

Evidence and Importance of Newborn Thermoregulation *at Birth*

Abbot Laptook MD

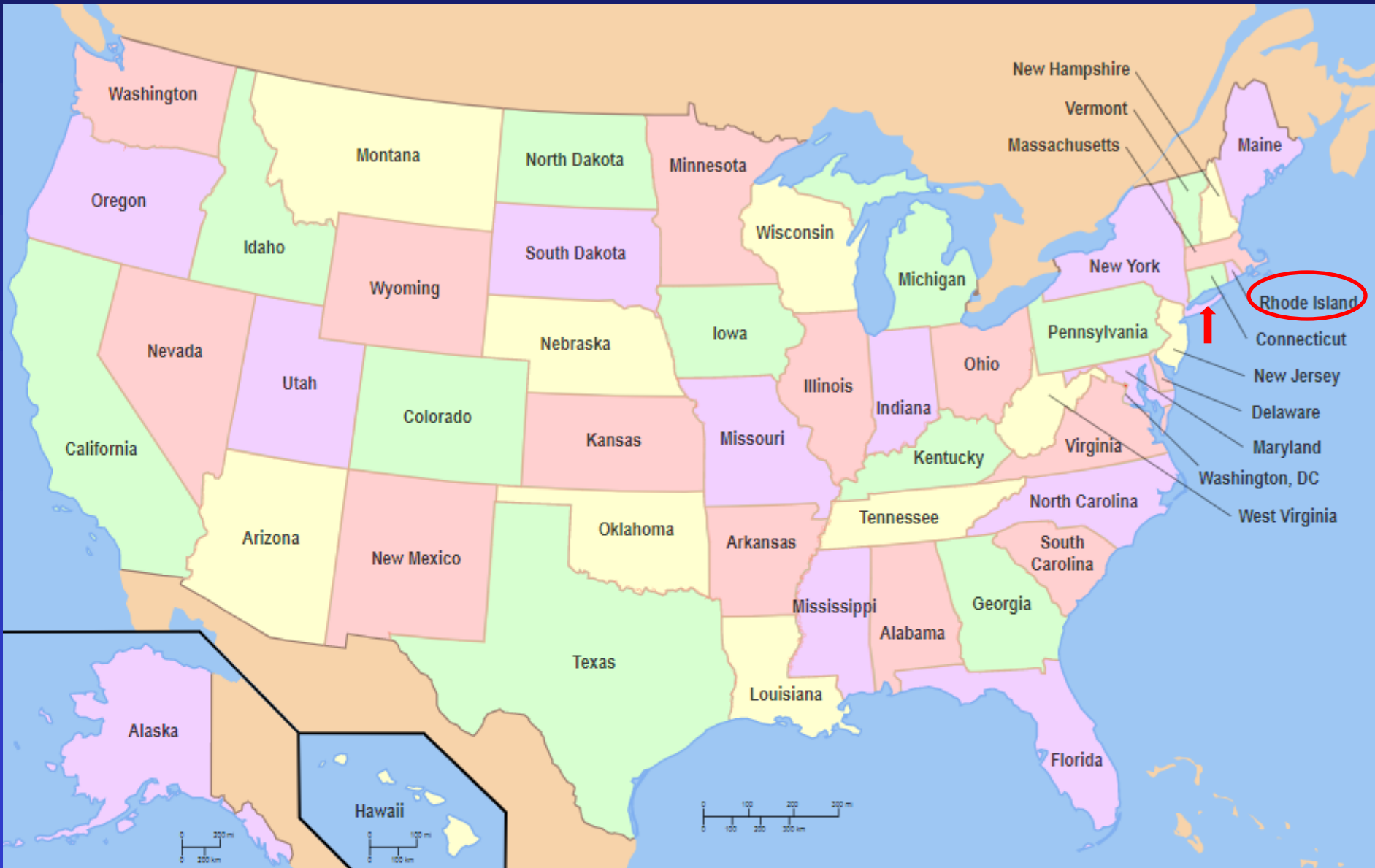
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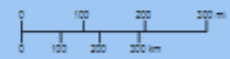
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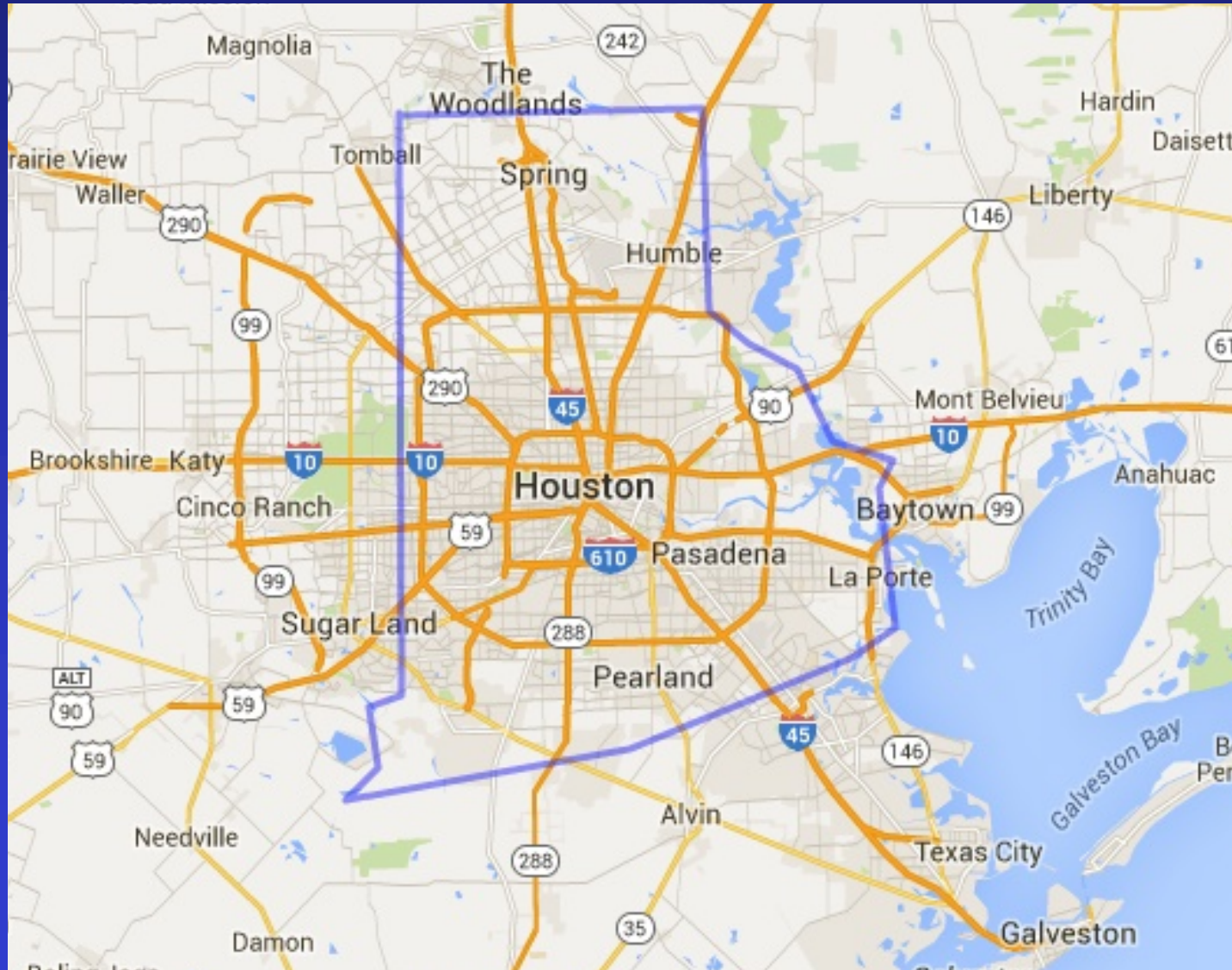
Alaska

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Florida



Rhode Island vs Houston



Objectives

- Thermal regulation at birth of preterm infants
 - ❖ Thermo-neutral range
 - ❖ Cold stress at birth
 - ❖ Cold stress, gestational age, birth weight
 - ❖ Interventions to reduced cold stress
 - ❖ Cold stress and mortality

Editorial, Journal of Pediatrics, 1999

Thermal management of the low birth weight infant: A cornerstone of neonatology

At birth, the body temperature of the newborn infant will approximate or slightly exceed that of the mother. Within minutes of birth, however, core temperature begins to fall, particularly in infants with birth weights <1500 g. These infants have a diminished ca-

capacity for metabolic heat production coupled with a high surface area to volume ratio and an immature epider-

See related article, p. 547.

mal barrier, leading to extraordinarily high evaporative heat losses. Consequently, low birth weight infants are highly vulnerable to the development of cold stress. In the late 1950s, Silverman et al¹ demonstrated that maintenance of body temperature through

control of the thermal environment significantly reduced mortality in LBW infants. This study was subsequently replicated by other investigators with the result that thermal management became a cornerstone of the new field of neonatology.

LBW Low birth weight

Focus on thermal management of the newborn led to a series of controversial topics surrounding the broad

J Pediatr 1999;134:529-31.

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Effect of Temperature on Mortality of Low Birth Weight Infants

	Air Temp 28.3-29.4°C	Air Temp 31.1-32.1°C	ERD*	95% CI
Death (0 – 5 days)	29/91 (31.9%)	15/91 (16.5%)	13	3.2-22.8
Death (0-28 days)	41/91 (45.1%)	20/91 (22.0%)	23.1	9.8-36.4

*ERD: event rate difference

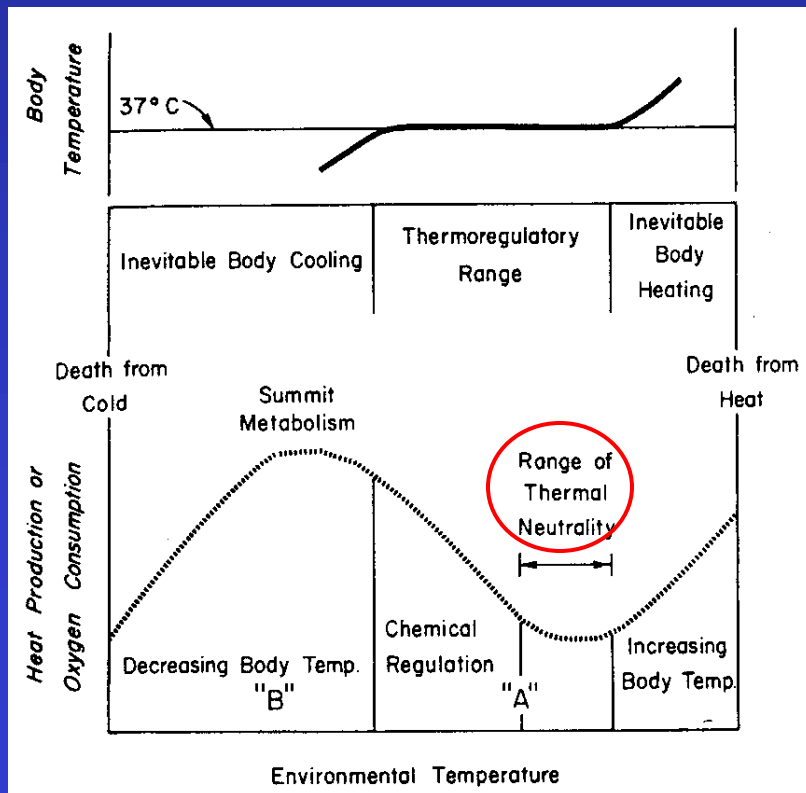
What about the Effects of
Temperature at Birth on Mortality?

Core Body Temperature (T_c): Definition

- Physiologic appropriate range of T_c: not rigorously defined
- Infants, children, adults: T_c = 37°C
- No a-priori reason for a different T_c in newborns
 - ❖ Target newborn T_c = 37.0°C
- Acceptable T_c range: 36.5-37.5°C
- T_c axilla or T_c rectal: closely correlated

Ideal Thermal Conditions for a Newborn

- Maintain an acceptable T_c range
 - ❖ Achieve T_c in a thermo-neutral ambient range (environmental conditions with a minimal O₂ consumption)
 - ❖ Steady state environmental conditions



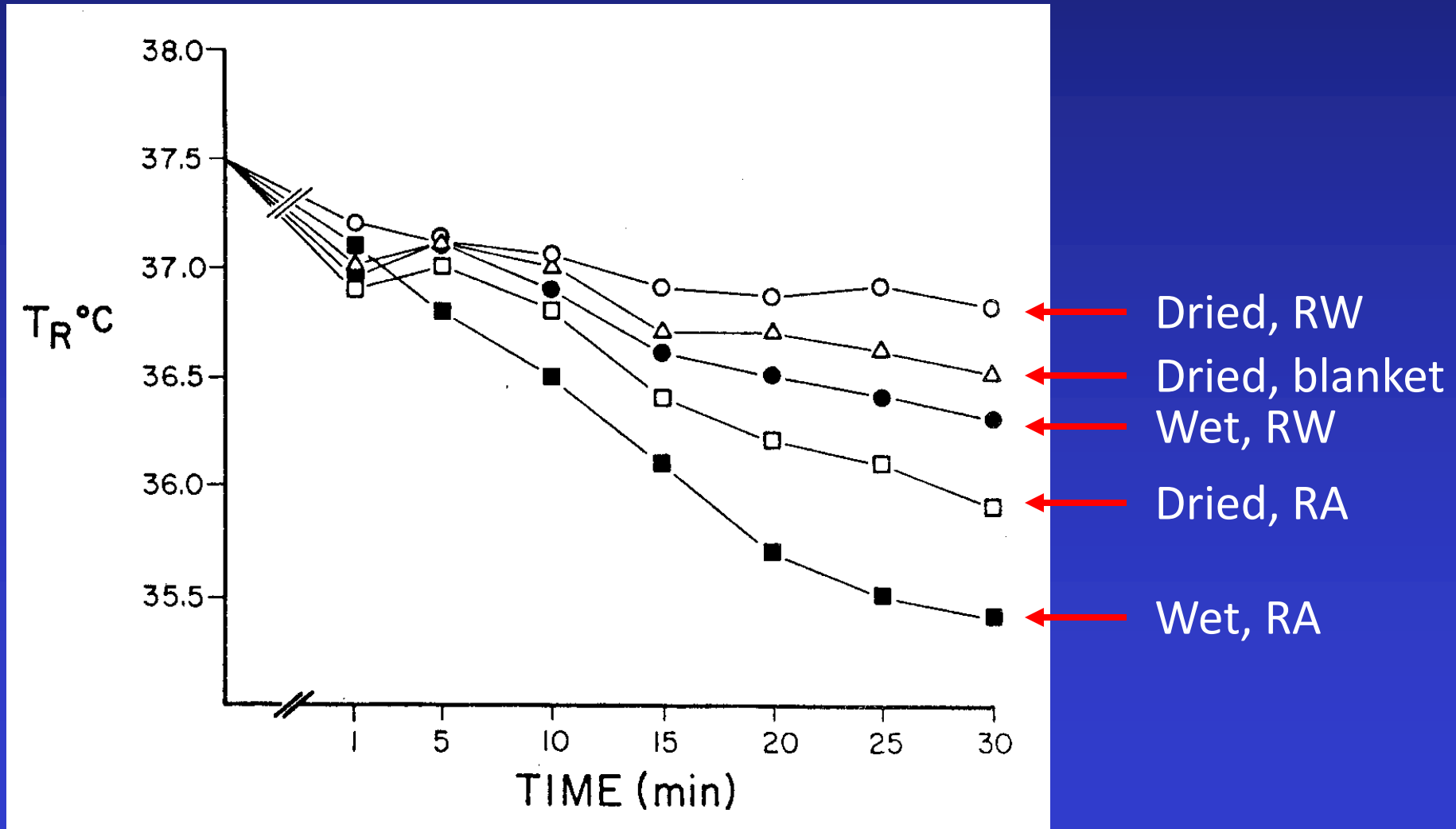
Environmental Cold stress

- ❖ Chemical regulation: \uparrow VO₂
- ❖ Non-shivering thermogenesis
- ❖ Thermogenic organ: brown fat

Environmental Conditions at Birth

- Delivery and operating rooms:
 - ❖ Non-steady state thermal conditions
 - ❖ Absence of a thermoneutral environment

Newborn Temperature in the Delivery Room



Why does Body Temperature Fall After Birth?

Stable temperature → thermal equilibrium

Heat production = heat loss



- ❖ Metabolic processes
 - Non-shivering thermogenesis
 - $\uparrow O_2$ consumption



- ❖ Evaporation
- ❖ Convection
- ❖ Conduction
- ❖ Radiant

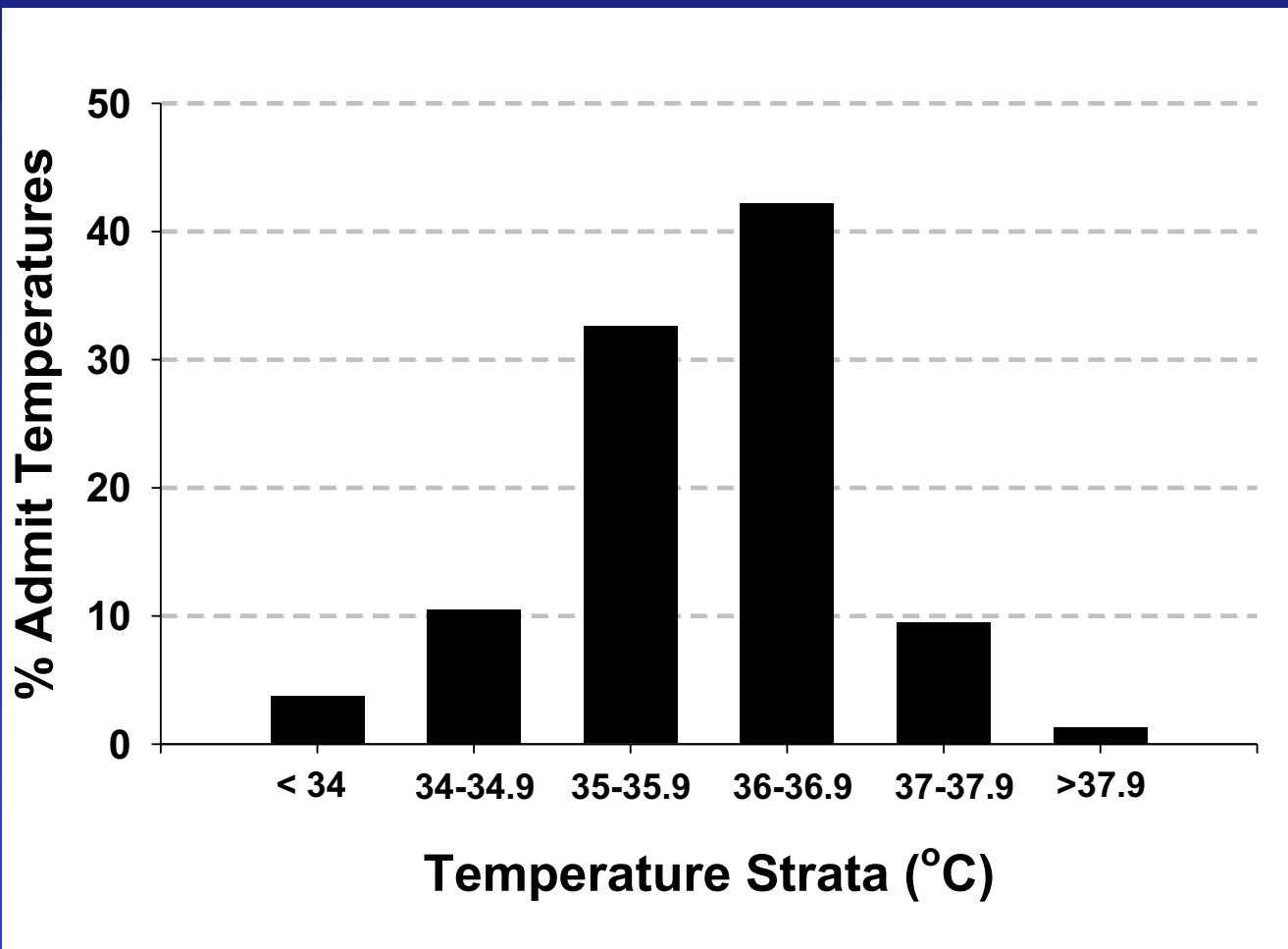
Cold Stress at Birth

- Inevitable
- Cold stimulation has a physiological role
 - ❖ Cold stimulation of cutaneous thermoreceptors: induces respirations¹
 - ❖ Intrapartum fever: lower Apgars, hypotonia and ↑ need for PPV²
- What extent of cold stress would be expected or considered acceptable?

¹Gluckman et al, J Physiol; 1983;343:495-506

²Lieberman et al, Pediatrics; 2000;105:8-13

Admission Temperatures Among LBW Infants: Neonatal Research Network 2002-2003

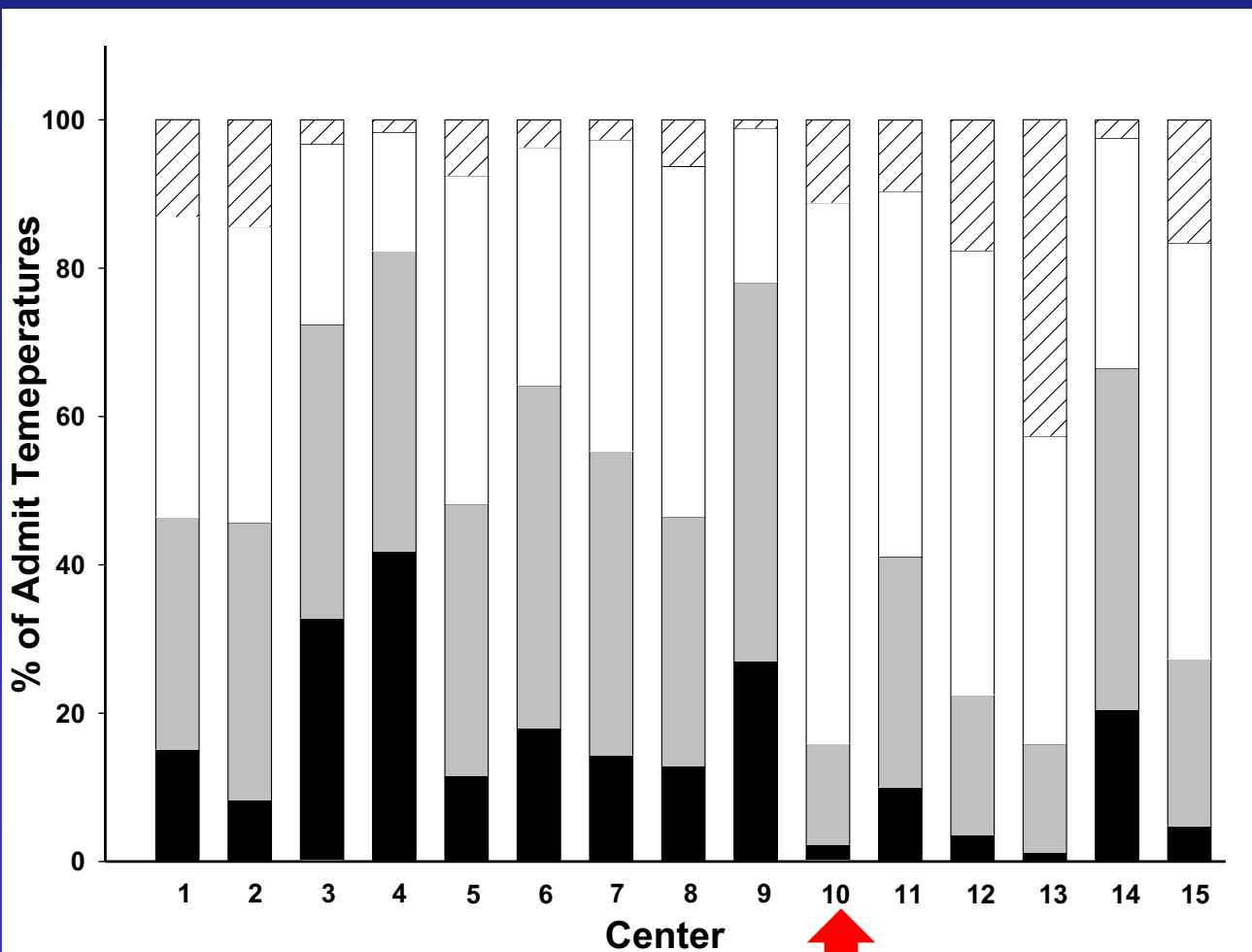


- ◆ N=5,277
- ◆ 15 centers
- ◆ BW < 1500g
- ◆ Direct NICU admit

Relationship Between Gestational Age and BW with Admit Temperature

Gestational age (wks)	n	Birth weight (gm, $x \pm sd$)	% admit temperature	
			< 35°C	< 36°C
28	643	1088 \pm 201	9.6	38.3
27	609	977 \pm 182	10.7	41.5
26	539	840 \pm 163	13.2	44.2
25	468	751 \pm 130	20.5	57.1
24	397	655 \pm 100	33.8	64.2
<24	187	598 \pm 118	43.9	71.1

Neonatal Research Network Centers: NICU Admission Temperatures



Relative to center 10

Mean admit temp varied:

❖ 1.5°C below

❖ 0.3°C above

❖ **Admit temp is modifiable**

Interventions to Reduce Heat Loss and Decrease Hypothermia in Preterm Infants

NRP

- ❖ Radiant warmer
- ❖ Drying (≥ 32 wk)
- ❖ Caps
- ❖ Polyethylene wraps (< 32 wk)¹
- ❖ Thermal mattress (< 32 wk)²
- ❖ Raise room temp³

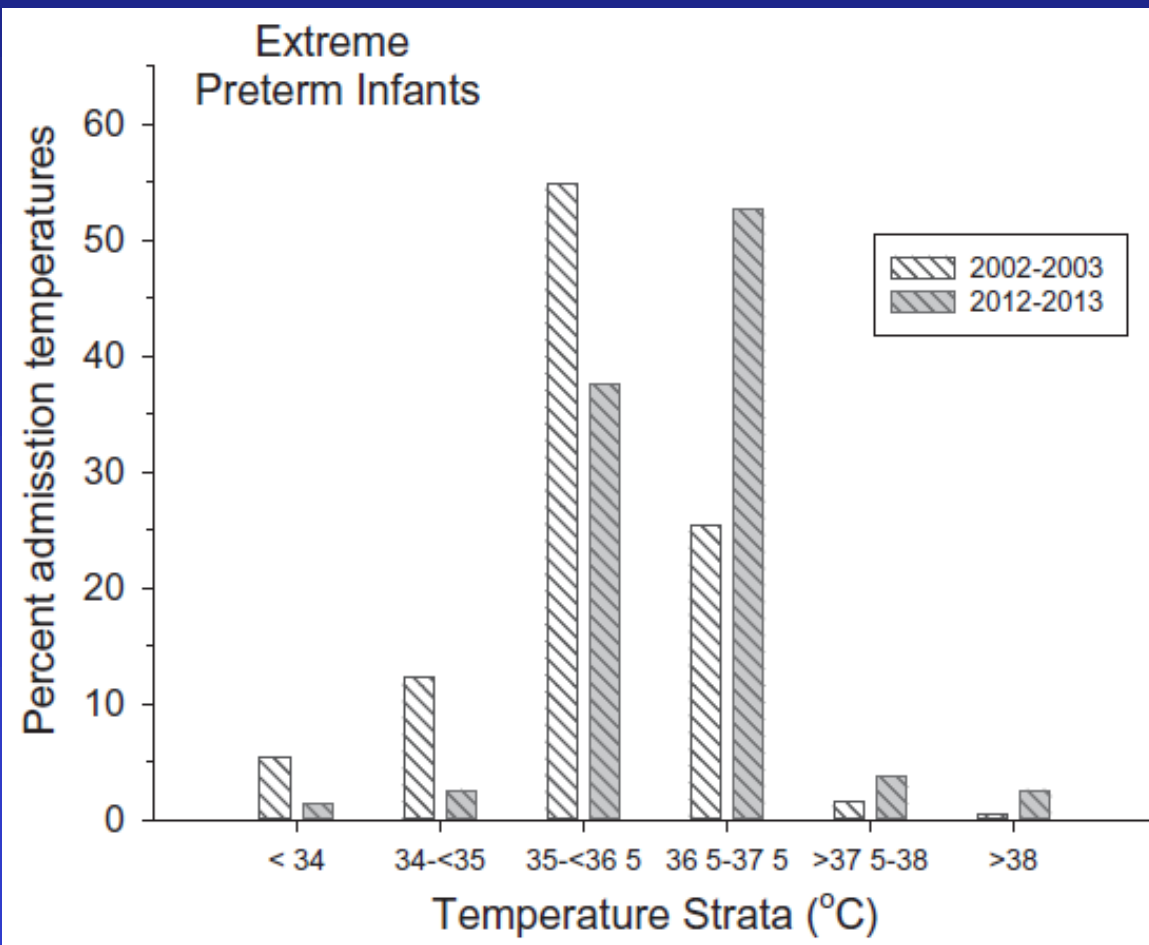
Not listed in NRP

- ❖ Polyethylene caps⁴
- ❖ Heated humidified gas⁵
- ❖ Active maternal warming⁶
- ❖ Skin to skin (resource limitation)⁷

¹Reilly MC et al, J Pediatr 2015;166:262; ²Chawla S et al, J Perinatol 2011;31:780

³Duryea EL et al, Am J Ob Gyn 2016; 214:505.e1; ⁴Trevisanuto D et al, J Pediatr 2010;156:914; ⁵Meyer MP et al, J Pediatr 2015;166:245; ⁶Horn EP et al, Anesth Analg 2002;94:409; ⁷Gabriel MA et al, Acta Paediatr 2010;99:1630

Admission Temperatures Among Extreme Preterm Infants: NRN 2012-2013 vs 2002-2003



- ❖ < 29 wks
- ❖ Centers common to both epochs
- ❖ Direct NICU admits
- ❖ 2002-03: n = 2270
- ❖ 2012-13: n = 2083

Newborn Admission Temperature

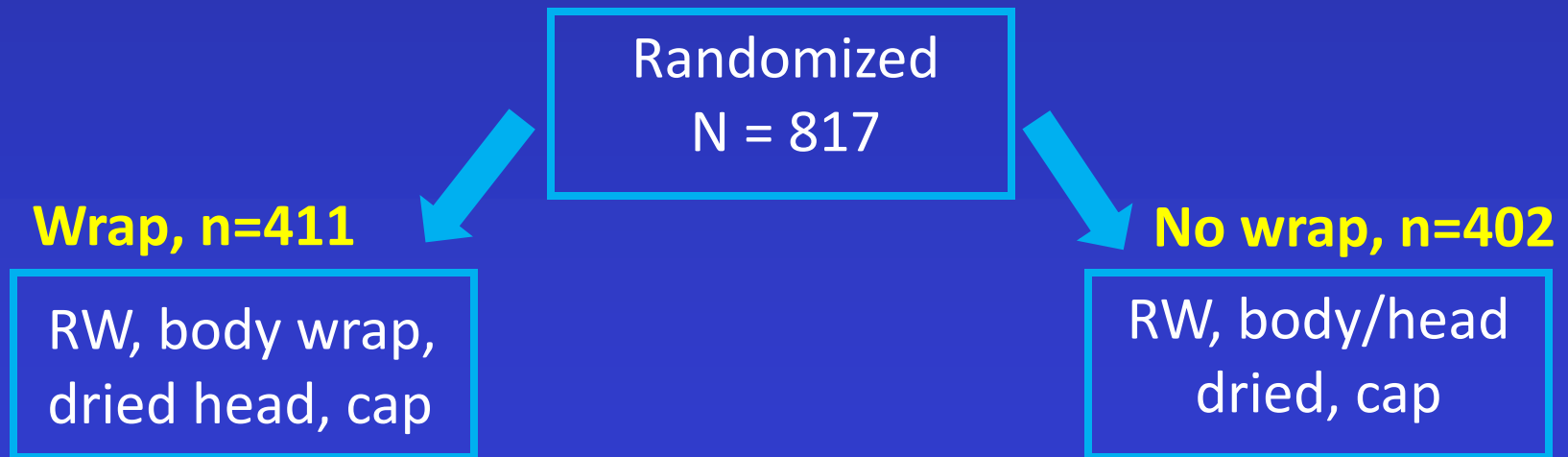
- Cold stress at birth is common among preterm infants
- The frequency and severity of cold stress increase with decreasing GA and BW
- Over a decade the extent of cold stress has been reduced
- Does it matter?

Associations Between Admission Temperature and Mortality in the NRN

- Multi-variable logistic regression
 - ❖ Adjusted for: antenatal steroids, sex, race, birth weight, intubation, Apgar at 5 min and center
- 2002-2003 (< 1500 gm BW)
 - ❖ For every 1°C decrease in admit temperature, mortality increased by 28% (OR 1.28, 95% CI, 1.16-1.41)¹
- 2012-2013 (< 34 wks GA)
 - ❖ For every 1°C increase in admit temperature, mortality decreased by 19% (OR 0.81, 95% CI, 0.71-0.91)²
- Inverse associations: no causal inference

HeLP Trial: Heat Loss Prevention in Preterm Infants

- Do occlusive wraps immediately after birth reduce mortality?
- Prospective randomized trial
- Infants 24⁰ – 27⁶ wks, stratified by GA
- Primary outcome: all cause mortality (25% RRR)



HeLP Trial: Results

Trial stopped after 50% enrollment: futility

Temperature (mean):

❖ Wrap gr: 36.3°C

❖ Non-wrap gr: 35.7°C

Temp distribution:

Mortality:

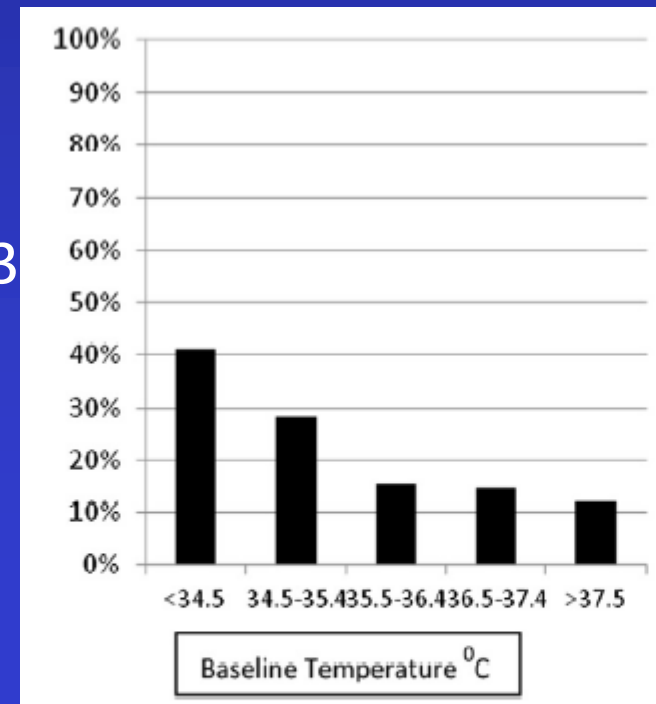
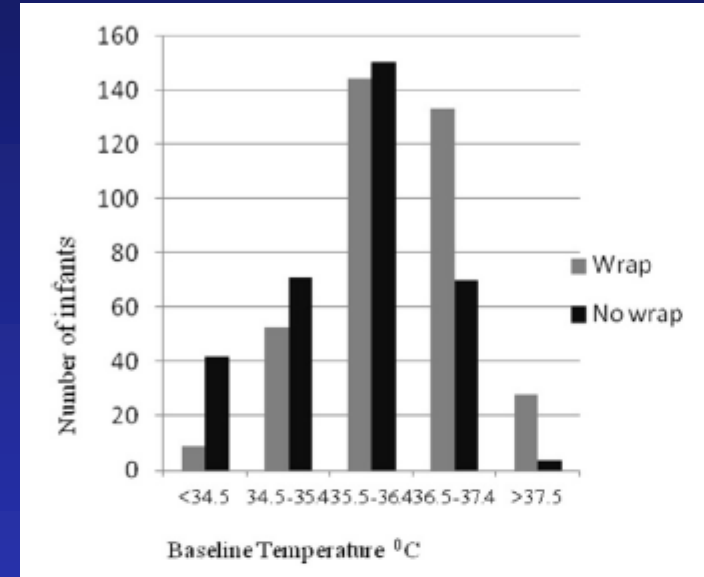
❖ Wrap gr: 20.5%

❖ Non-wrap gr: 20%

OR 0.9, 95% CI 0.6-1.3

Mortality/admit temp: inversely associated

Wrapping: no benefit to reduce mortality



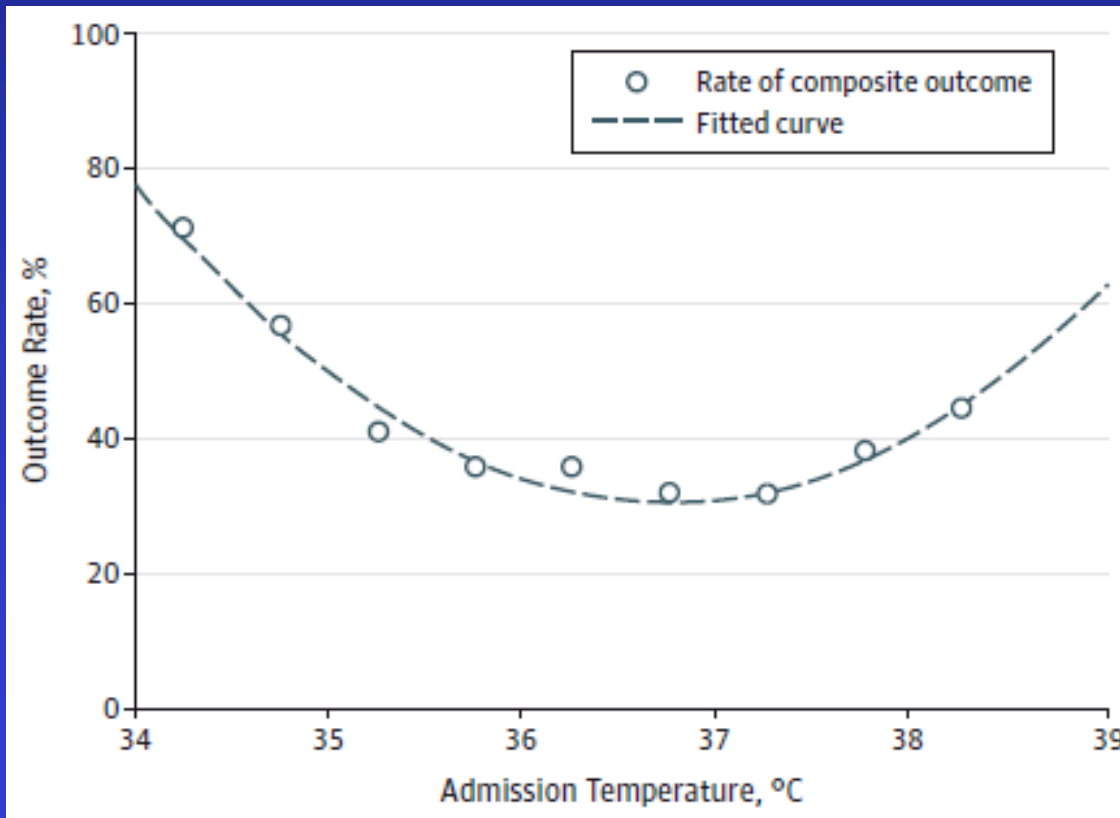
Admission Temperature and Mortality: Other Reports

- Inverse association between admission temperature and in-hospital mortality
 - ❖ EPICure study (< 27 wks)¹
 - ❖ California Perinatal Quality Care Collaborative (BW < 1500g)²
 - ❖ Brazilian Network of Neonatal Research (23-33 wks)³
 - ❖ Canadian Neonatal Network⁴

¹Pediatrics 2000;106:659-671, ²JPerinatol 2011;31(suppl 1):S49-56,
³JPediatr 2014;164:271-275,e1, ⁴JAMA Pediatr 2015;169(4):e150277

Association of Admission Temperature with a Composite Mortality/Morbidity Outcome

Canadian Neonatal Network



Inborns, n=9,833, < 33 wks

Composite adv outcome:

❖ Mortality or Neuro injury,
ROP, NEC, BPD, LOS

U shaped association

Nadir admit temp: 36.8°C

Conclusions

- Thermal regulation is a fundamental principle in care of newborns at birth and in the NICU
- Cold stress is common at birth
 - ❖ A little: necessary, stimulates respirations
 - ❖ Too much: inverse association with mortality
 - ❖ Associations with mortality: causal vs a marker
- Admission temperature: ***modifiable***
 - ❖ Vigilance for hyperthermia

DON'T MESS



with RHODE ISLAND
either.