

GEOGENIC IRON EXPOSURE: ACUTE RESPIRATORY CONDITIONS AND INFECTIONS AMONG IRON ORE WORKERS IN WESTERN AUSTRALIA

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Introduction: iron ore mining in Western Australia

2014 profitable iron ore deposits:

- **Australia** ranked first in the world (29%; 54 billion tonnes)

Australian Government, *Geoscience*

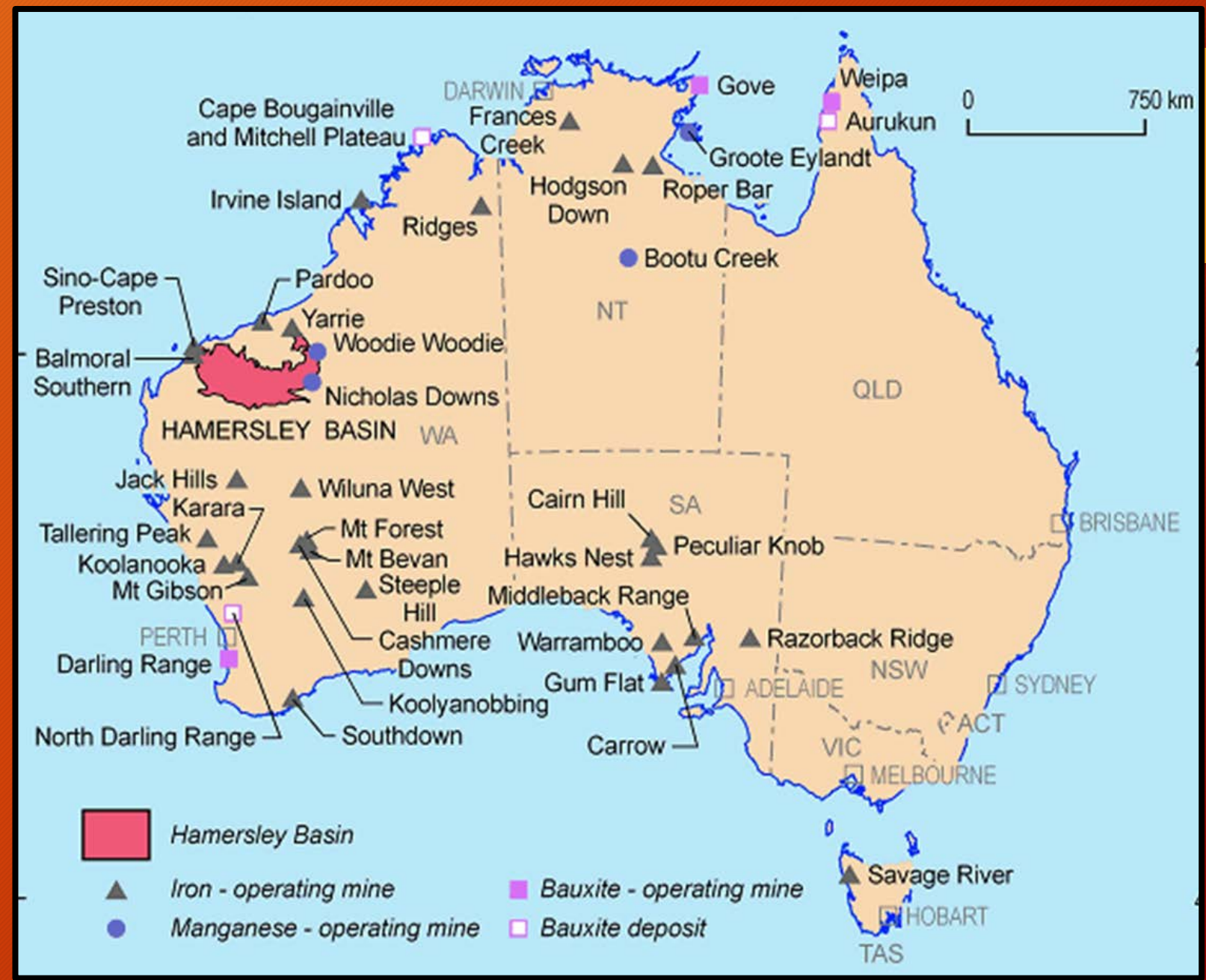
Australia www.australianminesatlas.gov.au

(March 2016)



80% in the Hamersley Basin

90% Australian iron ore deposits in Western Australia.



Iron exposure: chronic health effects, respirable fraction

Siderosis: a benign pneumoconiosis

Doig AT, McLaughlin AIG. X-ray Appearances of the Lungs of Electric Arc Welders. *Lancet* 1936;1:771-775.

- 16 electric arc welders: No normal CXR's, but few abnormal clinical signs or symptoms.

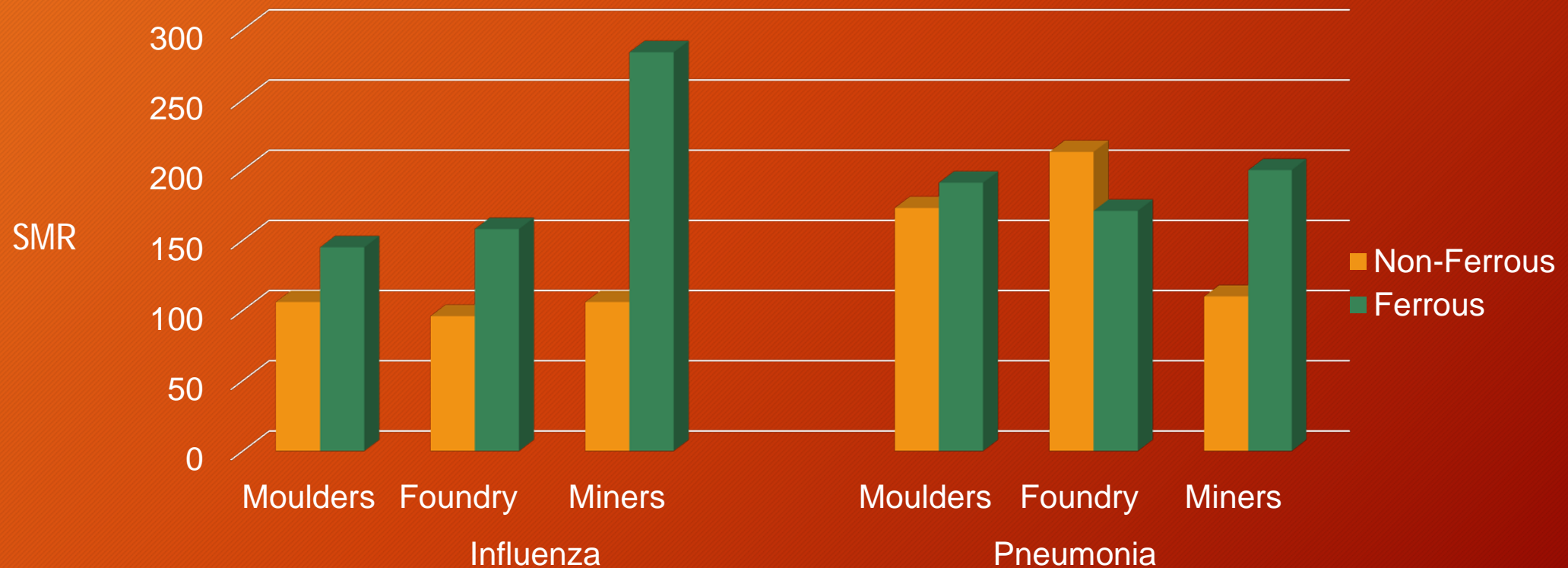
Mine Worker Health Surveillance, WA: 1996 to 2013

- neither prevented nor detected ill health at an early stage.

Does occupational exposure to iron promote infection?

Palmer K, Coggon D. *Occupational and Environmental Medicine*. 1997; 54:529-534.

Comparison of Standardised Mortality Ratios (SMR) for workers (aged 20 to 65 years) for metal working occupations 1930-32.



Iron bio-availability and infection

- Host mechanisms to decrease bio-availability of iron to invading pathogens.
Johnson EE, Wessling-Resnick M. Iron Metabolism and the Innate Immune Response to Infection. *Microbes Infect.* March 2012; 14(3):207-216.
- Iron acquisition strategies for pathogenesis of skin and upper respiratory tract commensal microbes such as gram positive *S.pneumoniae* and *S.aureus*¹, and *H.influenzae*².

¹ Sheldon JR, Heinrichs DE. Recent developments in understanding the iron acquisition strategies of gram positive pathogens. *FEMS Microbiol Rev* 2015 Jul; 39(4):592-630.

² Whitby PW, Van Wagoner TM, Seale TW, Morton DJ, Stull TL. Comparison of transcription of the Haemophilus influenzae iron/meme modulon genes in vitro and in vivo in the chinchilla middle ear. *BMC Genomics* Dec 2013 27: 14:925.

Geogenic iron: acute inflammatory response

Association between physiochemical properties of geogenic PM10 and early lung responses:

Response post exposure	Multi-variate linear regression analysis:
Inflammation: 6 hours	(-) Fe [p=0.007]
Inflammation: 7 days	(+) Fe [p<0.001], (-) Si [p<0.001], (+) Al [p=0.01], (+) GSD [p<0.001], (+) Endotoxin [p=0.007]
Lung function: 24 hrs	(+) Fe [p<0.001], (+) Endotoxin [p< 0.001]
Lung function: 7 days	(+) Fe [p<0.001], (-) Si [p=0.01], (+) GSD [p=0.03]

Zosky GR, Iosifidis T, Perks K, Ditcham WGF, Devadason SG, et al. (2014) The Concentration of Iron in Real-World Geogenic PM10 Is Associated with Increased Inflammation and Deficits in Lung Function in Mice. *PLoS ONE* 9(2).

Aim:

To determine acute health conditions and geogenic iron exposure levels for an iron ore mining population

Methods:

Design: Cross-sectional observational case study

- **Study population:** 9,709 FIFO workers; 3 Pilbara mine sites; same employer

• **Data:**

Case-based clinical data	Doctor-on-Call Service notifications	May 2013 to Dec 2014
Population exposure levels	Respirable and inhalable Dust NOS personal monitoring data	Jan 2012 to Nov 2014
Surface dust samples	Spectrometry analysis: iron and other elemental composition	

Doctor-on-Call Service Notification Data

Clinical case definitions:

Respiratory condition

Other Infections

Gastrointestinal

Musculoskeletal

Psychological

Other conditions

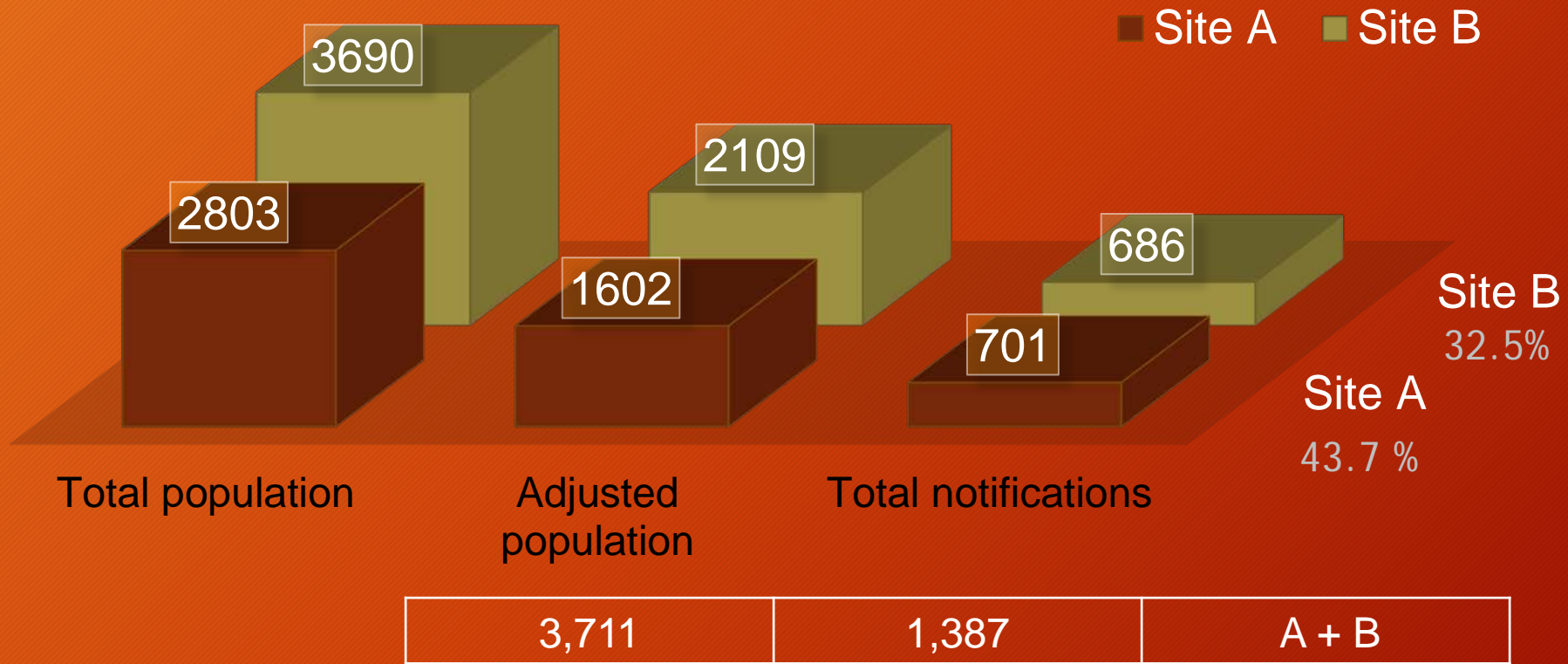
Individual notification
reports reviewed

Demographic data: sex, age.

Smoking, occupation were not available

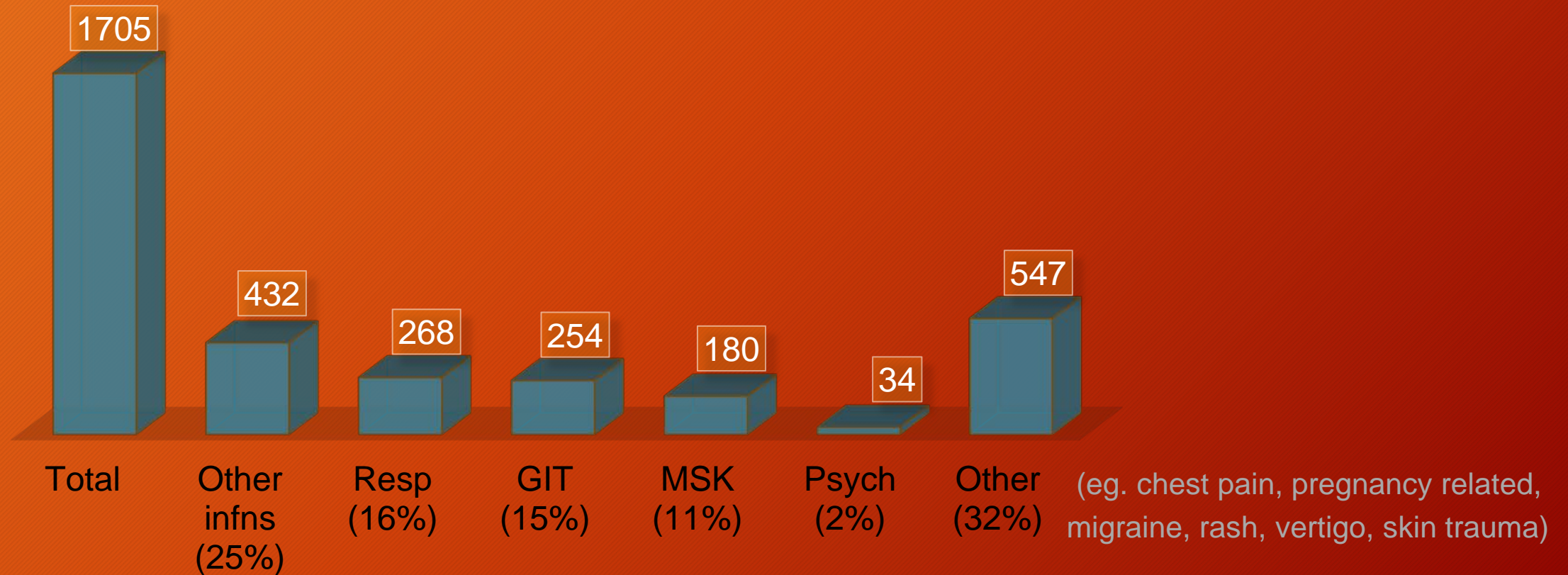
- Data was analysed using STATA Version 14.0 statistical software.
- *Curtin University* Health Research Ethics Committee approval; permission to use de-identified data.

Distribution of notifications per mine site

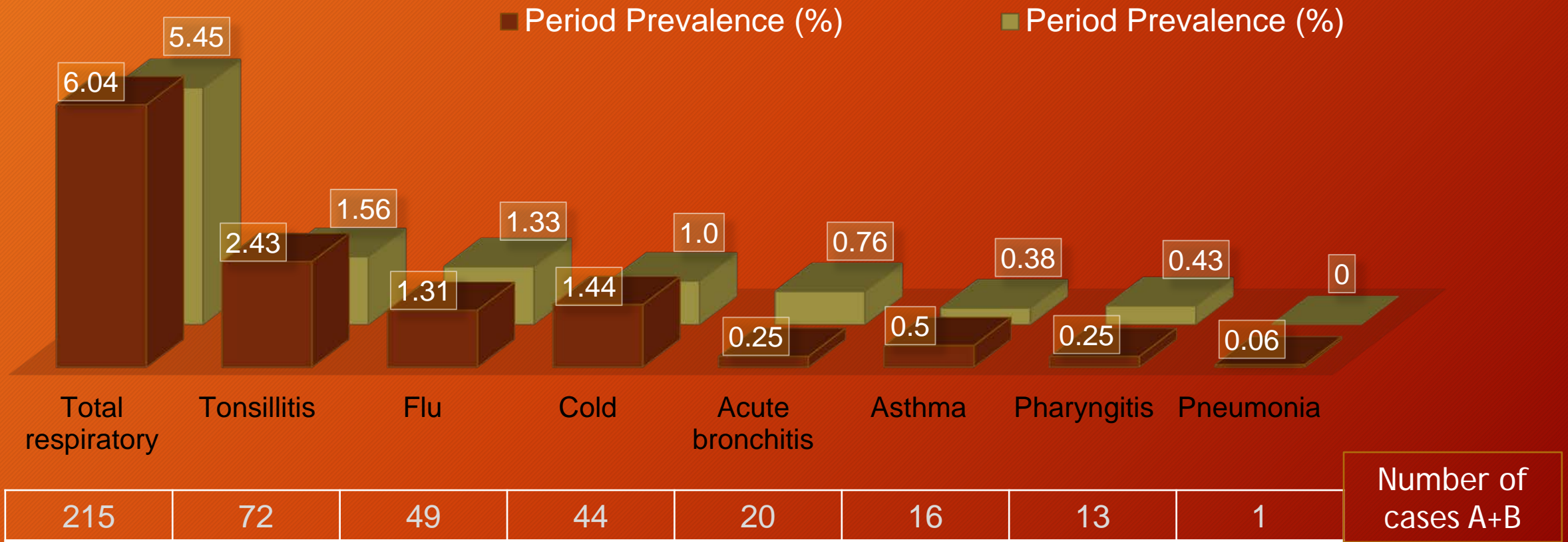


Proportion of total disease burden

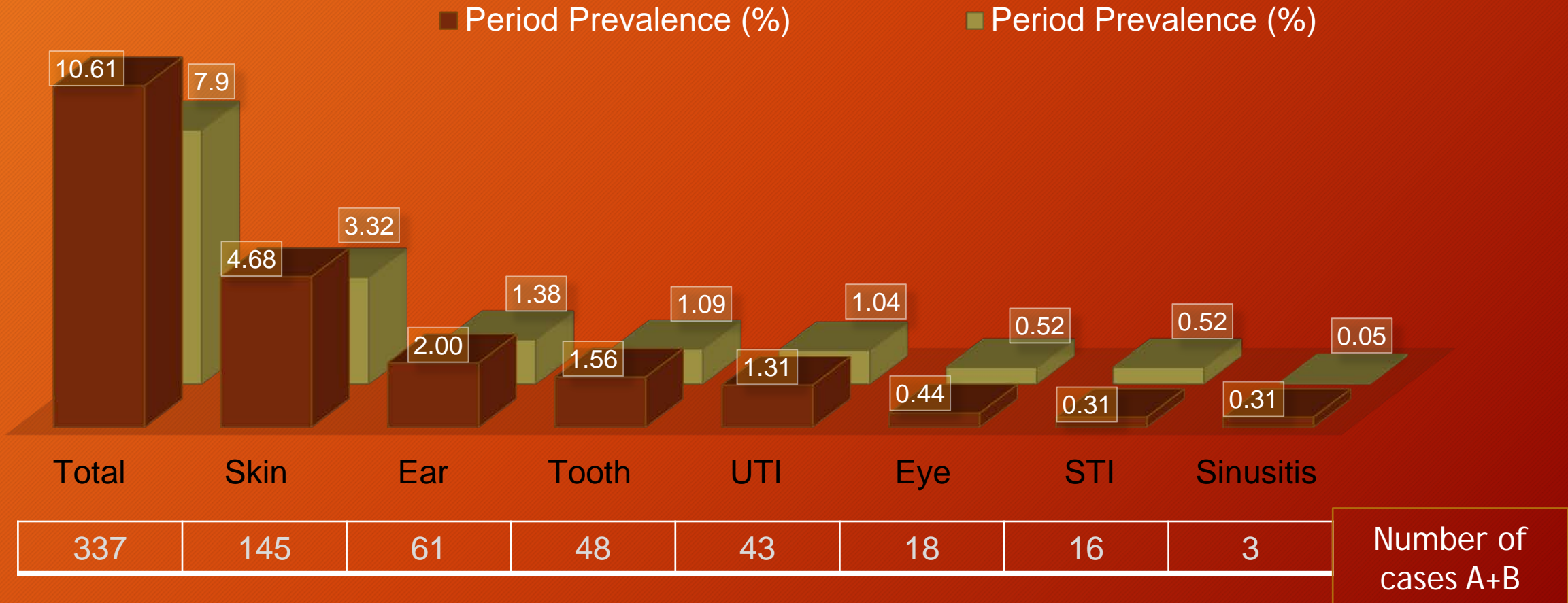
NUMBER OF NOTIFICATIONS (ALL SITES)



Respiratory conditions (Period prevalence)



Other infections (period prevalence)



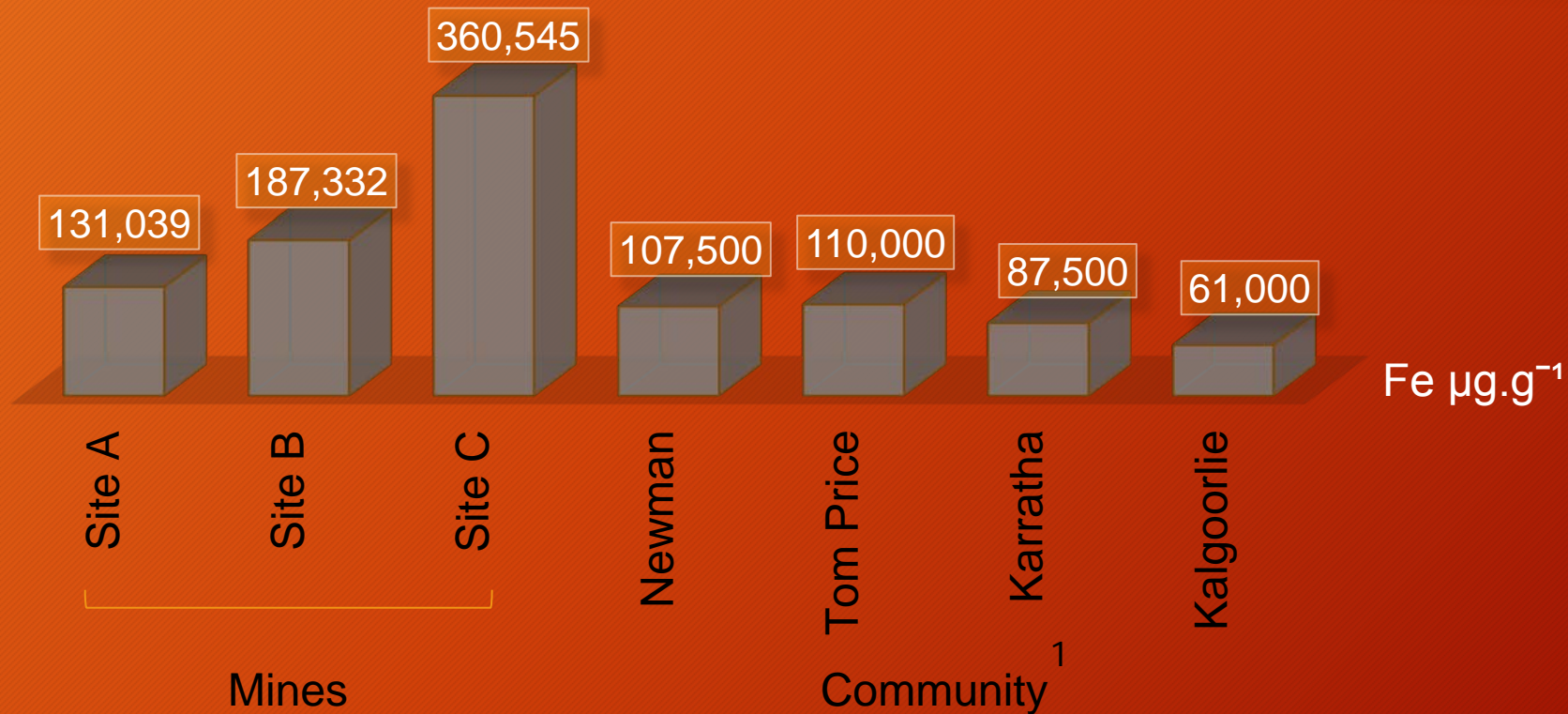
Personal monitoring data: Inhalable and Respirable Dust Not Otherwise Specified

	Site A	Site B	Site C	OES (ACGIH 2013) ¹	
Inhalable dust NOS (TWA 8hr)	1.86 mg.m⁻³ (n=292)	4.48 mg.m⁻³ (n=246)	2.06 mg.m⁻³ (n=204)	10 mg.m⁻³	
% of samples > OES	4 %	11 %	5 %		
Respirable dust NOS (TWA 8hr)	0.86 mg.m⁻³ (n=297)	1.20 mg.m⁻³ (n=262)	0.78 mg.m⁻³ (n=237)	3 mg.m⁻³	1.5 – 2.0 mg.m⁻³ U/G coal 0.6 mg.m⁻³ surface coal²
% of samples > OES	4 %	5 %	6 %		

¹American Conference of Governmental Industrial Hygienists (ACGIH)

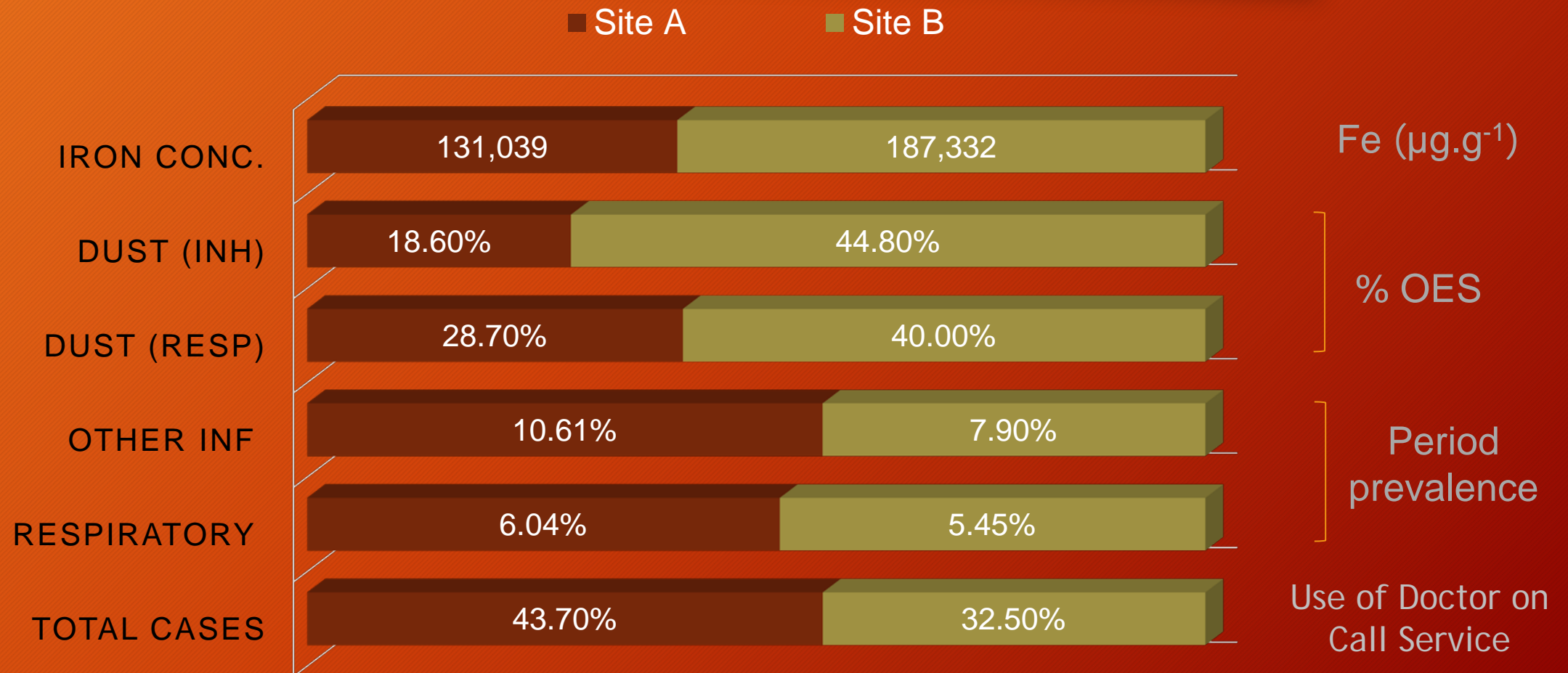
² AIOH Position Paper Dust NOS 2014

Surface ground dust samples: spectrometry analysis for Fe content ($\mu\text{g.g}^{-1}$)



¹ Zosky GR, Iosifidis T, Perks K, Ditcham WGF, Devadason SG, et al. (2014) The Concentration of Iron in Real-World Geogenic PM10 Is Associated with Increased Inflammation and Deficits in Lung Function in Mice. *PLoS ONE* 9(2).

Summary: Site A and B Comparison



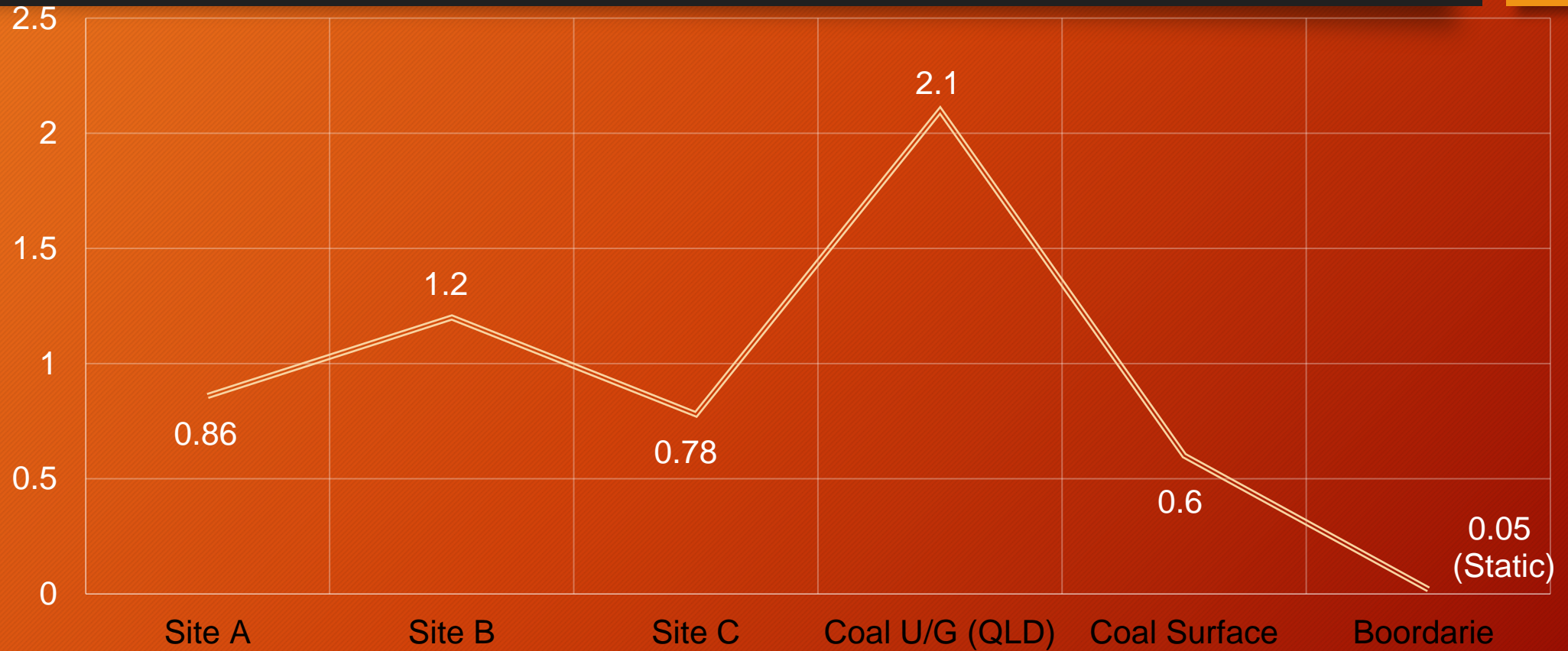
Conclusions

Geogenic iron health effects	<ul style="list-style-type: none">• Study population outcome unexpected.
	<ul style="list-style-type: none">• LRT cases : 16 asthma and 1 pneumonia.
Descriptive study	<ul style="list-style-type: none">• Prevalence of health conditions for FIFO iron ore miners (n=3,711).
	<ul style="list-style-type: none">• Occupational exposure levels for WA iron ore worker population.
Managing raw data	<ul style="list-style-type: none">• Unable to perform 3-way comparison of exposure and cases.
	<ul style="list-style-type: none">• Database design.

Acknowledgements:

- Project supervisors, Professor Lin Fritschi and Associate Professor Ben Mullins; Curtin University School of Public Health.

Respirable dust NOS comparison



AIOH Dust NOS Position
Paper, 2014

Dept. of Environment, WA