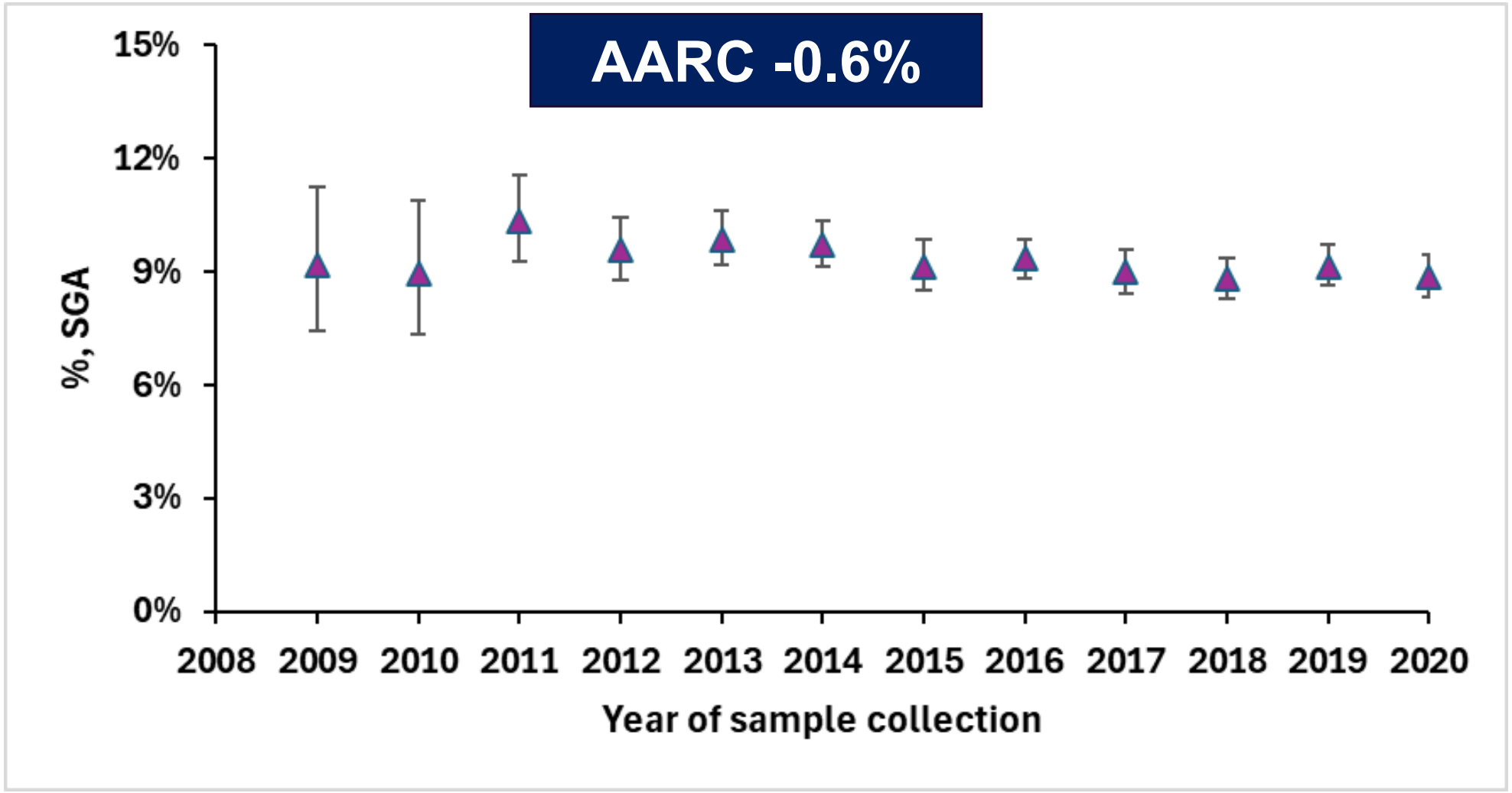
Results- Temporal patterns of small for gestation birth



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Results- Temporal patterns of low birthweight

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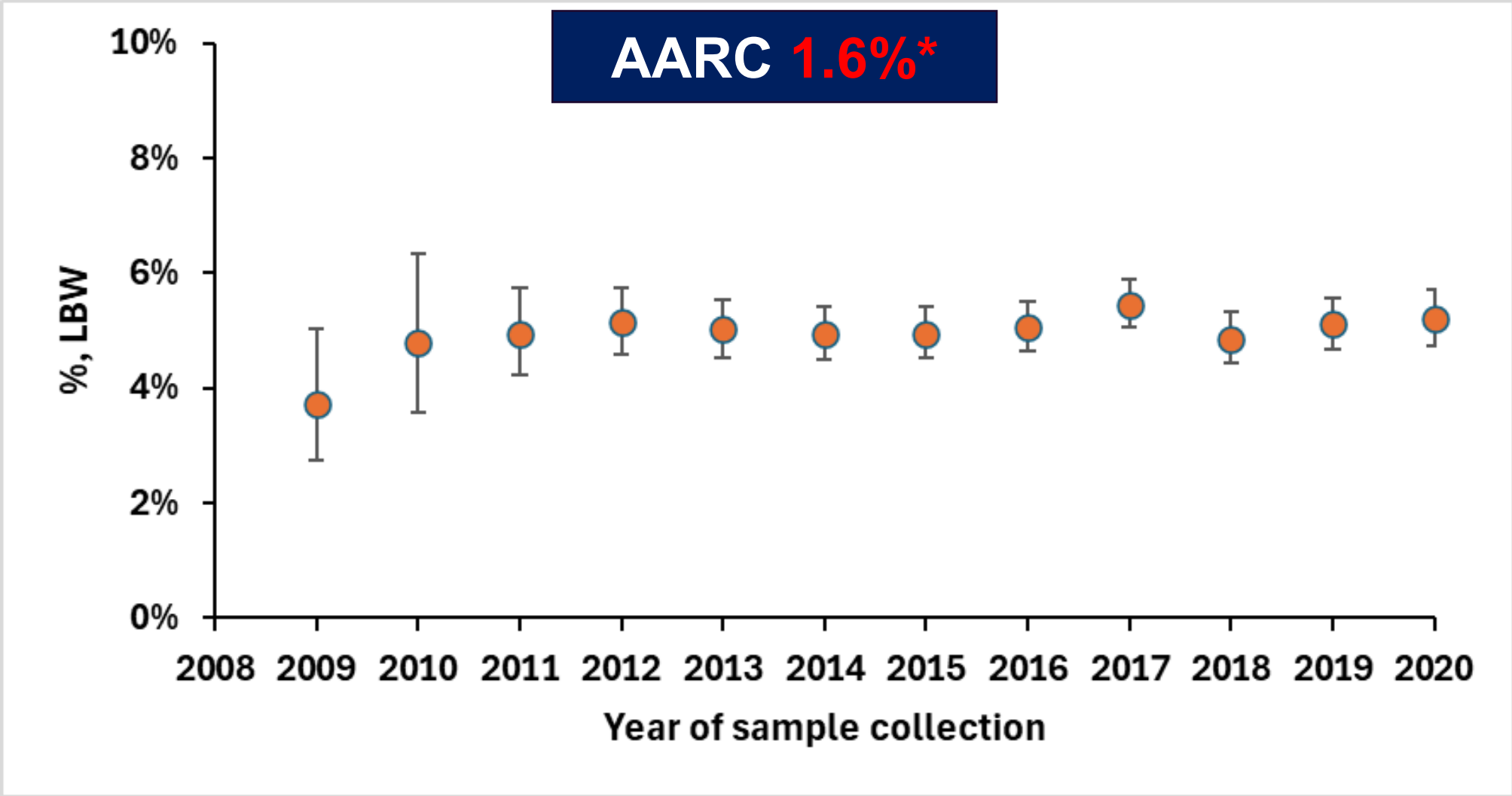

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Results- Low birthweight by Location

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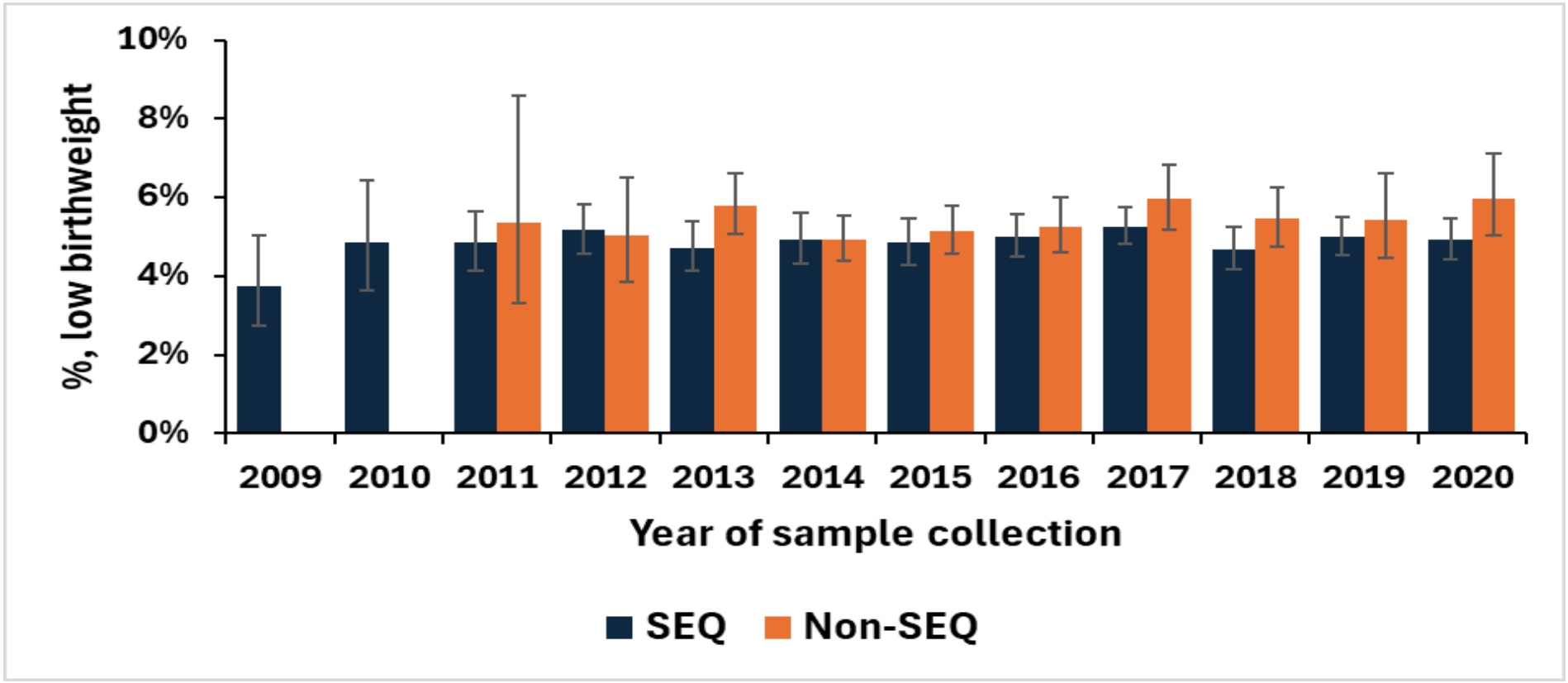

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Results- Low birthweight by geographical remoteness

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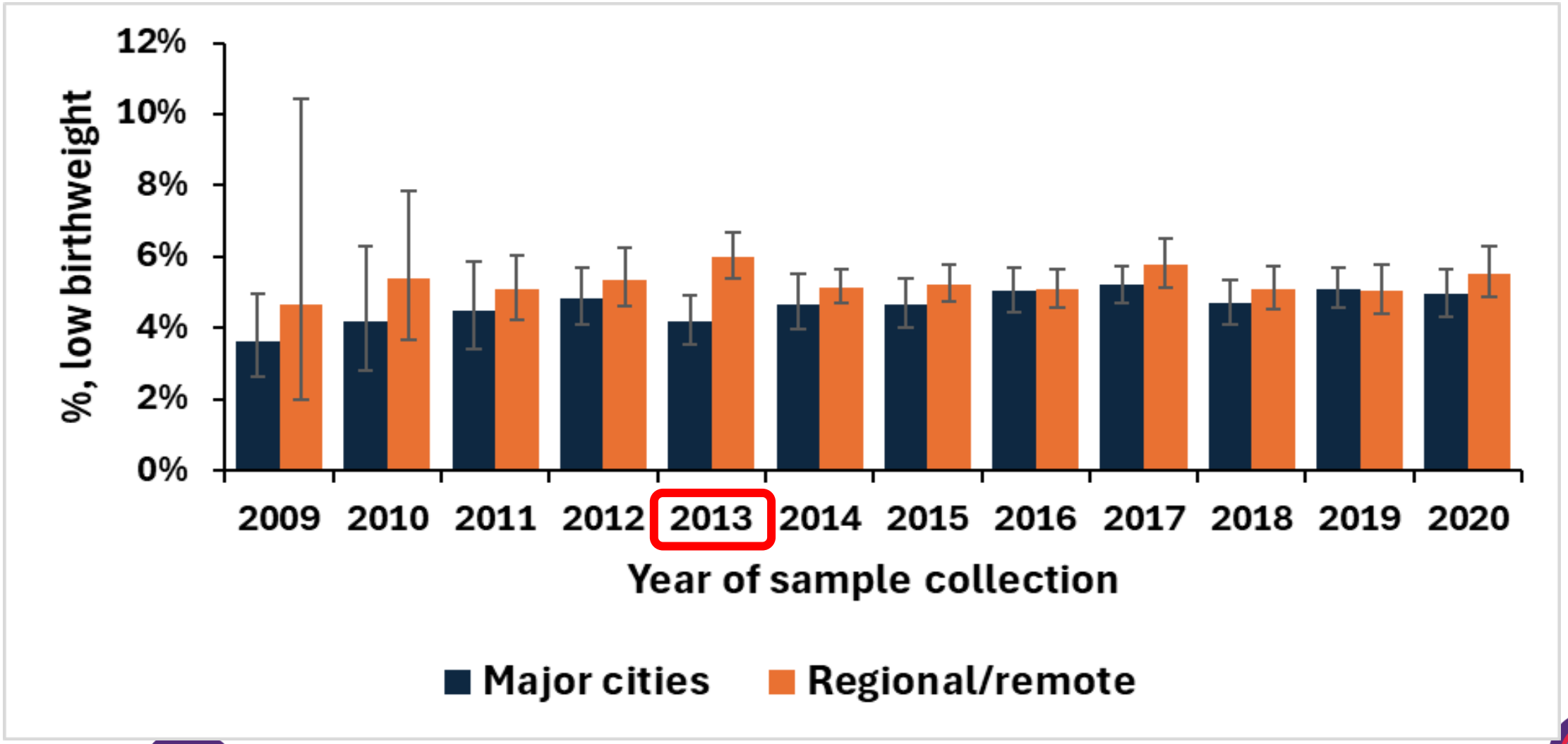

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Results- Low birthweight by SEIFA areas

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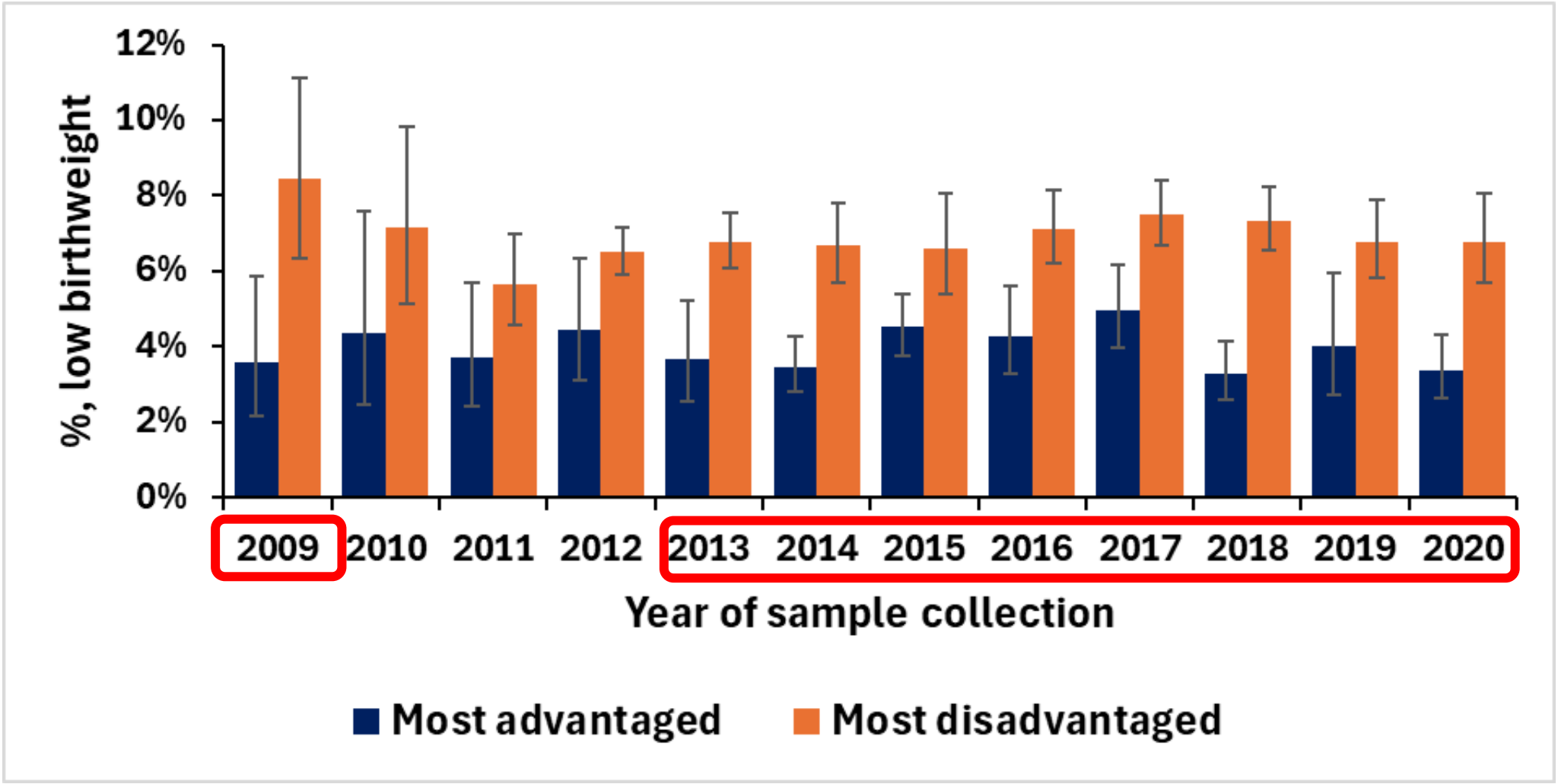

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Results- Exposure to trihalomethanes and adverse birth outcomes association

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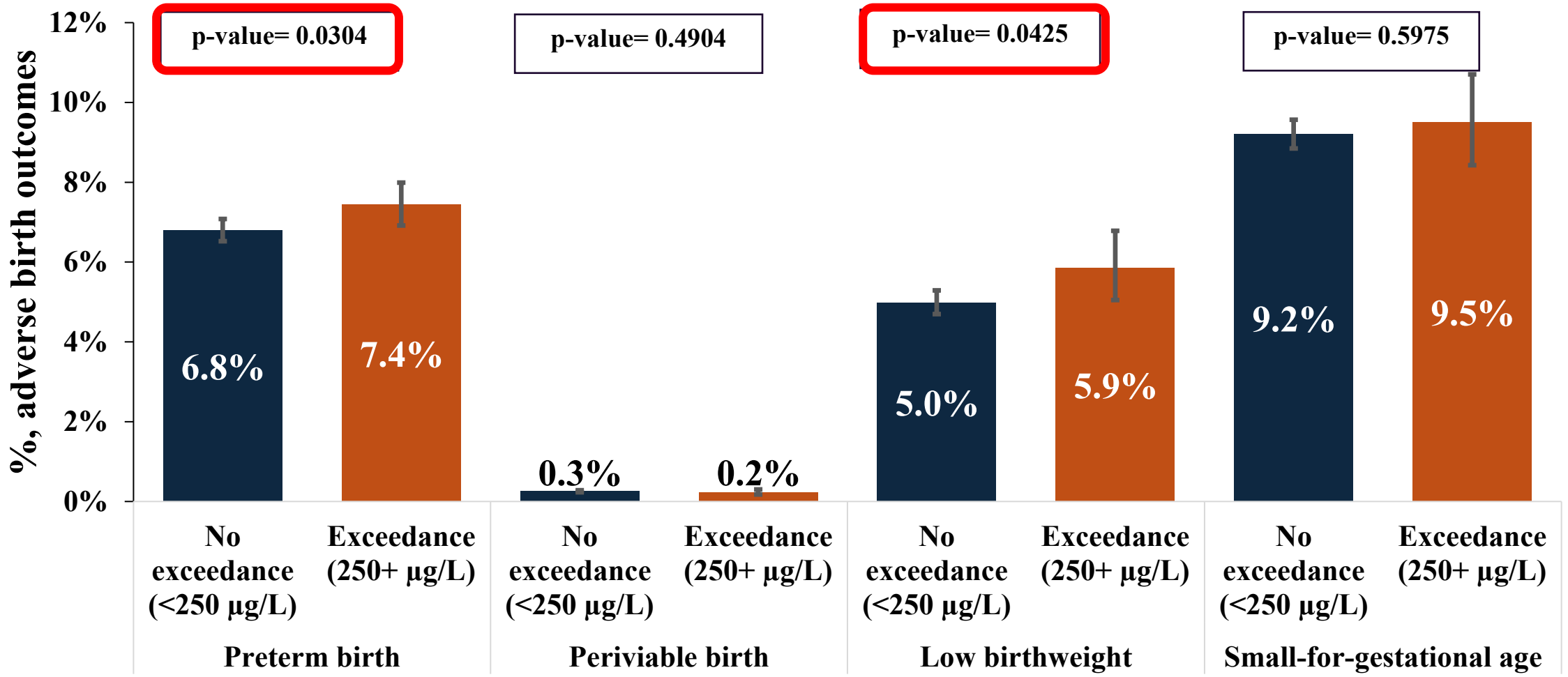

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Results- Exposure to trihalomethanes and adverse birth outcomes association

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- Mothers who were exposed to THM exceedance during pregnancy had significantly greater chance (1.14 times) to deliver low birthweight baby in unadjusted models, effects **NOT** retained in adjusted models

- Maternal exposure to THM exceedance was **NOT** significantly associated with preterm birth, periviable birth and small-for-gestational age birth

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Summary of THMs and Birth Outcomes Results

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The prevalence of adverse birth outcomes is greater in outside SEQ, regional/remote, and socioeconomically disadvantaged areas

Low birthweight prevalence is increasing over time, while others remain unchanged

Maternal exposure to THMs exceedance is associated with greater odds of LBW in unadjusted models, not in adjustment models

Overall conclusions and recommendations

Strengths and limitations

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Strengths

- Large-scale, linked health and administrative datasets that covers a relatively large geographic area, including 27 LGAs
- Applied rigorous statistical methods stratified by location, SEIFA, remoteness to understand geographical disparities
- Qualitative study offers practical insights into the challenges, preventative and management strategies, and potential opportunities for effective THM management in Queensland.
- A set of key adverse birth outcomes have been evaluated over a decade.

Limitations

- Exposure to THMs was a proxy measure, assessed at SA2 level, rather than at individual or household levels
- Do not know if women really consumed sample water with THM or not
- Trend analysis in adverse birth outcomes was based on cases where THM data was available (87%).
- Results could be influenced by potential unmeasured (unaccounted for) confounding factors.
- While valuable for Queensland, the findings may have limited generalisability and applicability to other geographic regions.

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Conclusions

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THMs exceedance is happening every year within the study period (2009-2020)

Elevated vulnerability of THMs exceedance in regional/remote and low socioeconomic areas

Substantial geographical disparities in the prevalence of adverse birth outcomes

Increase in low birthweight prevalence over time, with marked variations across geography

Mixed association between maternal exposure to THMs and adverse birth outcomes

Recommendations

Data Quality

- Consistent and regular monitoring and measurement of THM
- Inclusion of drinking water within QPDC

Water Quality

- Seasonal adaptive water treatment strategies
- Infrastructure upgrades, especially in socioeconomically disadvantaged regions
- Advanced understanding of the context-specific factors contributing to the elevated THM concentration is crucial for developing effective mitigation strategies

Birth outcomes

- Targeted health interventions for those at risk of high burden of adverse birth outcomes
- Continued epidemiological studies with better design and measurement is needed for conclusive decisions about the THMs exposure and adverse birth outcome association

Next steps/Way forwards

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Next steps

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Step 1
- Research prioritization

Step 2
- Building partnerships and research collaboration

Step 3
- Funding opportunities

Step 4
- Research implementation

Step 5
- Evidence generation

Step 6
- Informed policy recommendation and decision making

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