Cooking Outdoors: A Safer Alternative

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Introduction

- What is indoor air pollution (IAP)?
- How do stoves affect IAP?

- Why is indoor cooking a problem?
  - 1,500,000 deaths per year[1]

1. http://www.who.int/indoorair/publications/nationalburden/en/index.html

Background

- What has been discussed in the literature?
  - “[IAQ] ranks second only to poor water/sanitation/hygiene among environmental health risk factors.”[1]
  - “Improved ventilation of the cooking and living area can contribute significantly to reducing exposure to smoke.”[2]
- What hasn’t been discussed as much?

1. Naeher, L. P., Smith, K. R., et al., Critical Review of the Health Effects of Woodsmoke, 2005.
2. http://www.who.int/indoorair/interventions/en/, accessed 25 January, 2011.

Project Objectives

- Goals:
  - Compare emissions of 1 traditional & 1 improved wood burning stove, both inside & outside
  - Show basic methods of reducing emissions exposure

Project Objectives

- Why?
  - Demonstrate IAP in field
    - Portable
    - Affordable
    - User-friendly
  - Get solid scientific support for:
    - Making cooking location recommendations
    - Influencing policy and stove project decisions

Methodology

- IAP monitor
- Technical specifications
  - CO detector
  - PM detector

Methodology

- Written protocol
  - Typical cooking task
  - 60 minutes
- Experimental setup
  - Open fire
  - TLUD
  - 9.89 ± 0.11 m^3
  - 1.0 m horizontally & 1.6 m vertically from stove center

Findings

Example of collected data

3 Stone Fire Indoor Data		
		Test 1
PM Background	ug/m3	174.99
CO Background	ppm	0.14
Average PM Concentration	**ug/m3**	**11094.94**
Average CO Concentration	**ppm**	**75.61**
Highest PM Concentration	ug/m3	19540.55
Highest CO Concentration	ppm	130.76
Highest 15-minute PM Concentration	ug/m3	13468.93
Highest 15-minute CO Concentration	ppm	102.39
Lowest 15-minute PM Concentration	ug/m3	8913.88
Lowest 15-minute CO Concentration	ppm	33.17

Findings

- Indoor performance
  - Open fire
  - TLUD

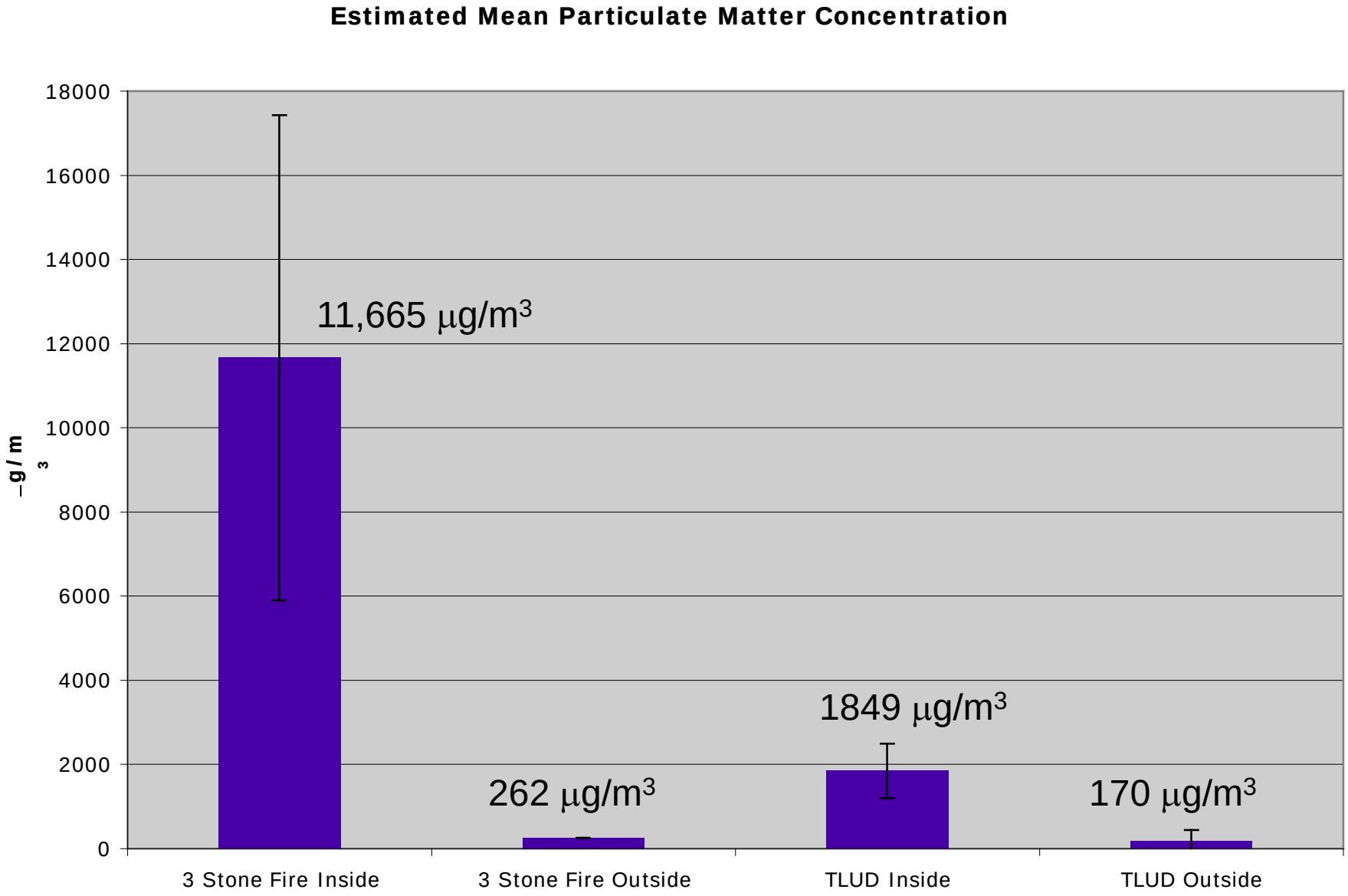
Stove	Measurement	Units	Estimated mean	Estimated error on mean
3 Stone Fire Inside	Average PM concentration	ug/m3	11664.75	5760.40
TLUD Inside	Average PM concentration	ug/m3	1848.61	643.38
3 Stone Fire Inside	Average CO concentration	ppm	85.88	36.69
TLUD Inside	Average CO concentration	ppm	17.62	13.58

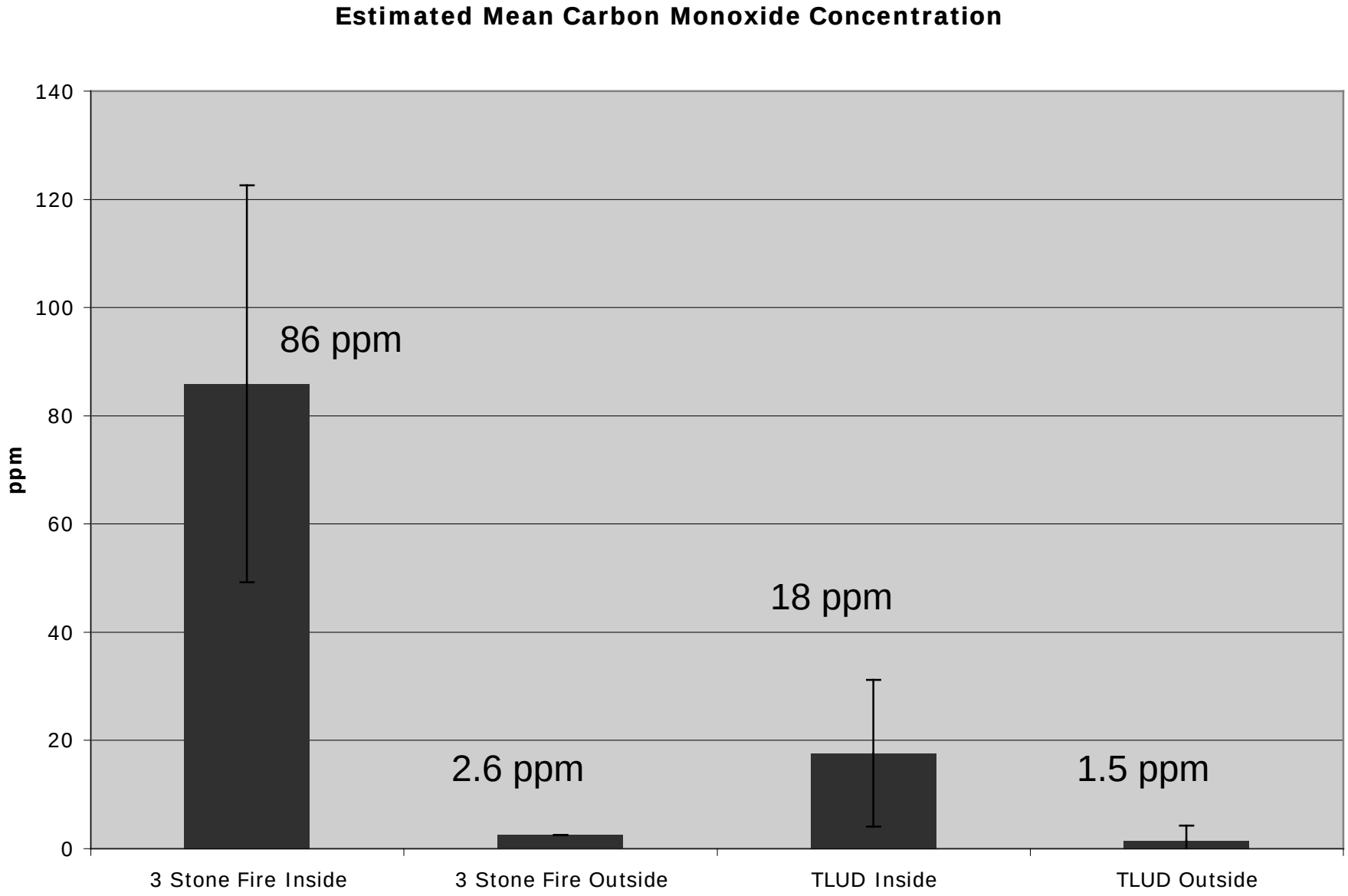
Findings

- Outdoor performance
  - Open fire
  - TLUD

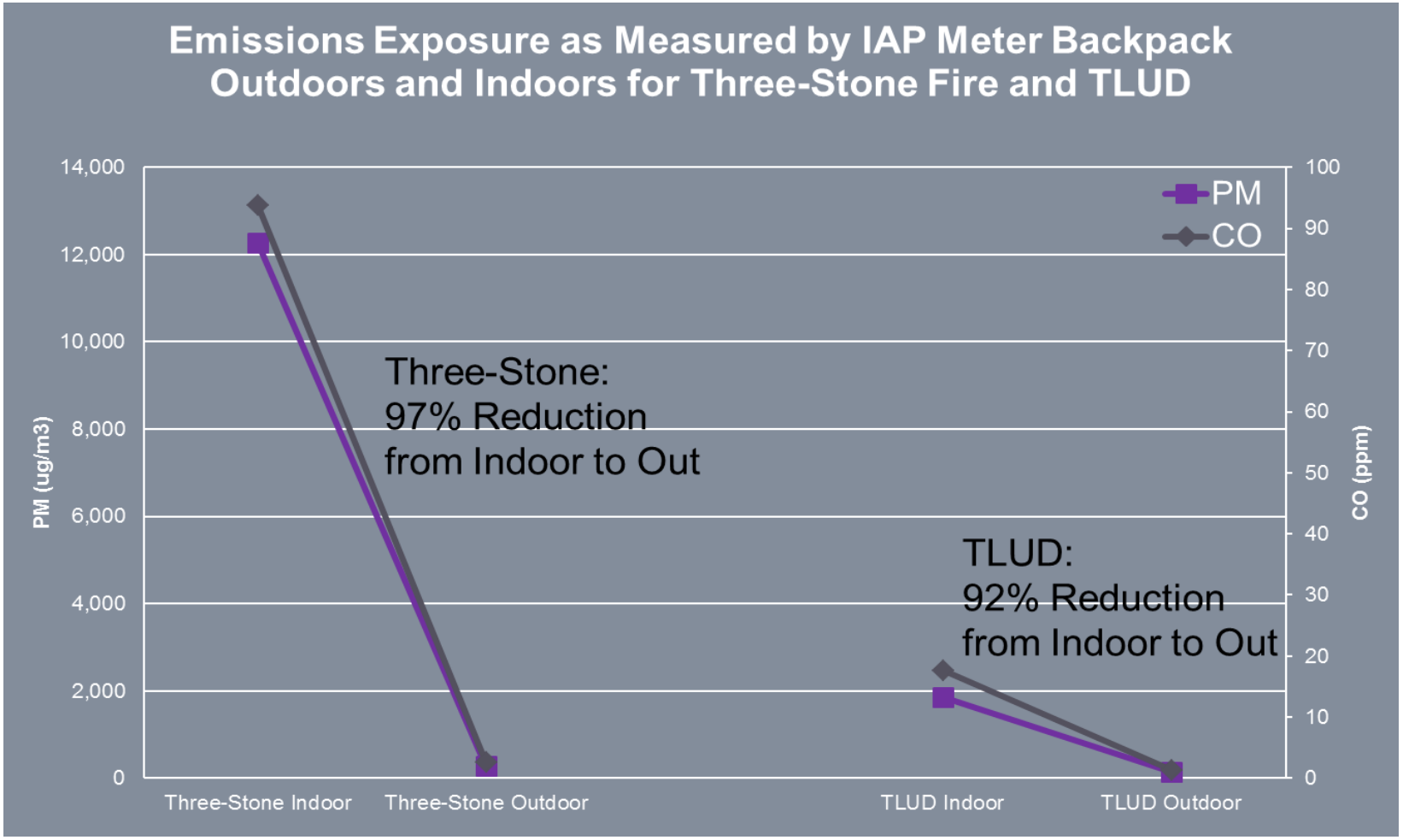
Stove	Measurement	Units	Estimated mean	Estimated error on mean
3 Stone Fire Outside	Average PM concentration	ug/m3	261.58	6.80E-08
TLUD Outside	Average PM concentration	ug/m3	170.49	267.13
3 Stone Fire Outside	Average CO concentration	ppm	2.57	4.27E-10
TLUD Outside	Average CO concentration	ppm	1.49	2.77

More information about how data were processed may be seen on the penultimate slide “Error Analysis”.


Estimated Mean Particulate Matter Concentration
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
_g / m 3
11,665 μg/m3
262 μg/m3
1849 μg/m3
170 μg/m3
3 Stone Fire Inside
3 Stone Fire Outside
TLUD Inside
TLUD Outside

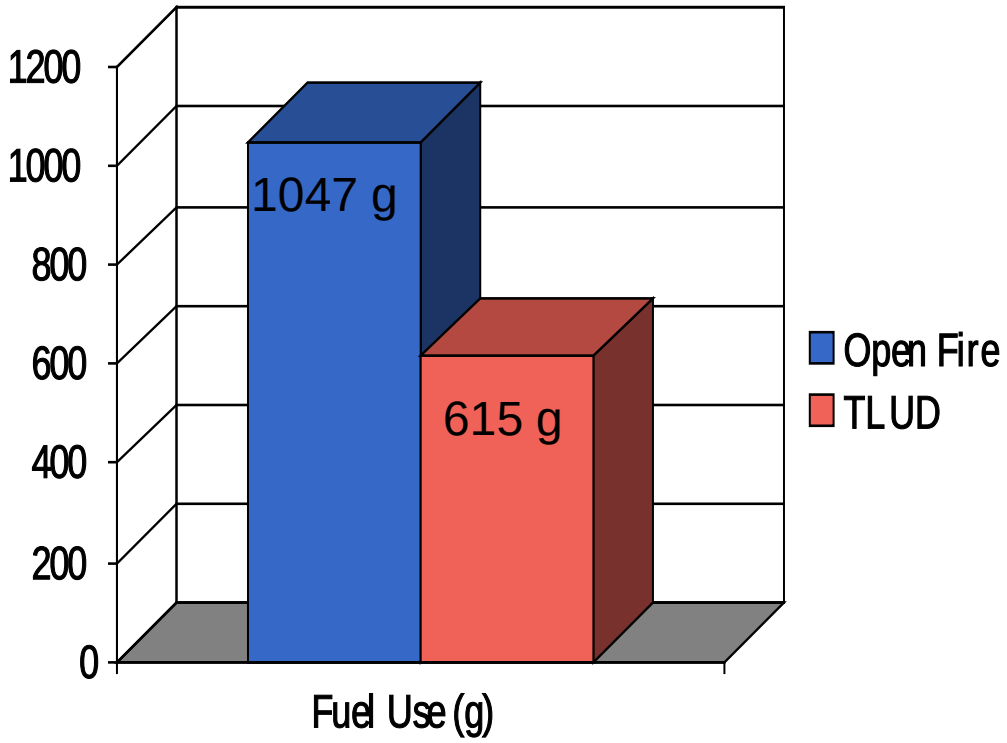

Estimated Mean Carbon Monoxide Concentration
ppm
140
120
100
80
60
40
20
0
86 ppm
2.6 ppm
18 ppm
1.5 ppm
3 Stone Fire Inside
3 Stone Fire Outside
TLUD Inside
TLUD Outside

Personal Exposure



Fuel Consumption

- Indoor versus outdoor
- Open fire versus TLUD
- Fuel use, CO_2 emissions, & carbon credits



Conclusions and Discussion

- Improvement of TLUD over open fire
- What was significant?
- What was not?
- Why is that important?

Recommendations

- Is it better to cook outdoors on a traditional fire, or to cook on a TLUD, in terms of:
  - Health?
  - Deforestation?
  - Climate change?

Issues yet to be addressed

- Will more stoves be tested?
- What if a cook cannot cook outside?
- What about outdoor air pollution?

Looking Forward

- Continue testing
- Key points to remember for future
  - Ventilation
  - End user
  - Indoors versus outdoors
    - Emissions same
    - Personal exposure different

Sources Referenced and Cited

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Error Analysis

Standard format

- True mean (μ)
- Estimated mean (m)
- Estimated standard deviation of mean (s_m)
- Student's t at 95% ($t_{(N-1,95)}$)

Reporting and display

- $\mu = m \pm t_{(N-1,95)} \bullet s_m$
- Bar graphs display m
- Error bars display $\pm t_{(N-1,95)} \bullet s_m$

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