



# Sudden Infant Death Syndrome and Safe Infant Sleep

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**Chair, California SIDS Advisory Council**

**Professor of Pediatrics, Physiology and Biophysics**

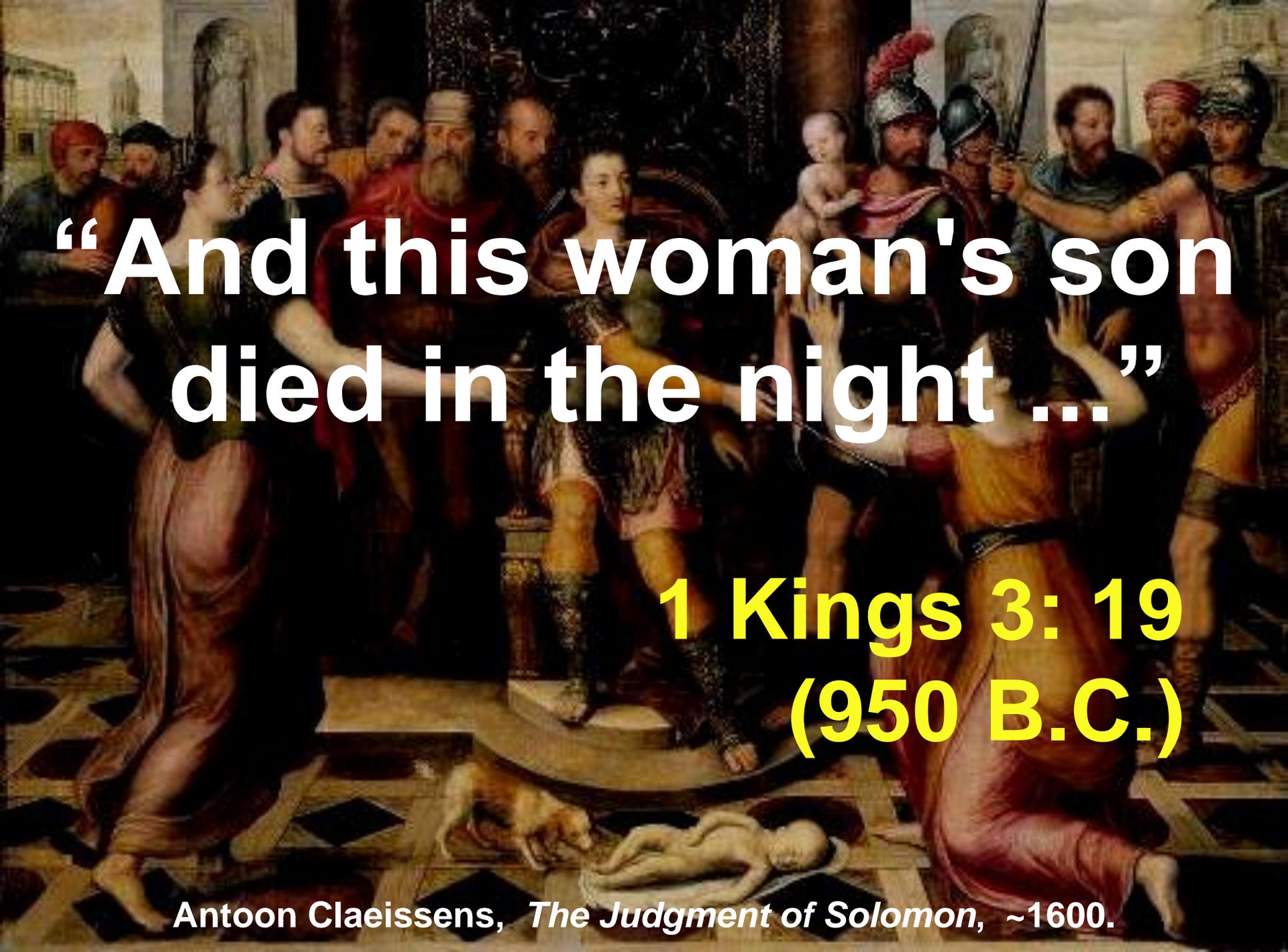
**Keck School of Medicine of the University of Southern California**

**Division of Pediatric Pulmonology and Sleep Medicine**

**Children's Hospital Los Angeles**



**No Conflicts of Interest to Disclose**



**“And this woman's son  
died in the night ...”**

**1 Kings 3: 19  
(950 B.C.)**

Antoon Claeissens, *The Judgment of Solomon*, ~1600.

LAPSE OF TIME FROM MOMENT WHEN LAST SEEN ALIVE TO THE  
DISCOVERY OF DEATH (96 Cases)

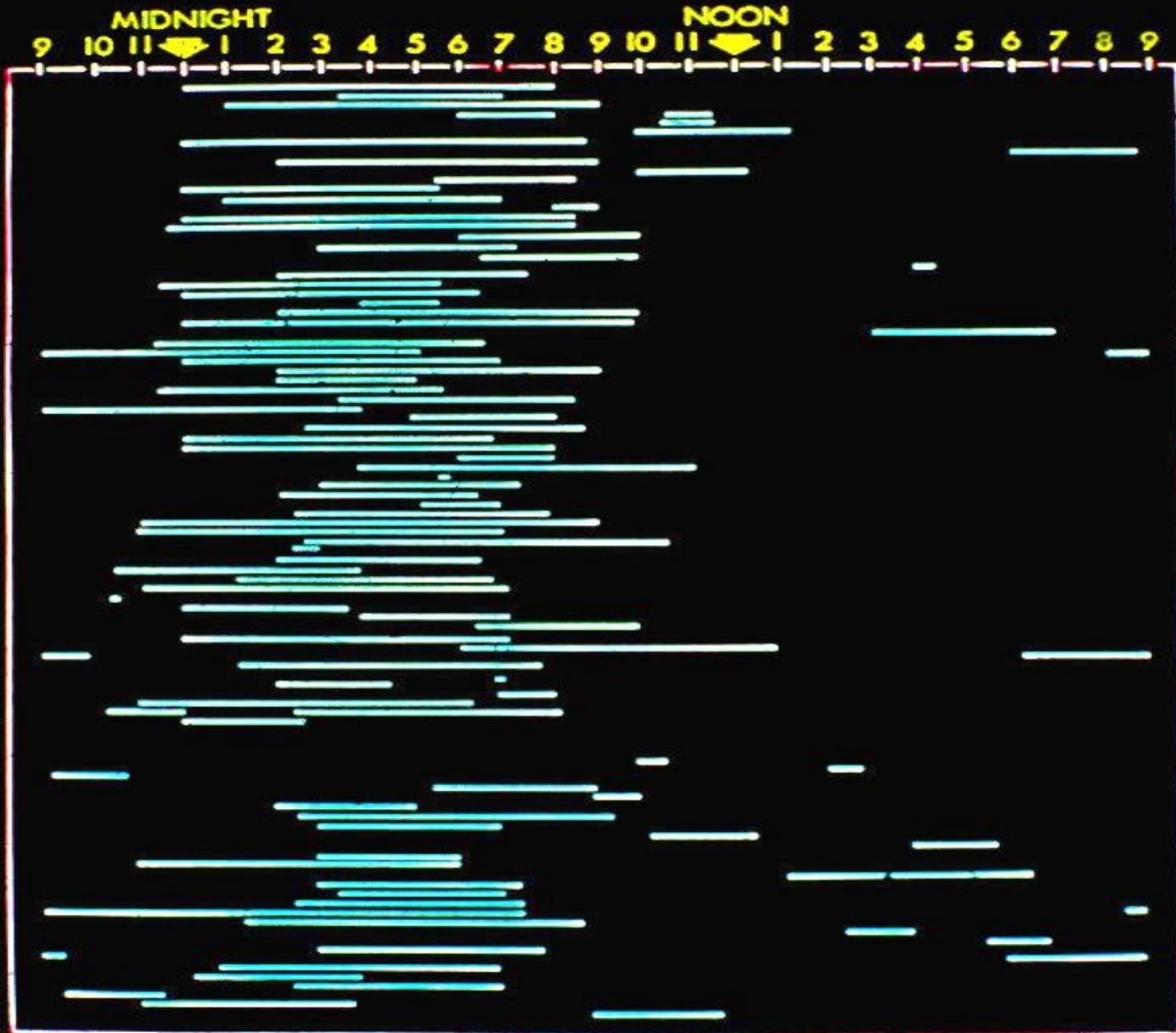


Figure Courtesy of Doctor Maria Valdes-Dapena



**ACTION 10**  
**HD NEWS**

# Baby Death Investigation

1400 blk of Corban

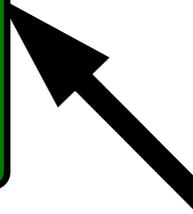
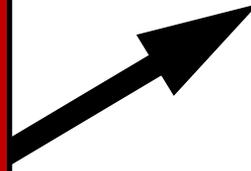
**Sudden  
Death  
of an Infant**

**Emergency  
Responders**

**Coroner's  
Investigation**

**Determination  
of the Cause  
of Death**

**Autopsy**



# Sudden Infant Death Syndrome



**The sudden unexpected death of an infant, under one-year of age, with onset of the fatal episode apparently occurring during sleep, that remains unexplained after a thorough investigation, including performance of a complete autopsy, and review of the circumstances of death and the clinical history.**



**Krous, H.F., J.B. Beckwith, R.W. Byard,  
T.O. Rognum, T. Bajanowski, T. Corey, E. Cutz,  
R. Hanzlick, T.G. Keens, and E.A. Mitchell.**

***Pediatrics, 114: 234-238, 2004.***

# Sudden Infant Death Syndrome

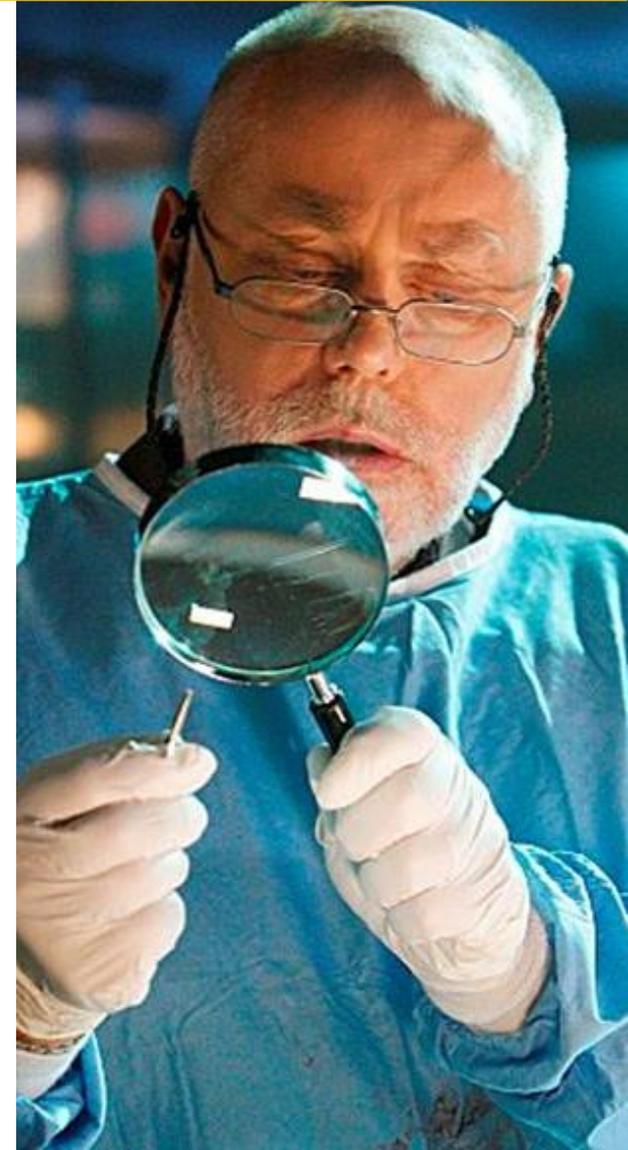


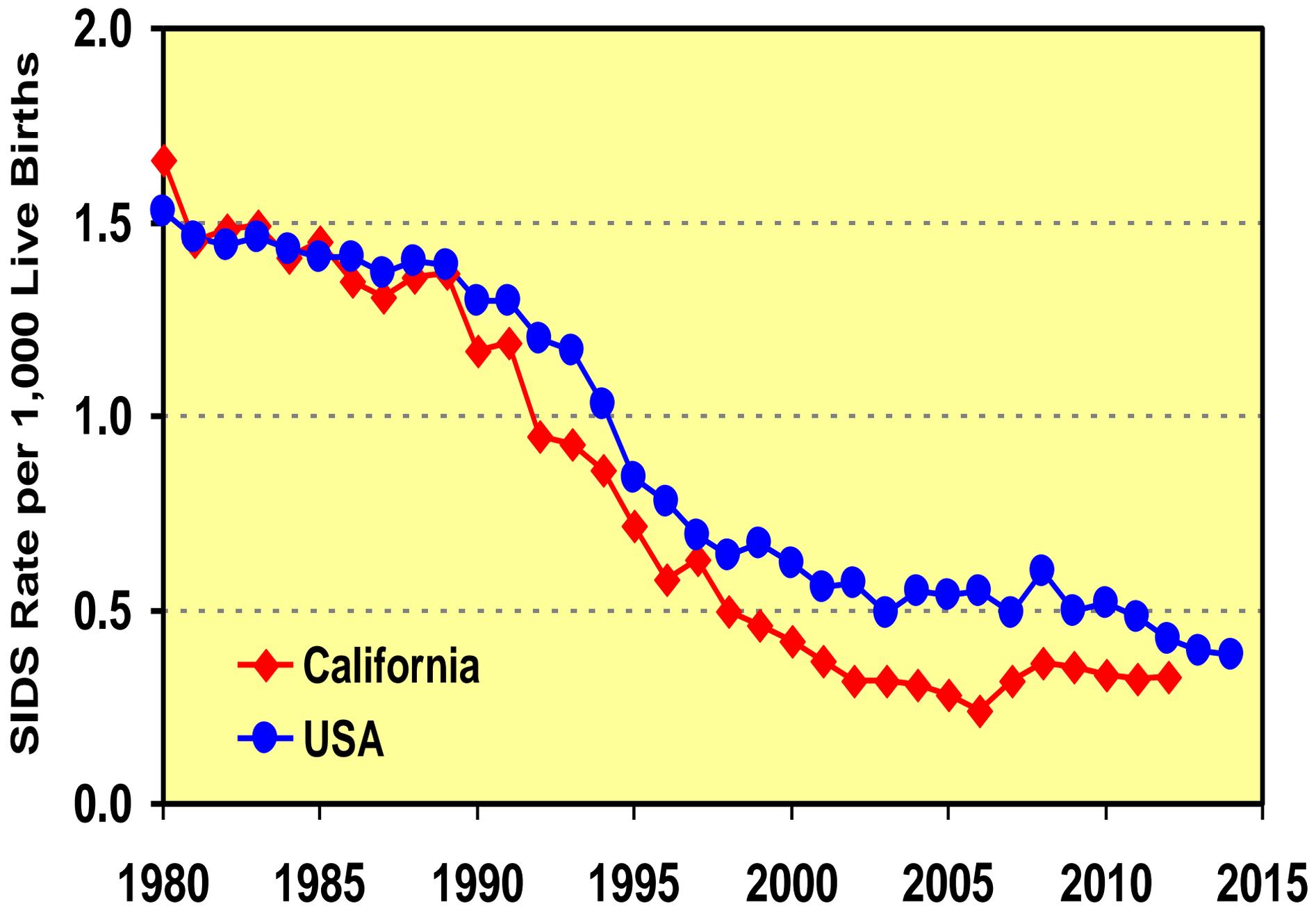
In this presentation, the following terms are considered synonymous:

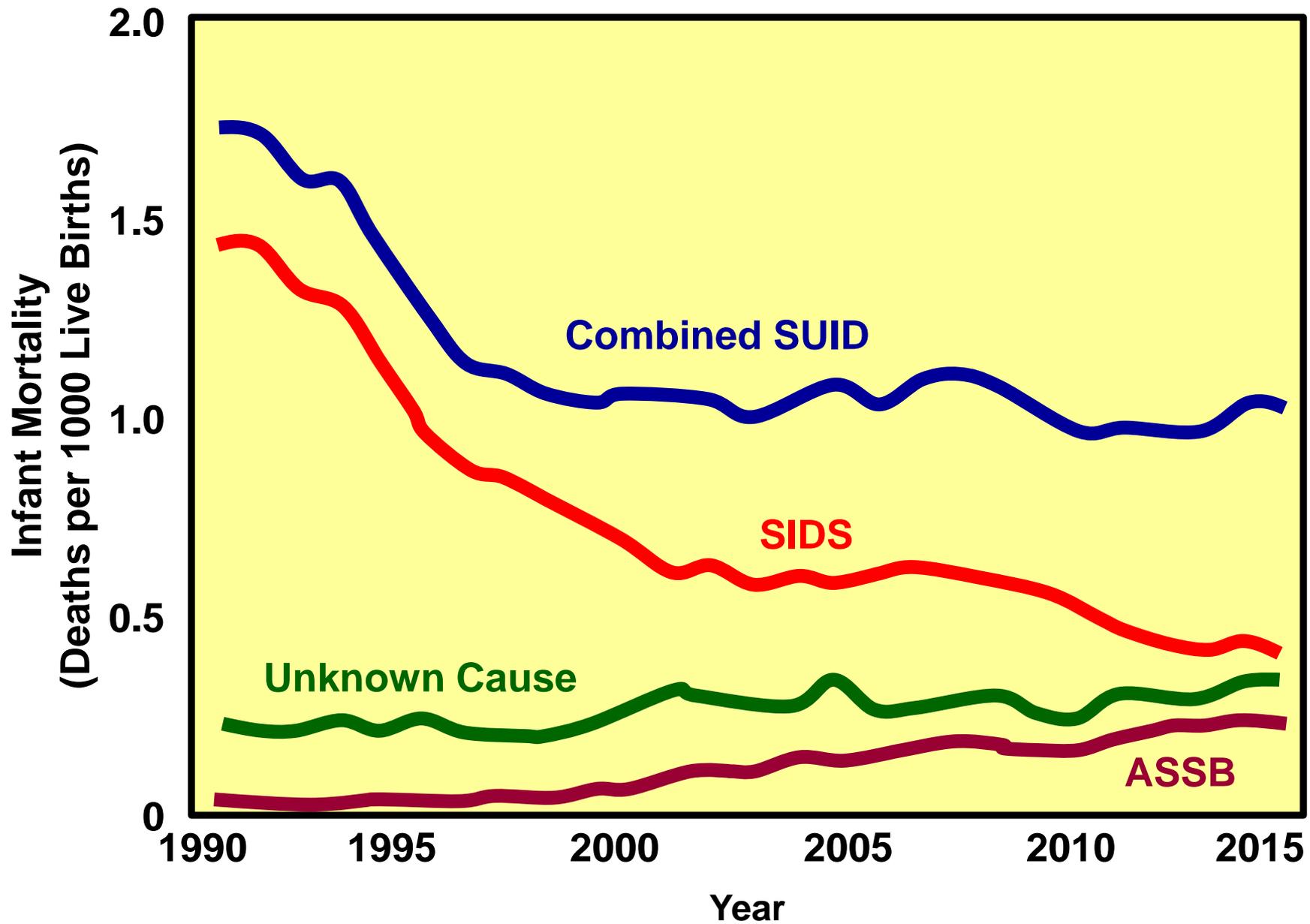
- SIDS
- SUID
- SUDI
- Undetermined

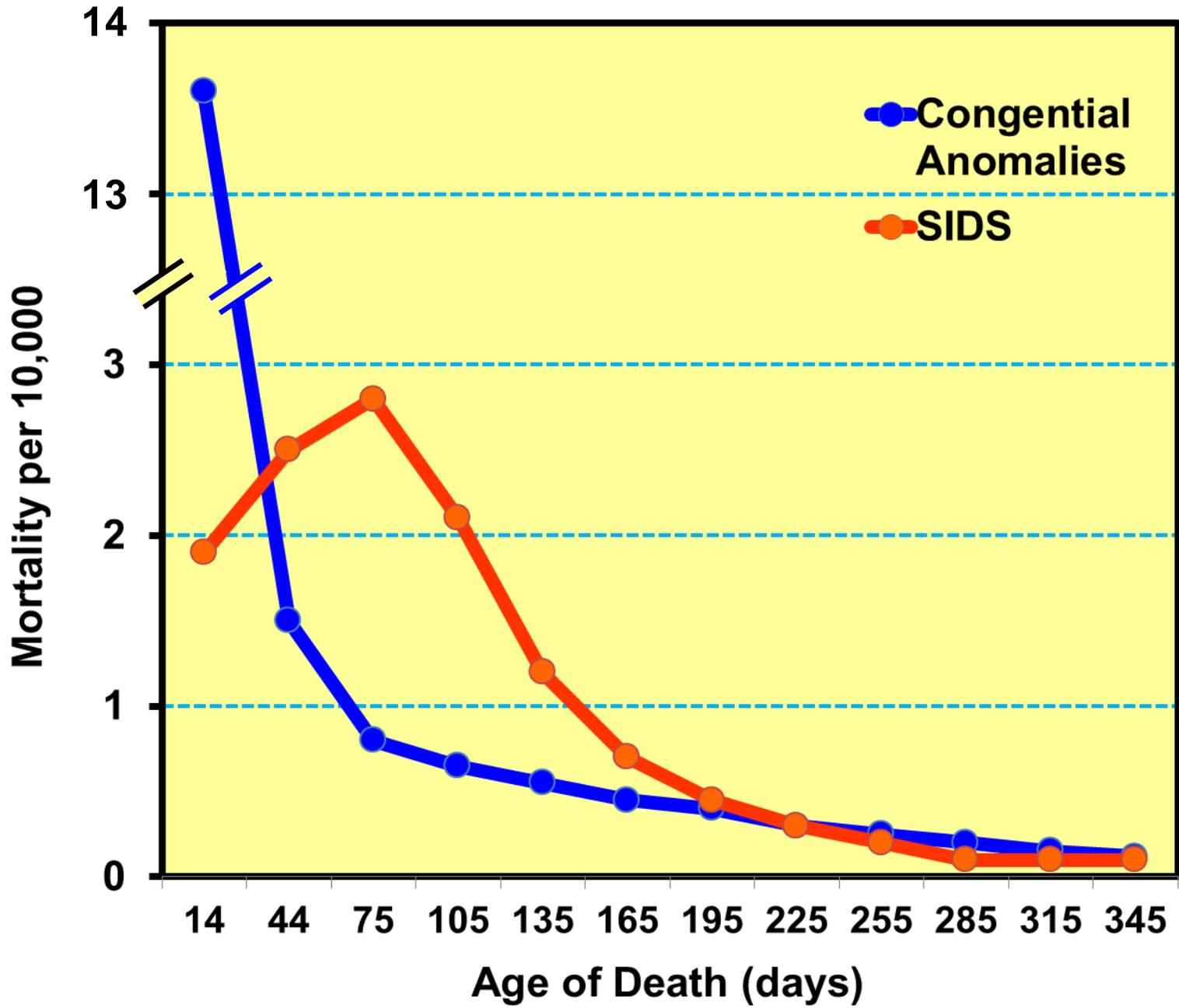
They all mean the same thing; that the infant's death is *unexpected* and *unexplained*.

Cutz, E. *JAMA Pediatr.*, 170: 315-316, 2016.

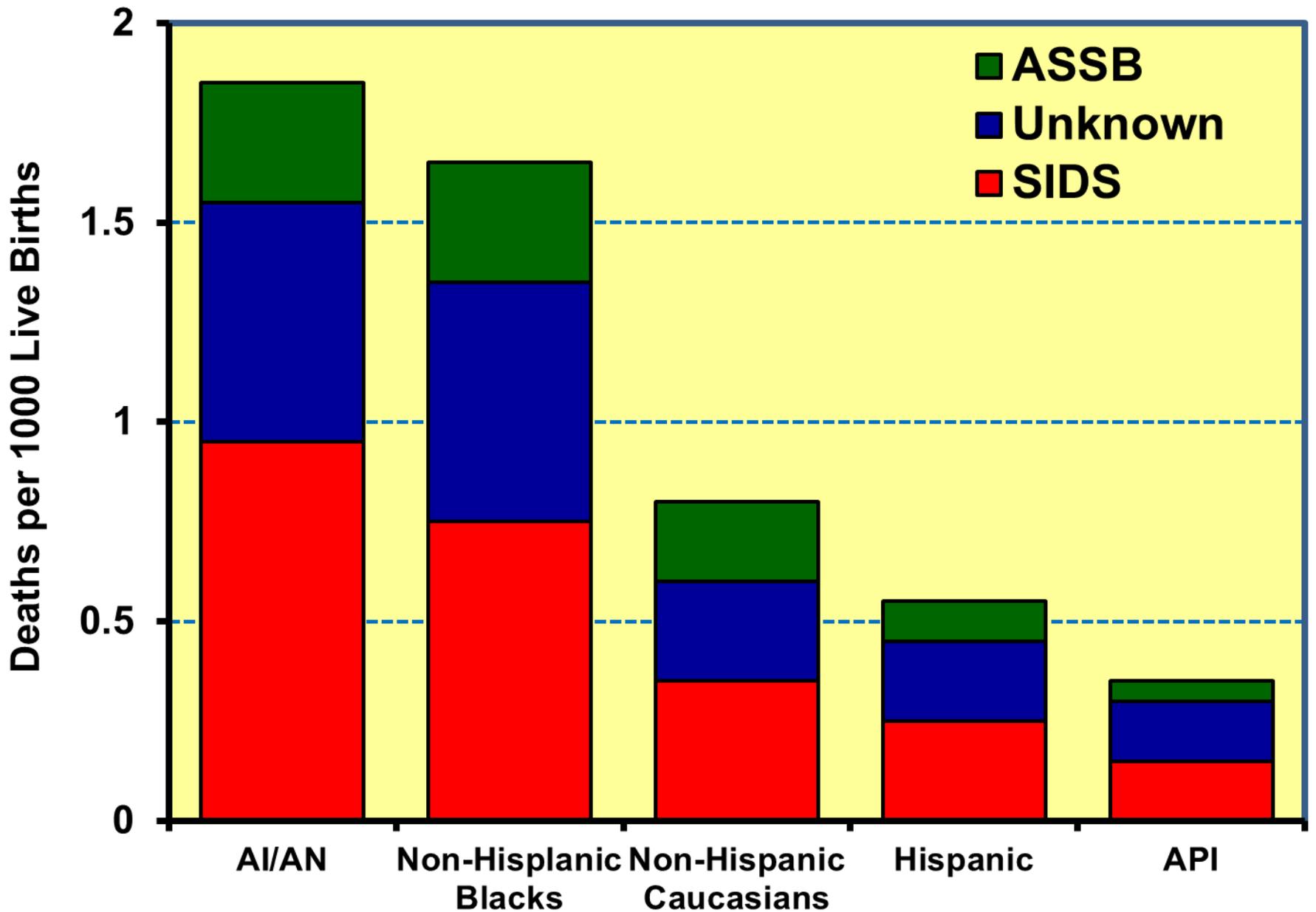






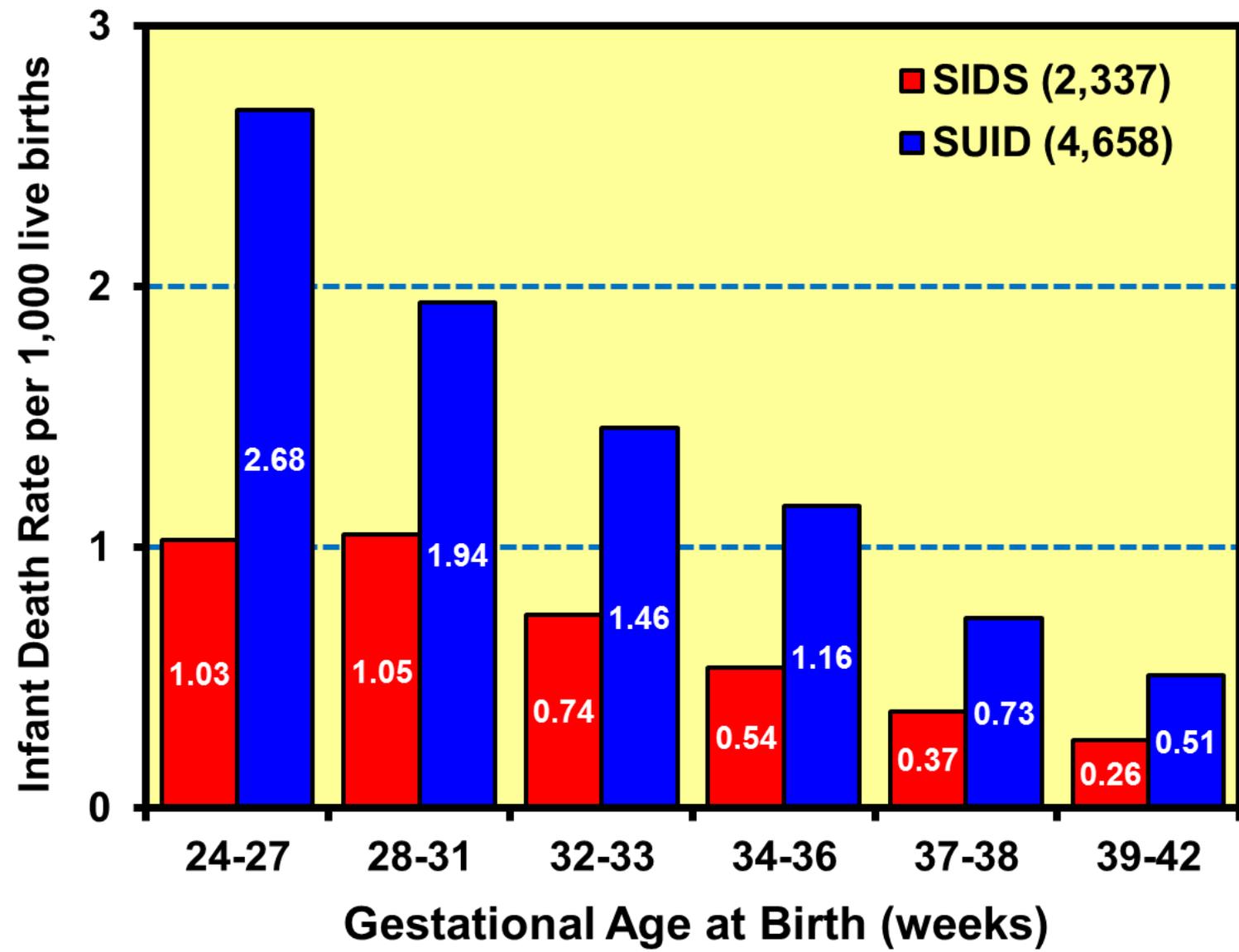


Guntheroth, W.G., and P.S. Spier. *Pediatrics*, 110: 110;e64, 2002.



<https://www.cdc.gov/sids/data.htm>

# Infant Deaths by Gestational Age

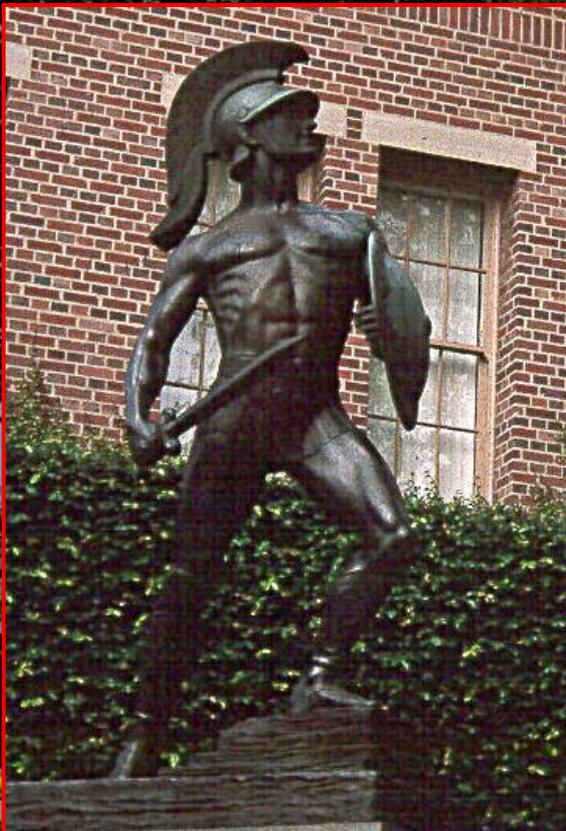


Ostfeld, B.M., et al. *Pediatrics*, 140: e20163334, 2017.

- **No identifiable cause of death.**
- **No signs of severe illness.**
- **No signs of significant stress.**
- **Diagnosis of exclusion**

# With the perseverance of Trojans ...

- Faithful.
- Scholarly.
- Skillful.
- Courageous.
- Ambitious.



**USC**  
University of  
Southern California



**USC**

“Here are provided seats of meditative joy,  
Where shall arise again the destined reign of Troy.”

Virgil, *Aeneid*

**Imagine a car driving up  
a steep mountain road.**

**The car has stopped.**

**Why can't the car  
continue up the hill?**

Imagine a car driving up a steep mountain road. The car has stopped.

Why can't the car continue up the hill?

## Medical Model.

- There is a flat tire.
- Identify the problem.
- Find a solution to the problem.
- Fix the problem.

Modified after Professor Jacopo P. Mortola. McGill University.

# Medical Model of SIDS



- **Cardiac causes.**
- **Respiratory causes.**
- **Arousal disorders.**
- **Metabolic disorders.**
- **Infections.**
- **Vitamin deficiency.**
- **Environmental toxins.**



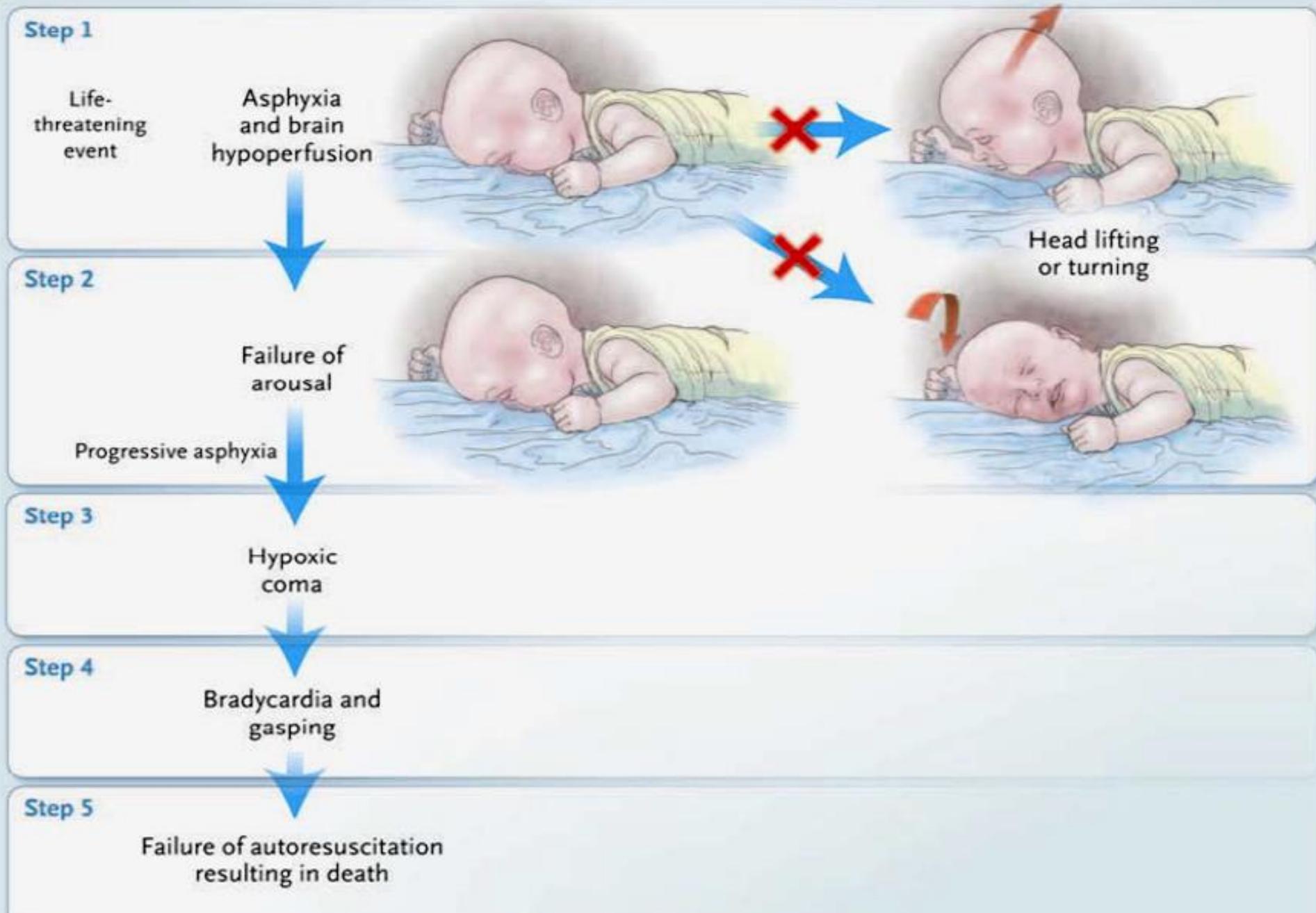
Imagine a car driving up a steep mountain road. The car has stopped.

Why can't the car continue up the hill?

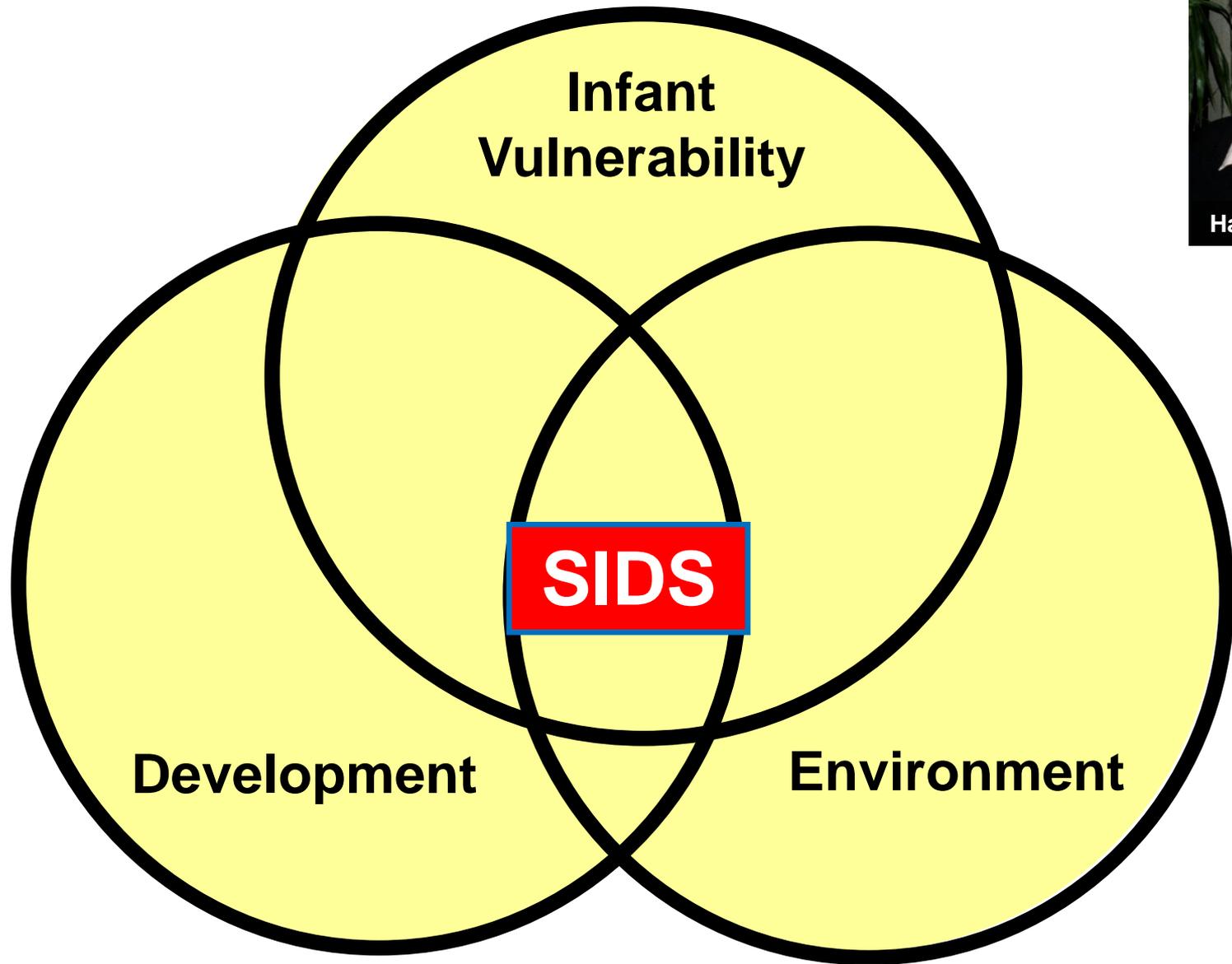
## **A New Way of Thinking.**

- There are too many passengers.
- The engine is not powerful enough.
- The road is too rocky.
- The road is too steep.

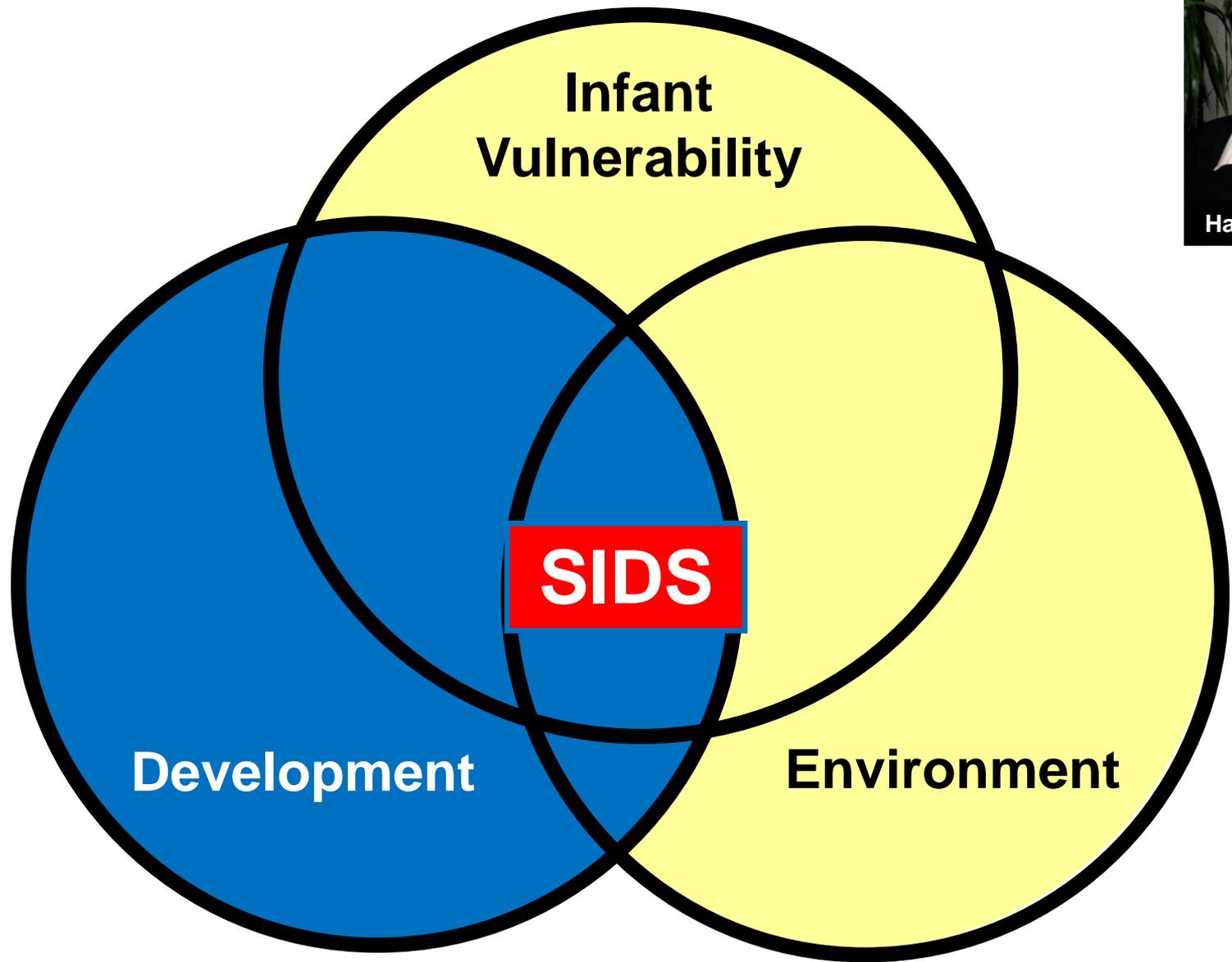
**Modified after Professor Jacopo P. Mortola. McGill University.**



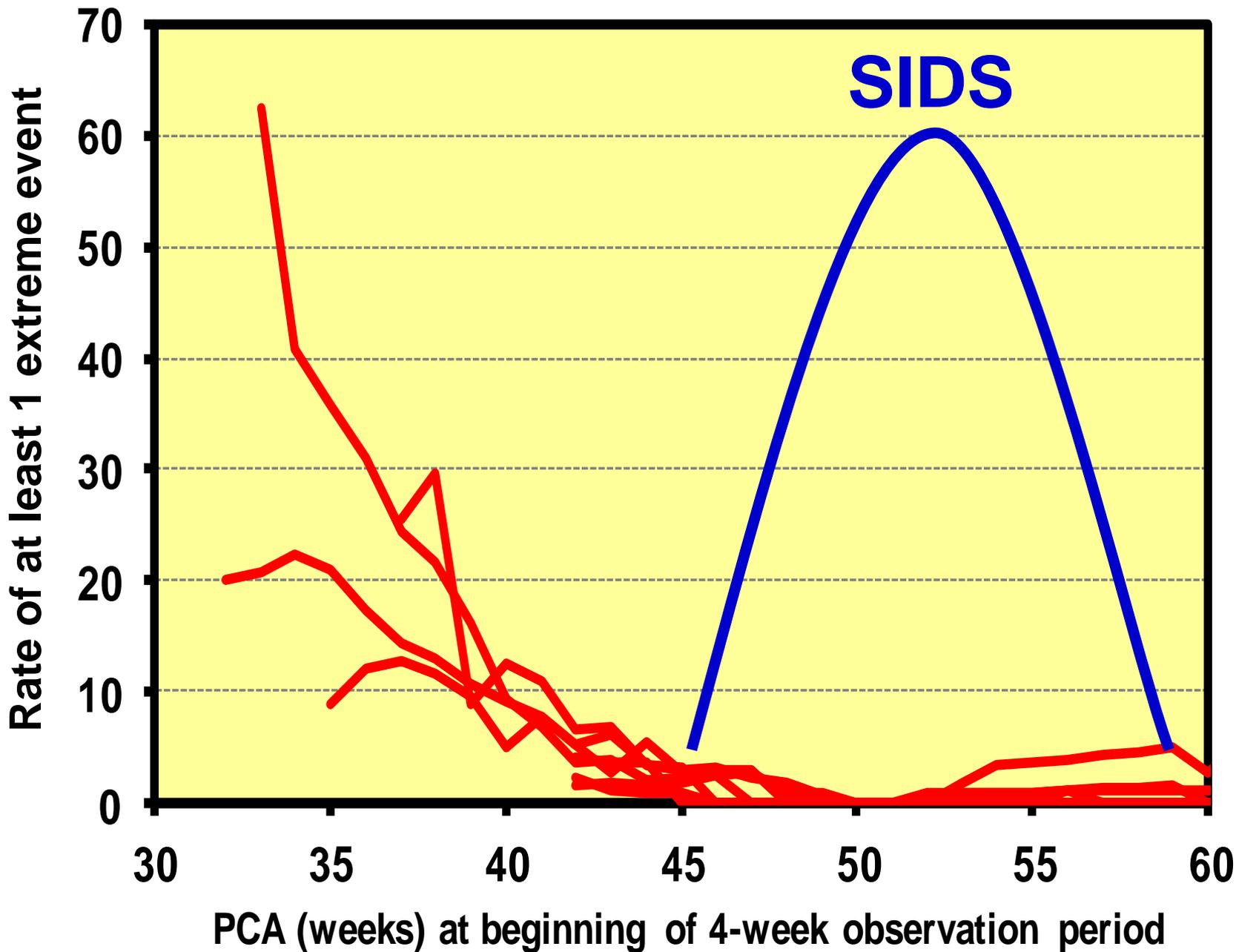
**Kinney, H.C., and B.T. Thach. *N. Eng. J. Med.*, 361: 795-805, 2009.**



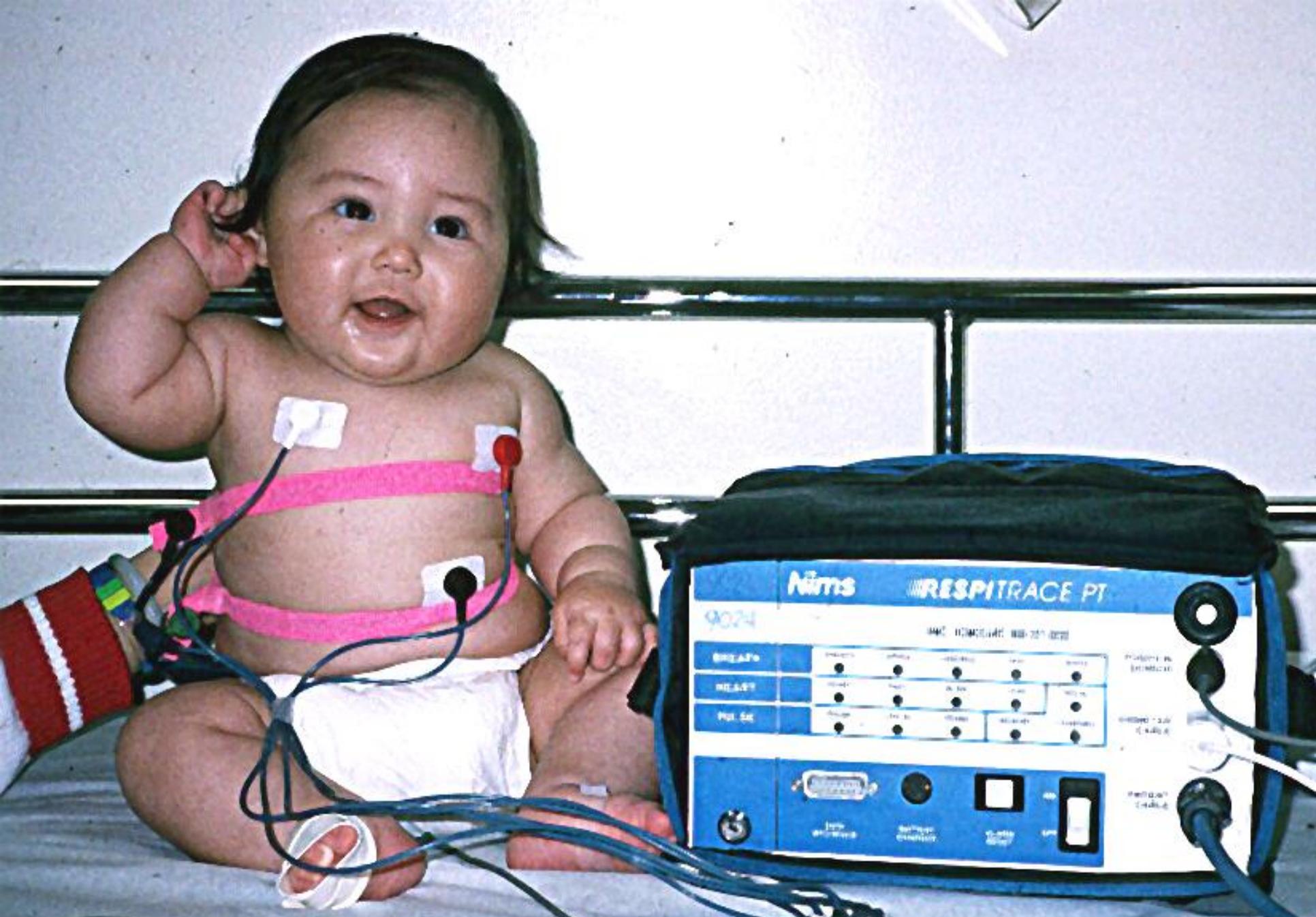
Filiano, J.J., and H.C. Kinney. *Biol. Neonate*, 65: 194-197, 1994.



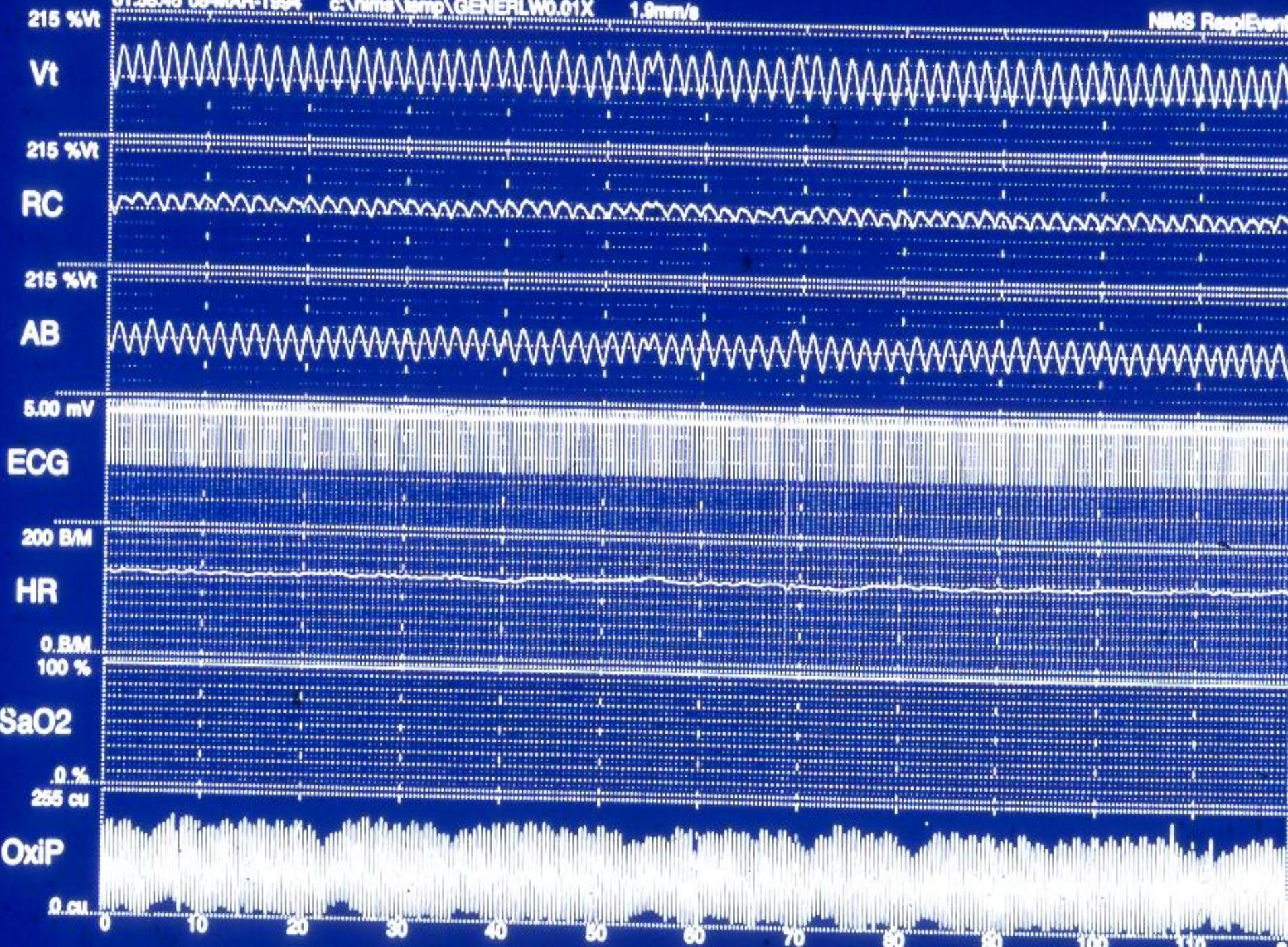
Filiano, J.J., and H.C. Kinney. *Biol. Neonate*, 65: 194-197, 1994.

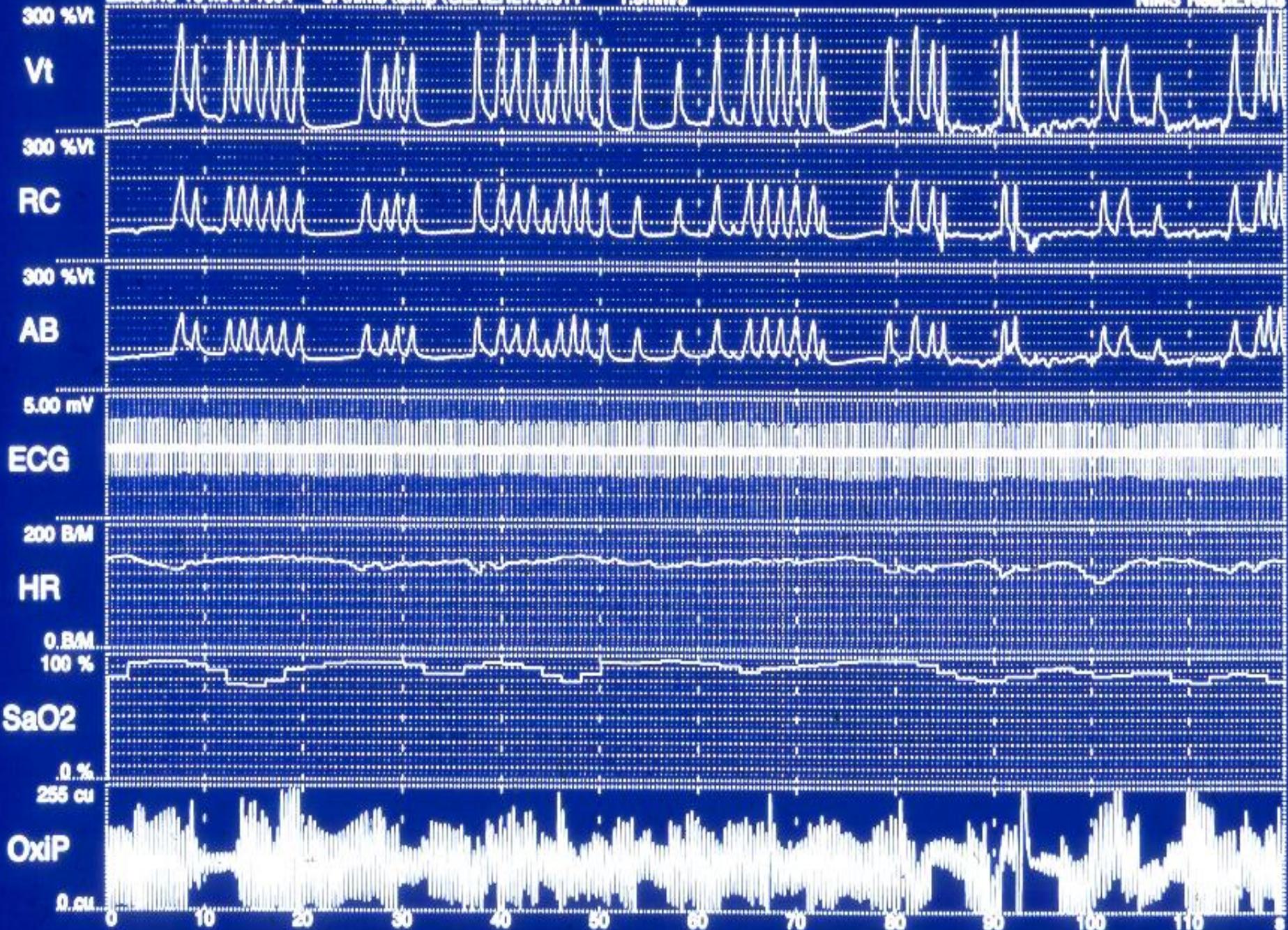


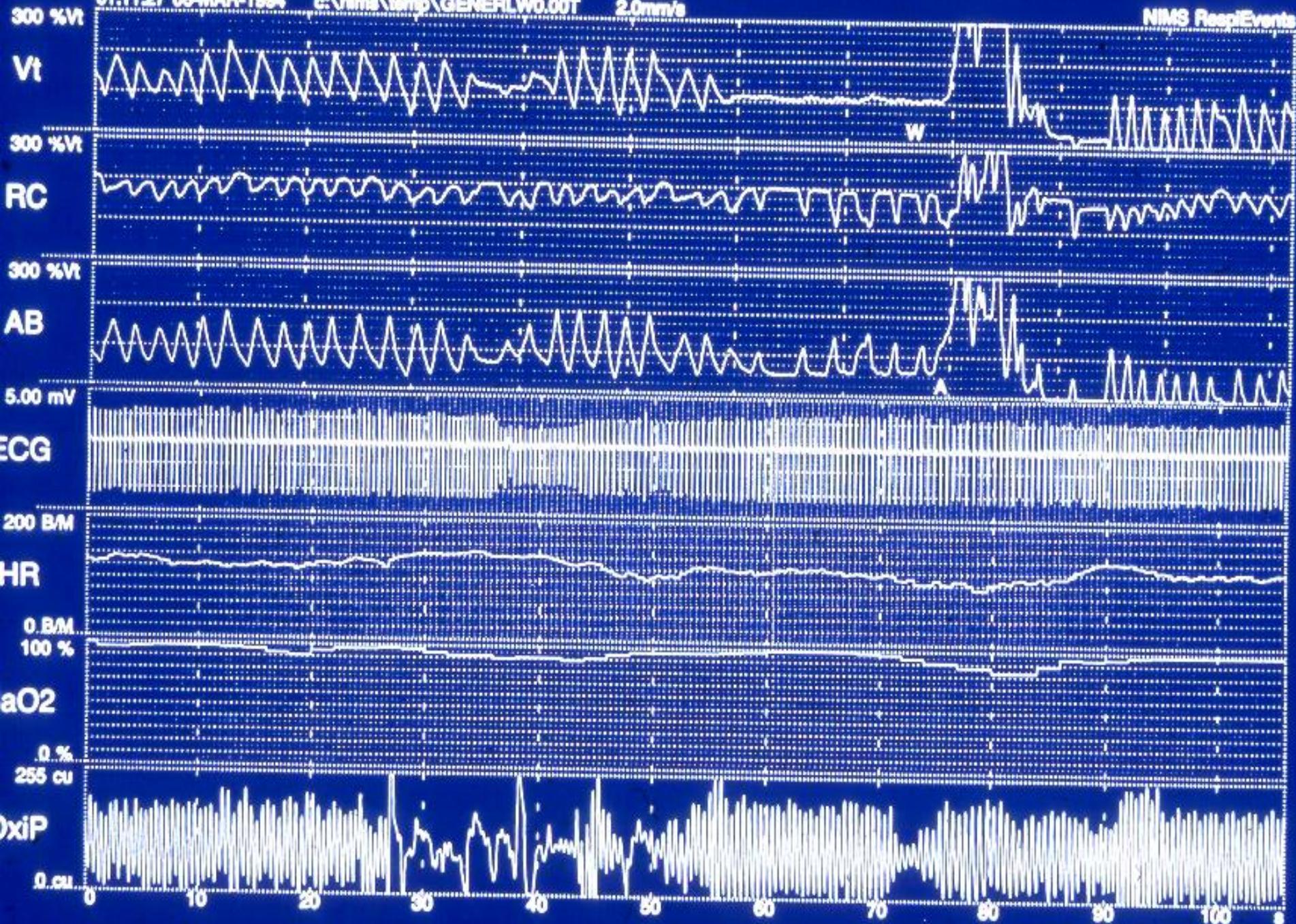
Ramanathan, R., and CHIME. *J. Amer. Med. Assoc.*, 285: 2199-2207, 2001.



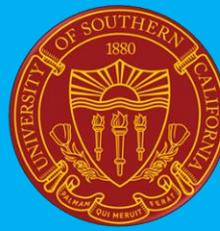
Neuman, M.R., et al., and CHIME. *Physiol. Meas.*, 22: 267-286, 2001.



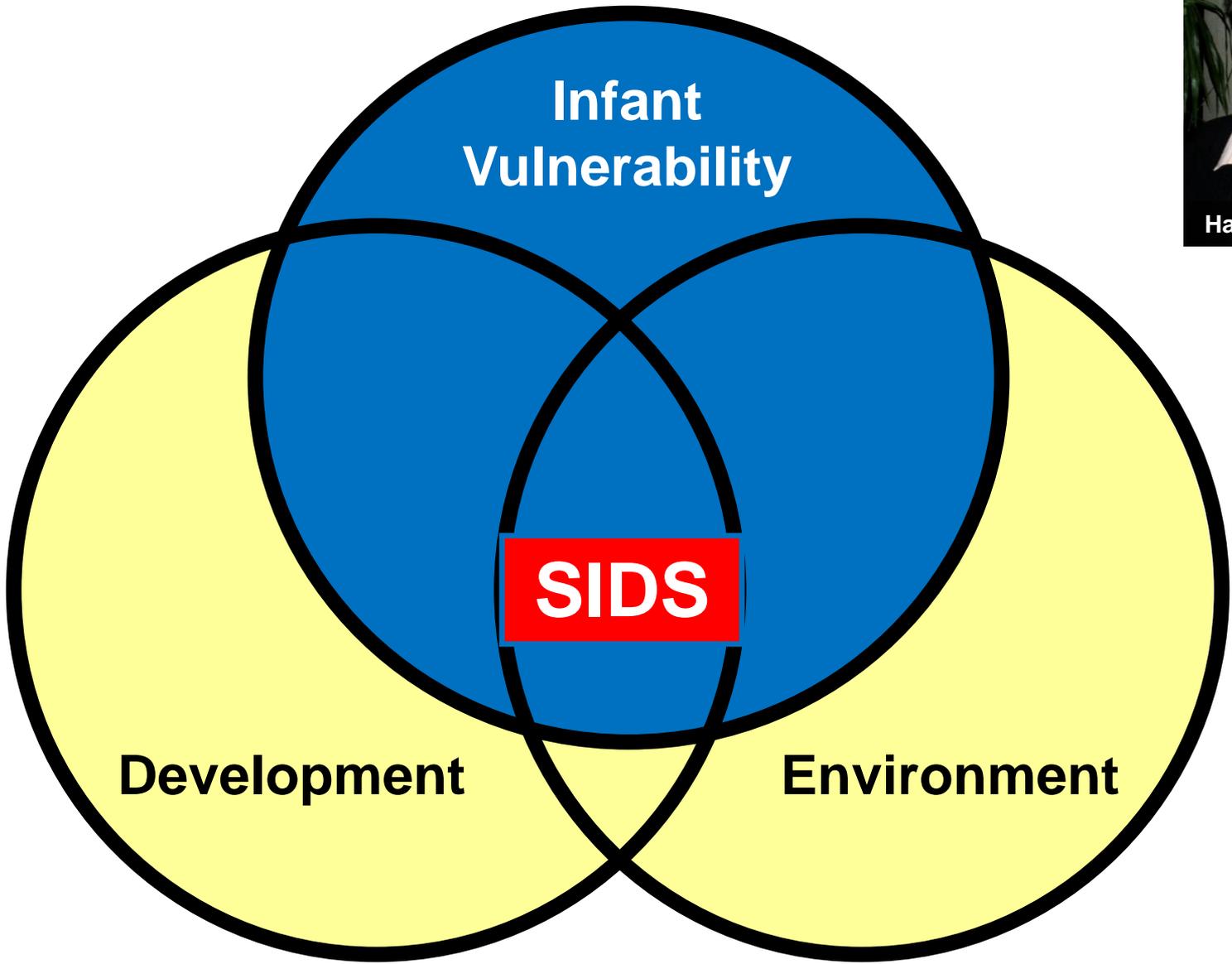




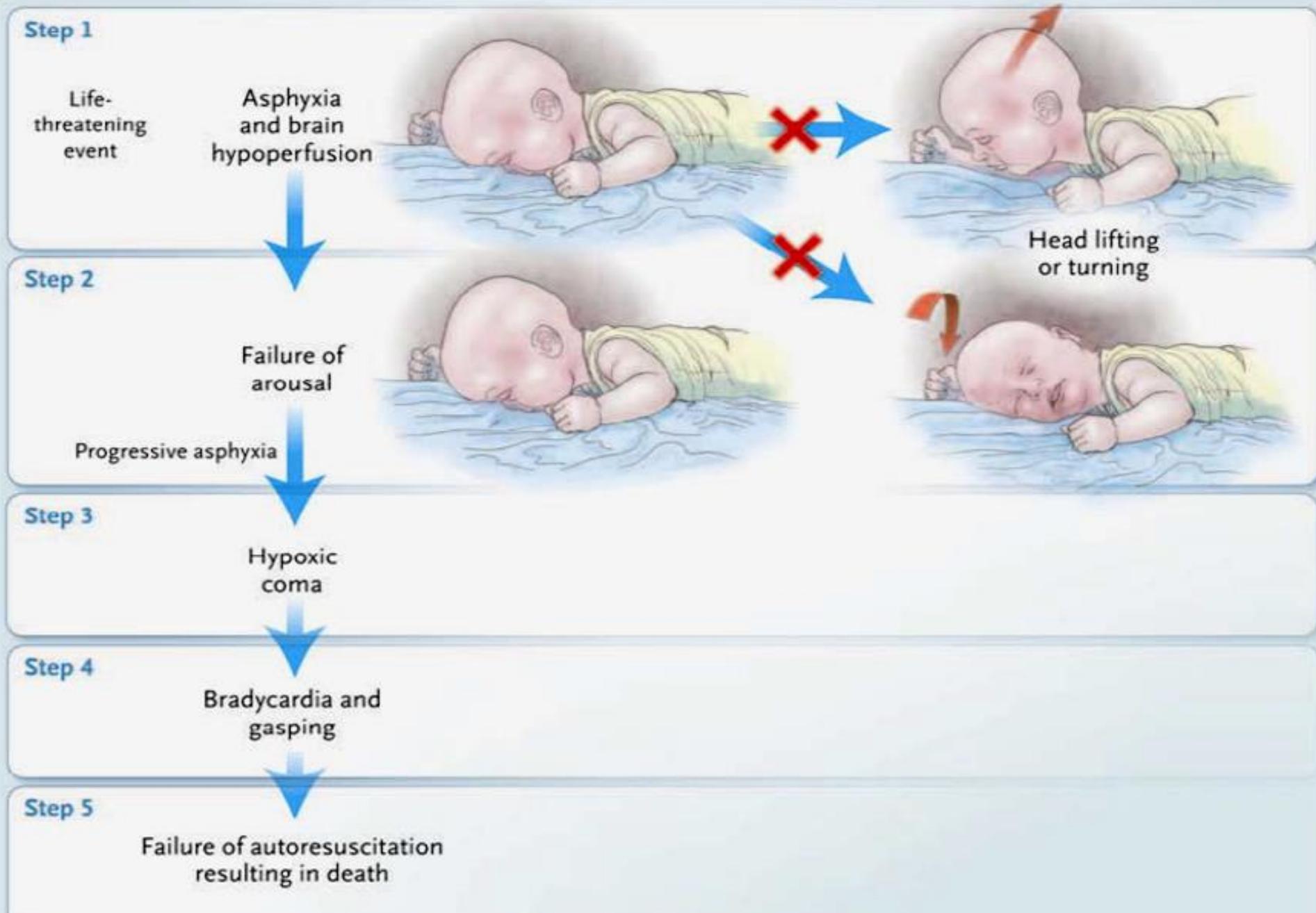
# Is SIDS a Catastrophic Physiologic Crisis?



- **If normal infants do not precisely control breathing, heart rate, and oxygenation ...**
- **Then SIDS may not have to be a catastrophic physiological crisis.**
- **Maybe it just needs to be a small problem which nudges or pushes a vulnerable infant over the edge.**

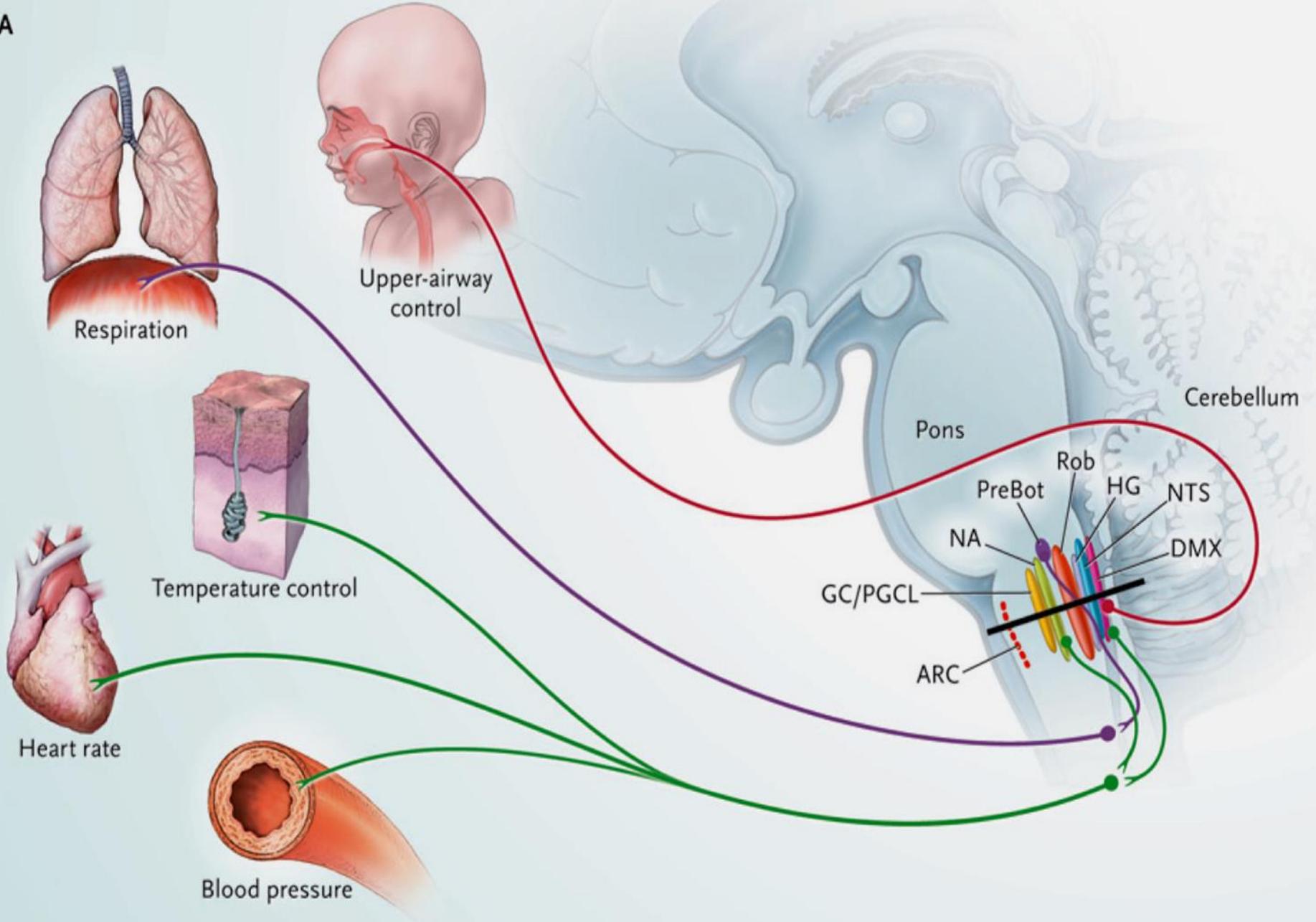


Filiano, J.J., and H.C. Kinney. *Biol. Neonate*, 65: 194-197, 1994.

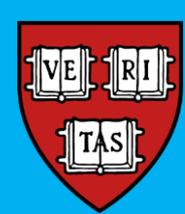


**Kinney, H.C., and B.T. Thach. *N. Eng. J. Med.*, 361: 795-805, 2009.**

A



**Kinney, H.C., and B.T. Thach. *N. Eng. J. Med.*, 361: 795-805, 2009.**



# Brainstem Neurotransmitters in SIDS



- **Brainstem is the *life support* portion of the brain.**
- **Autopsy studies found decreased serotonin (5-HT) and serotonergic neurotransmitter receptor binding activity in brainstems of SIDS vs controls infants.**

Panigrahy, A., et al. *J. Neuropath. Exp. Neurol.*, 59: 377-384, 2000.

Kinney, H.C., et al. *J. Neuropath. Exp. Neurol.*, 60: 228-247, 2001.

Kinney, H.C., et al. *J. Neuropath. Exp. Neurol.*, 62: 1178-1191, 2003.

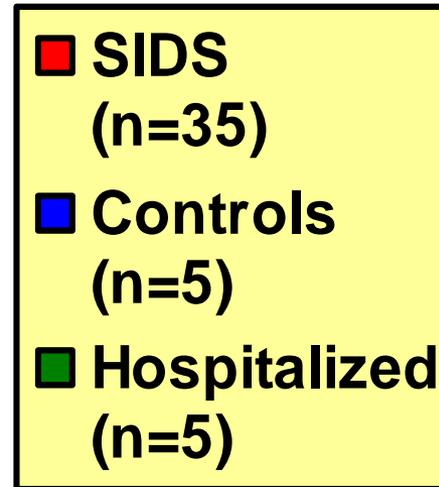
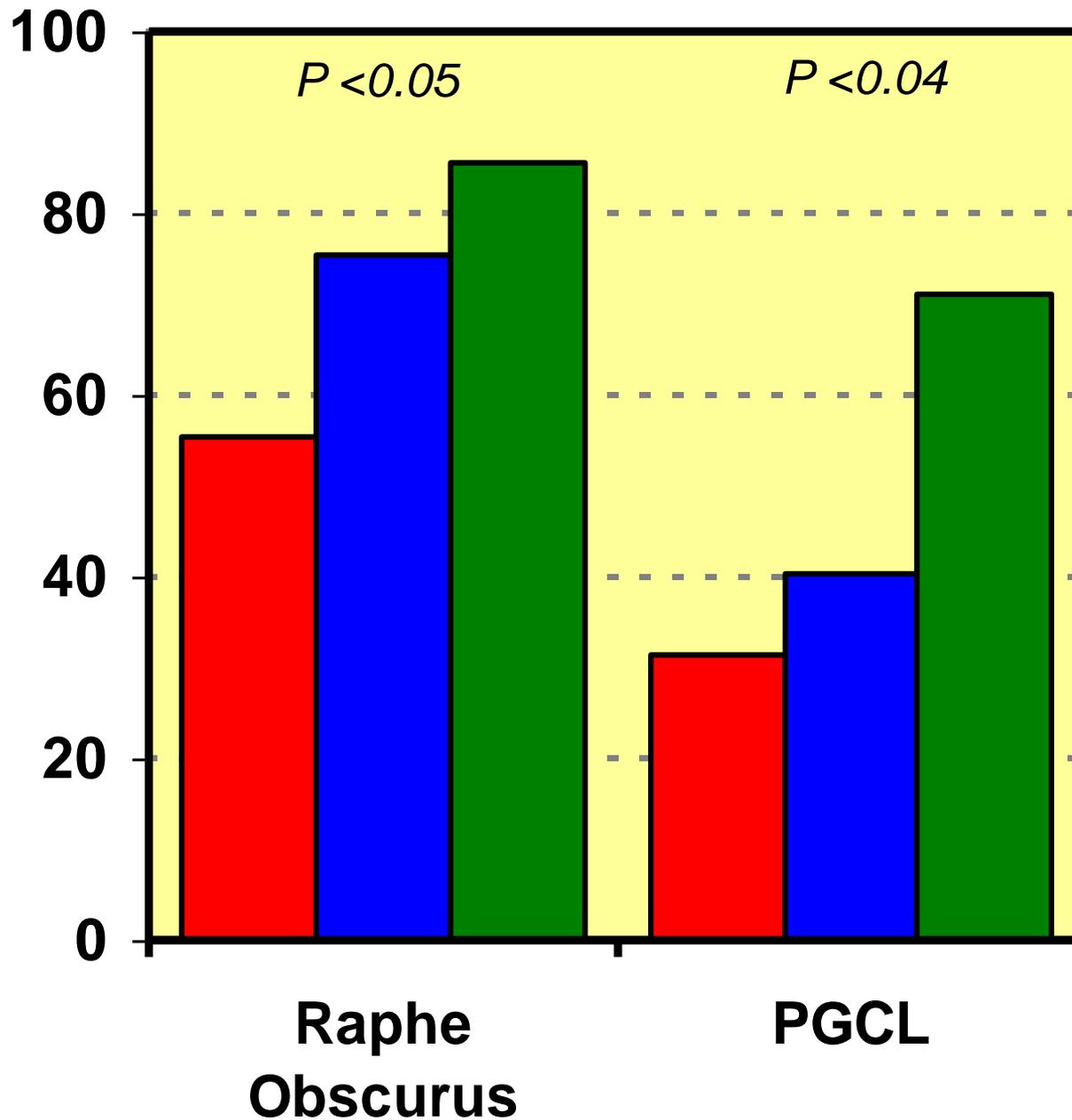
Paterson, D.S., et al. *J. Amer. Med. Assoc.*, 296: 2124-2132, 2006.

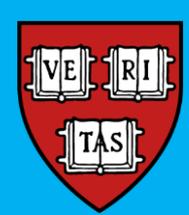
Duncan, J.R., et al. *J. Amer. Med. Assoc.*, 303: 430-437, 2010.

Randall, B.B., et al. *Pediatrics*, doi: 10.1542/peds.2013-0700. 2013.

Goldstein, R.D., et al. *Pediatrics*, 137: e20154661, 2016.

Brainstem Serotonin Concentration  
(pmol/mg)

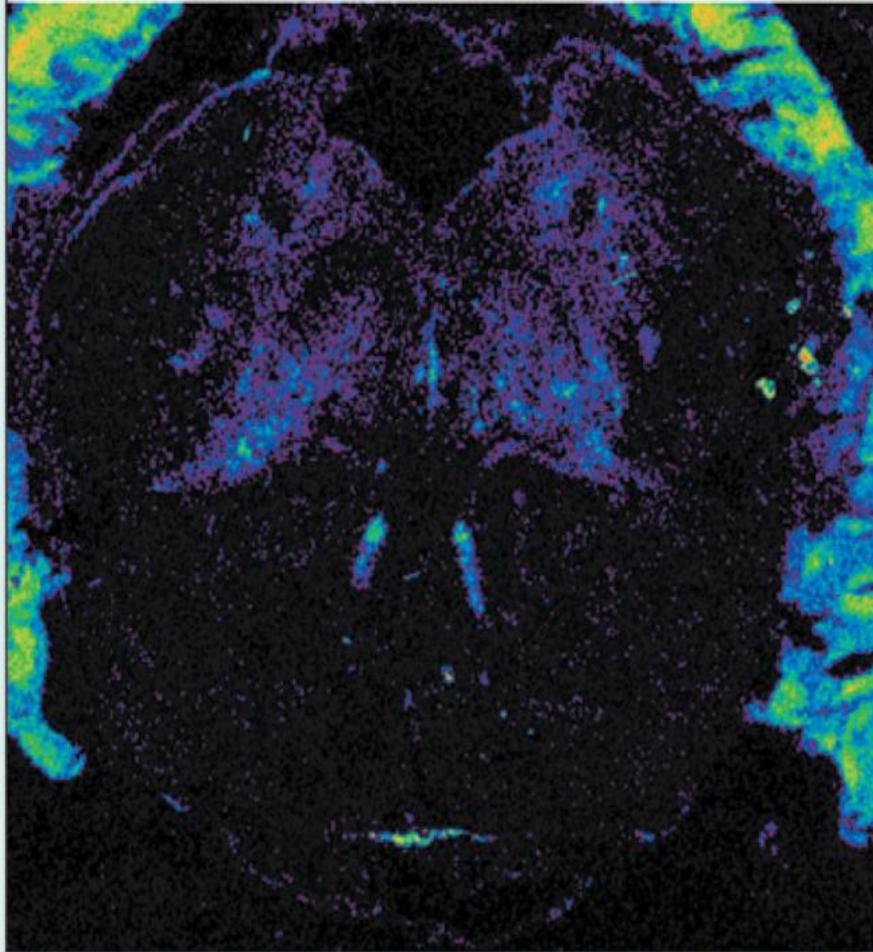




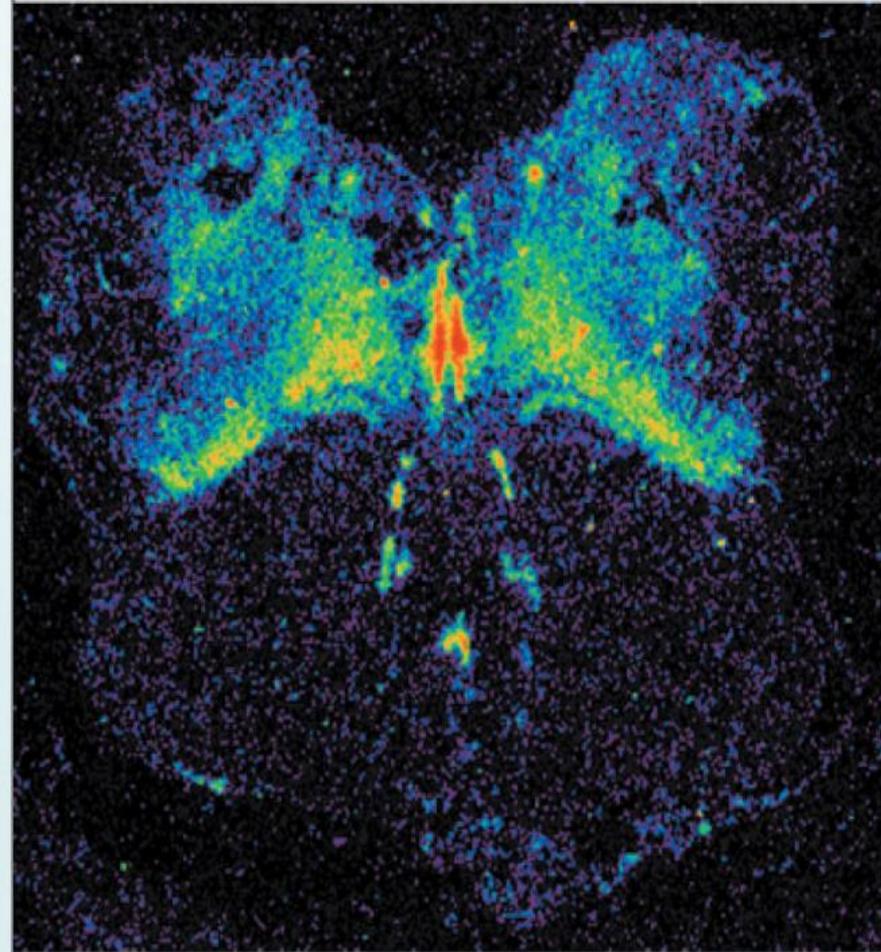
# 5-HT<sub>1A</sub> Receptor Binding Density in the SIDS Mid-Medulla



**B** Infant with Sudden Infant Death Syndrome



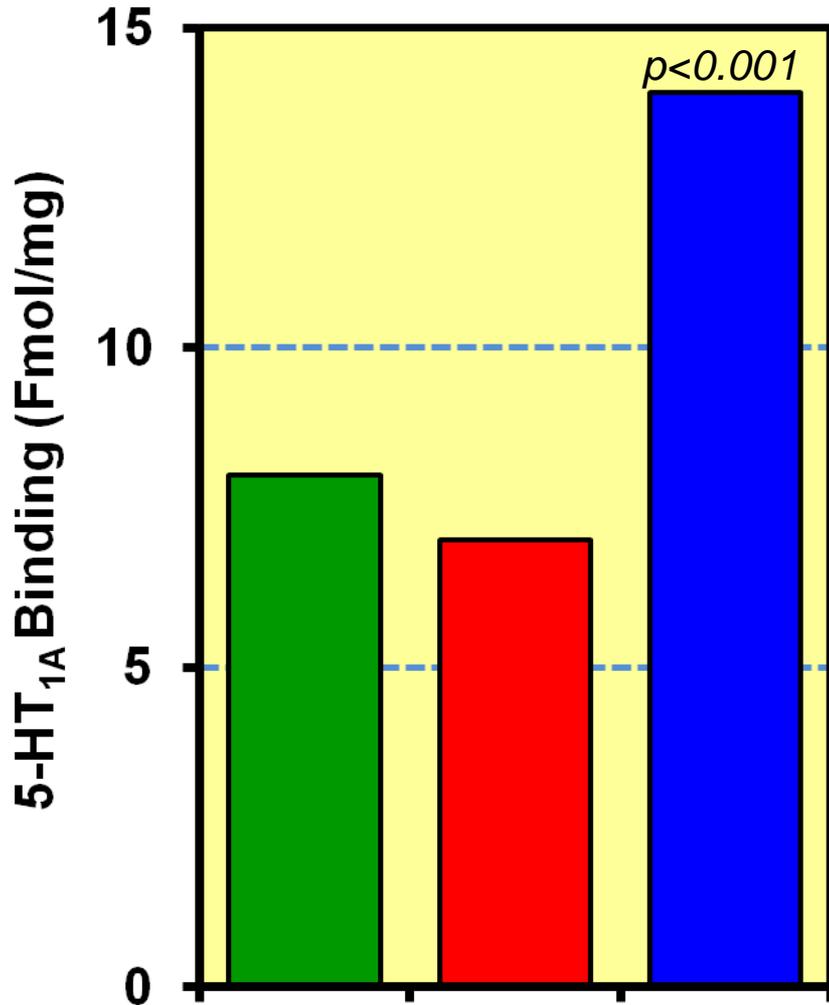
**C** Control Infant



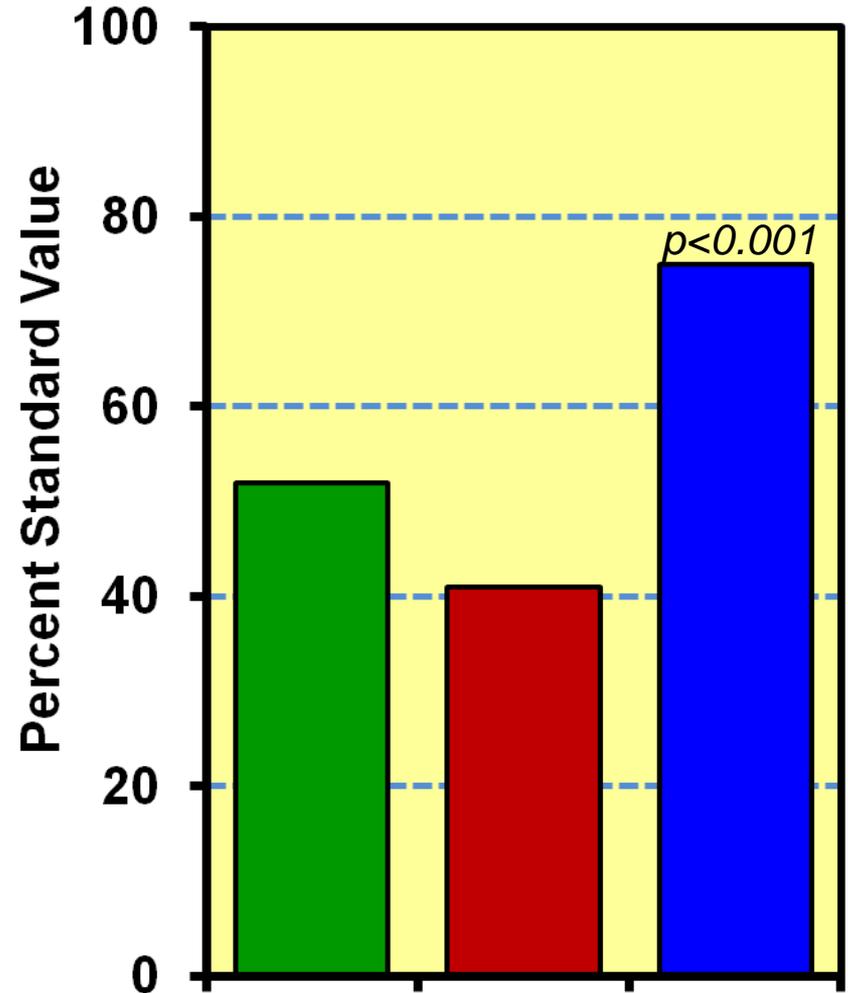
Paterson, D.S., et al. *J. Amer. Med. Assoc.*, 296: 2124-2132, 2006.

- Sudden death without Asphyxia
- Sudden death with Asphyxia
- Known Cause of Death

### Solitary Tract Nucleus



### Gigantocellularis



# Brain Abnormality

**Small**

**Intermediate**

**Severe**

**Accidental  
Asphyxia or  
Suffocation**

**Sudden  
Death with  
Asphyxia**

**Sudden Death  
without  
Asphyxia**

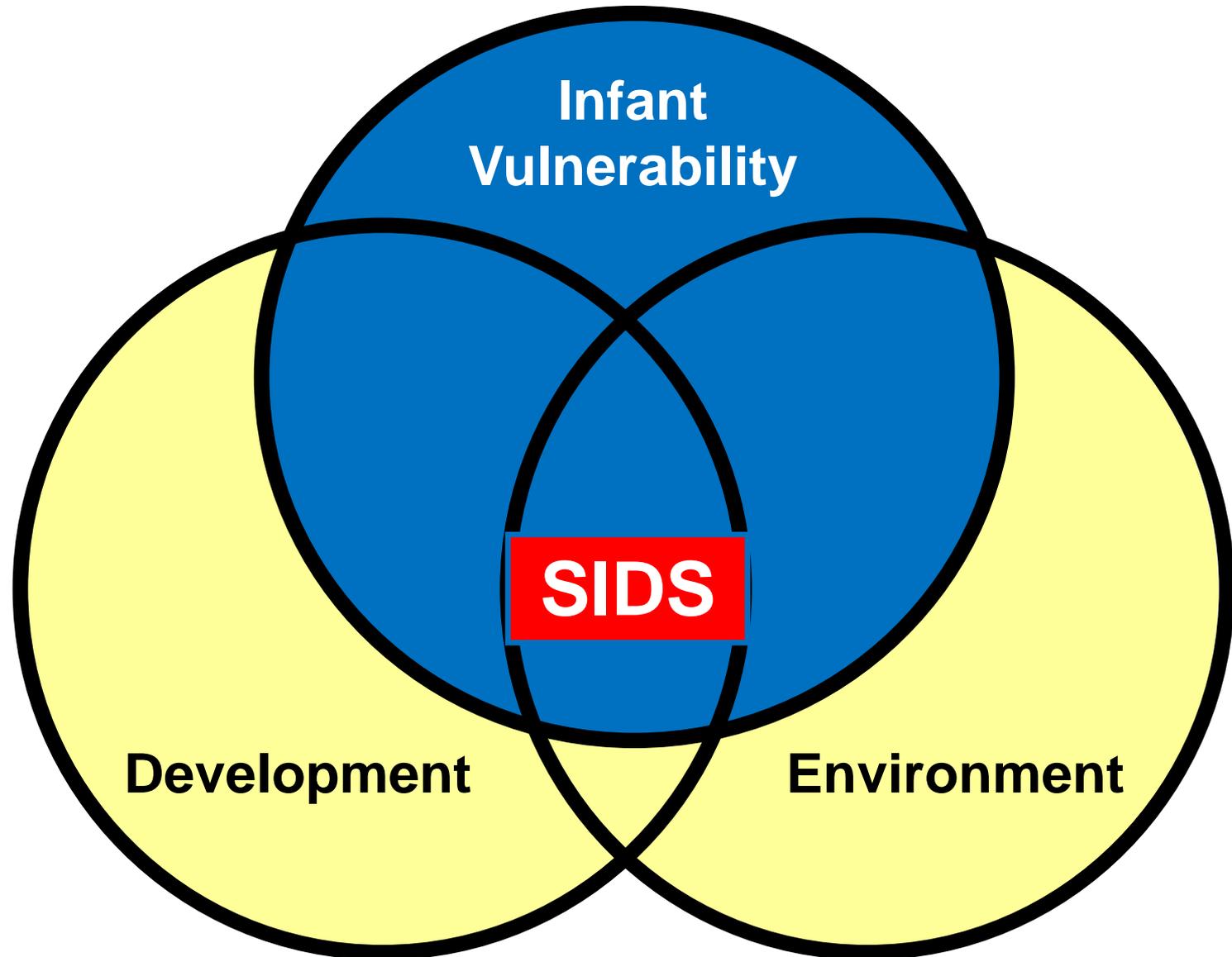
# Asphyxial Insult

**Severe**

**Intermediate**

**Small**

# Infant Vulnerability may have Many Causes



Filiano, J.J., and H.C. Kinney. *Biol. Neonate*, 65: 194-197, 1994.

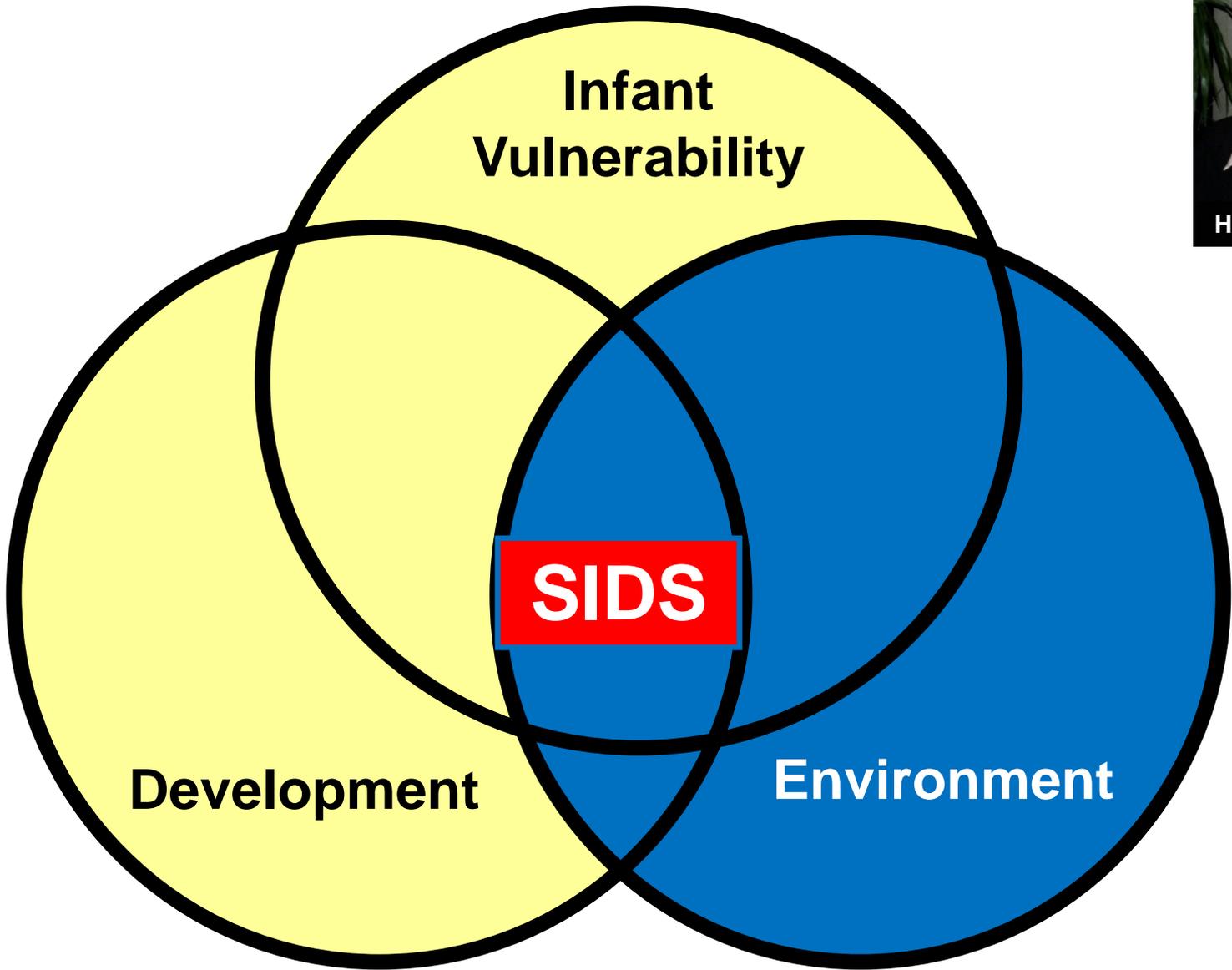
Imagine a car driving up a steep mountain road. The car has stopped. Why can't the car continue up the hill?

## A New Way of Thinking:

- Some cars are Ferrari's.
- Some cars are Jeep's.

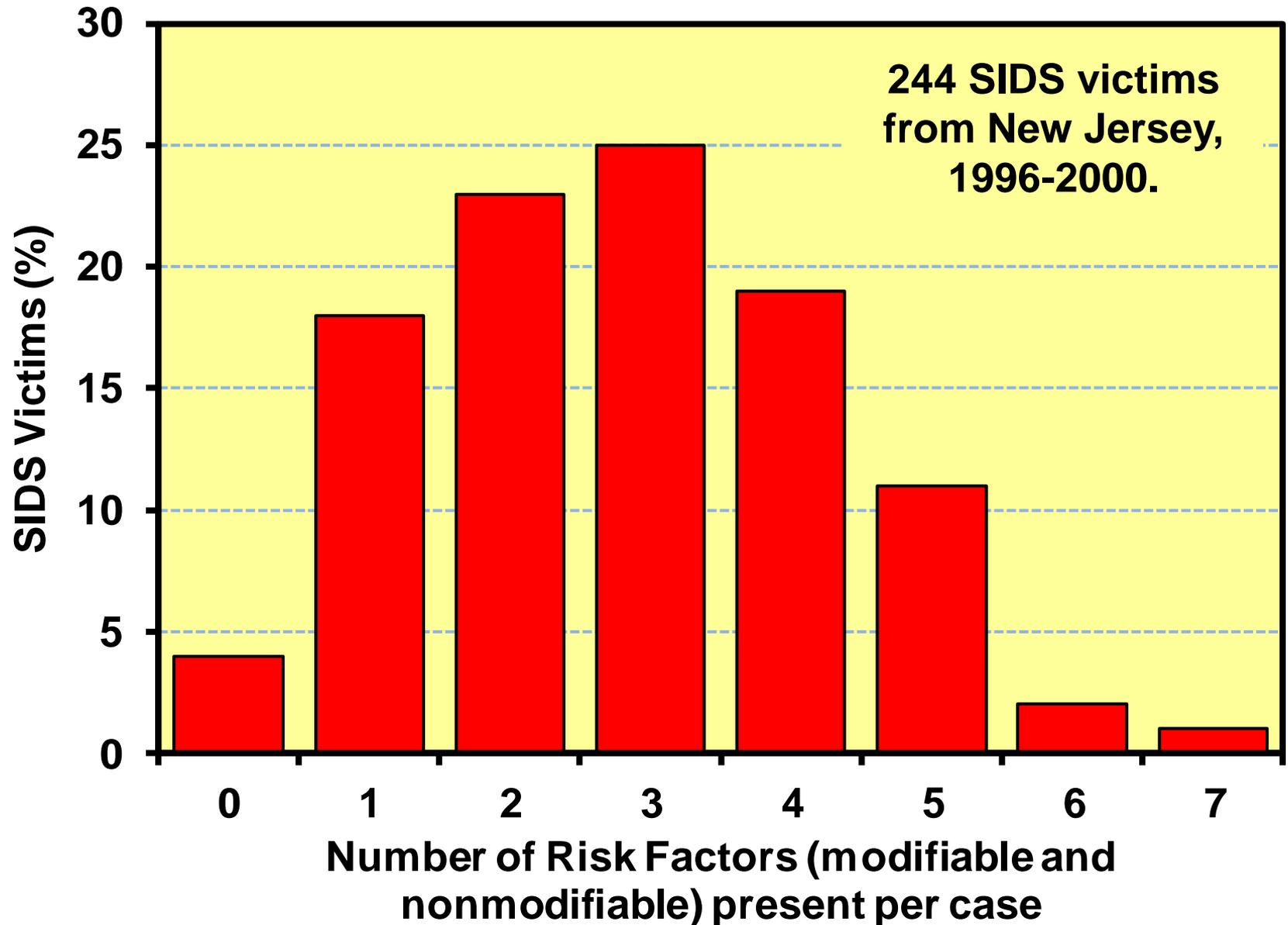


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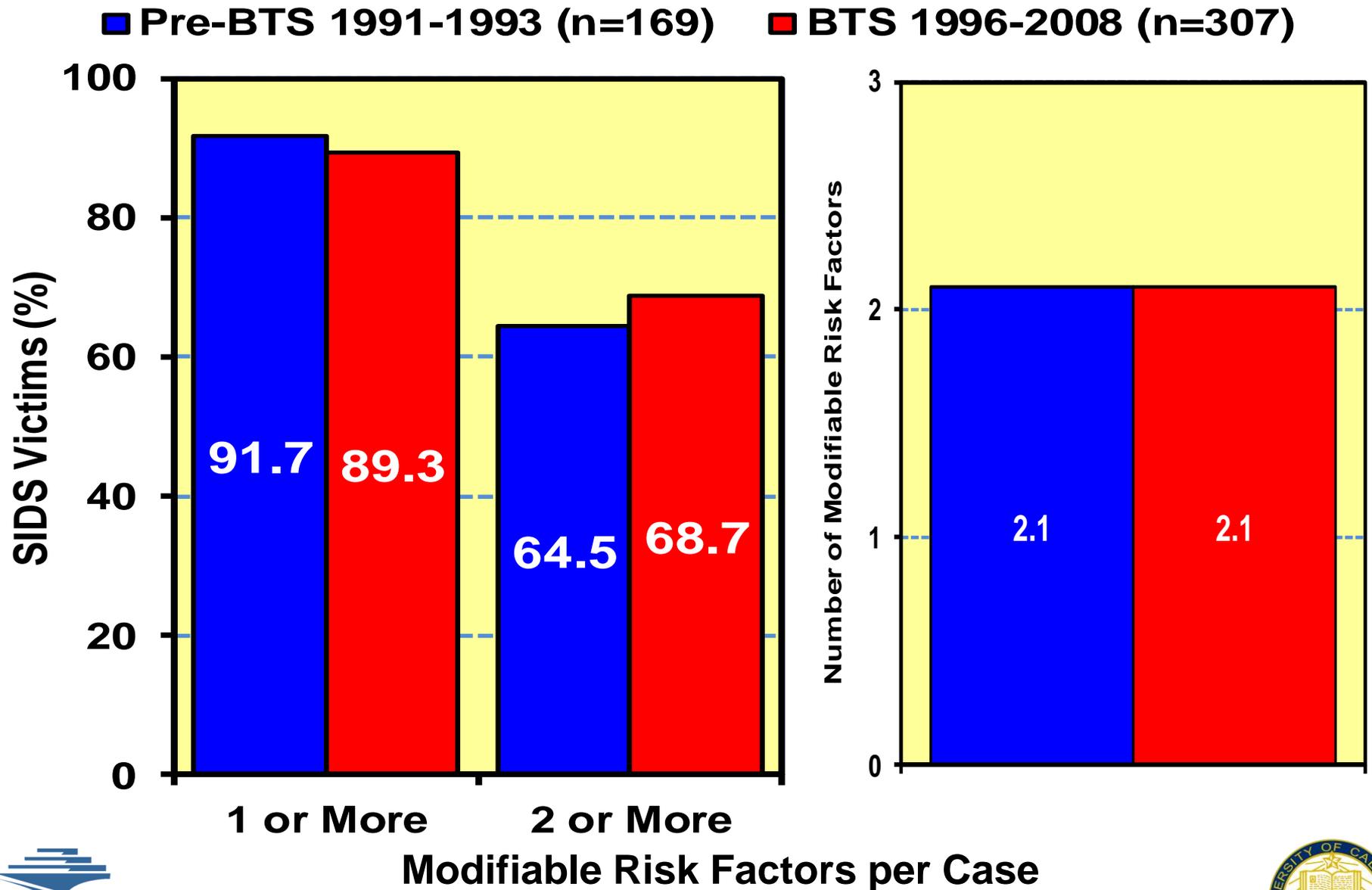
Filiano, J.J., and H.C. Kinney. *Biol. Neonate*, 65: 194-197, 1994.

# The majority of SIDS victims have $\geq 1$ Risk Factor



Ostfeld, B.M., et al. *Pediatrics*, 125: 447-453, 2010.

# The majority of SIDS victims have $\geq 1$ Risk Factor



# How can we, as a population, reduce the risks of SIDS?



Keck School  
of Medicine  
of USC



USC



USC  
University of  
Southern California

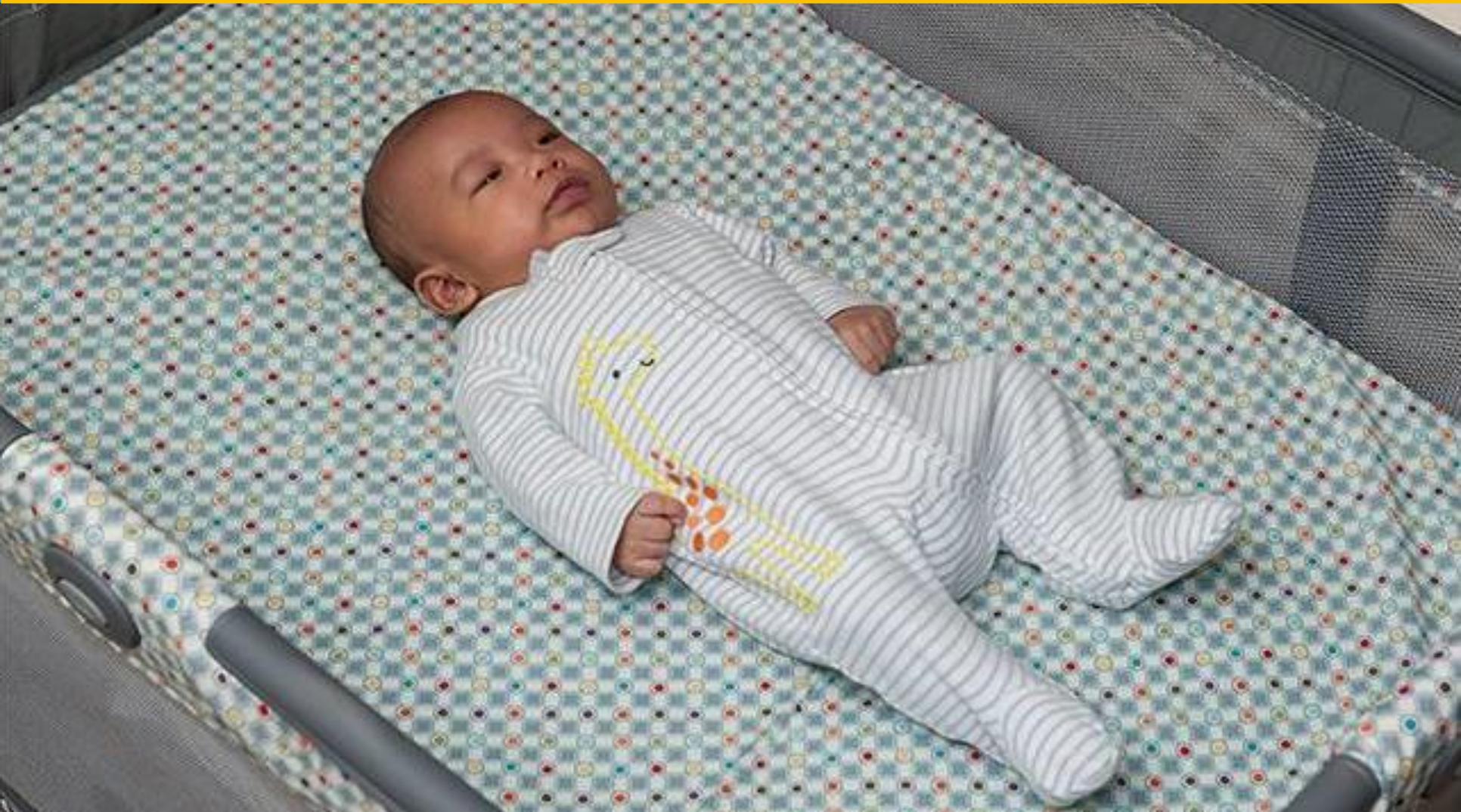


# **Risk Factors $\neq$ Causes**

- **Most infants with risk factors will not die from SIDS.**
- **Some infants without risk factors will die from SIDS.**
- **However, infants with risk factors are at increased risk of dying from SIDS.**



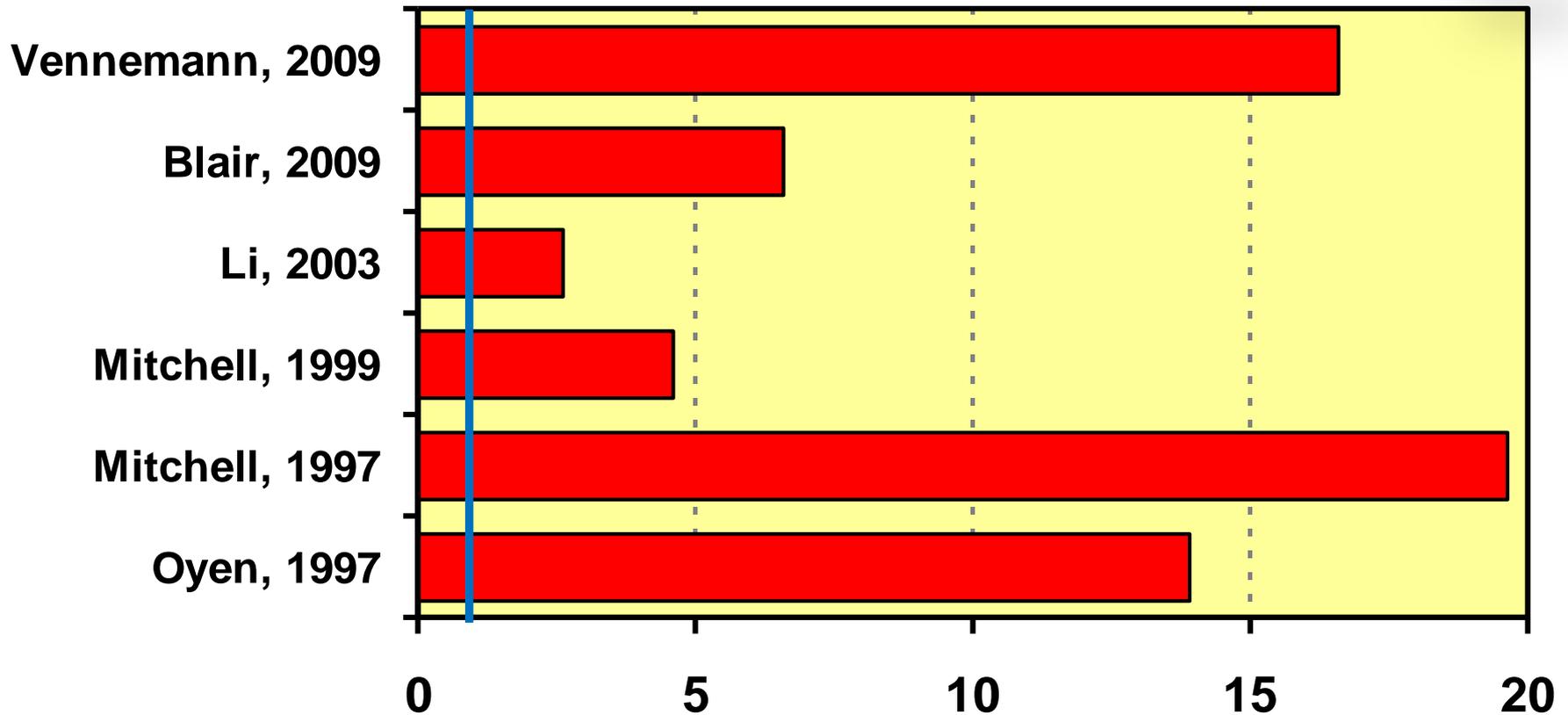
# Babies Should Sleep on their Backs for Every Sleep



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**

<http://www.medscape.com/features/slideshow/safe-sleep-principles?>

# Prone Sleeping and SIDS (Odds Ratios vs Non-Prone Sleeping)



Vennemann, M.M., et al. *Pediatrics*, 123: 1162-1170, 2009.

Blair, P.S., et al. *B.M.J.*, 339: b3666, 2009.

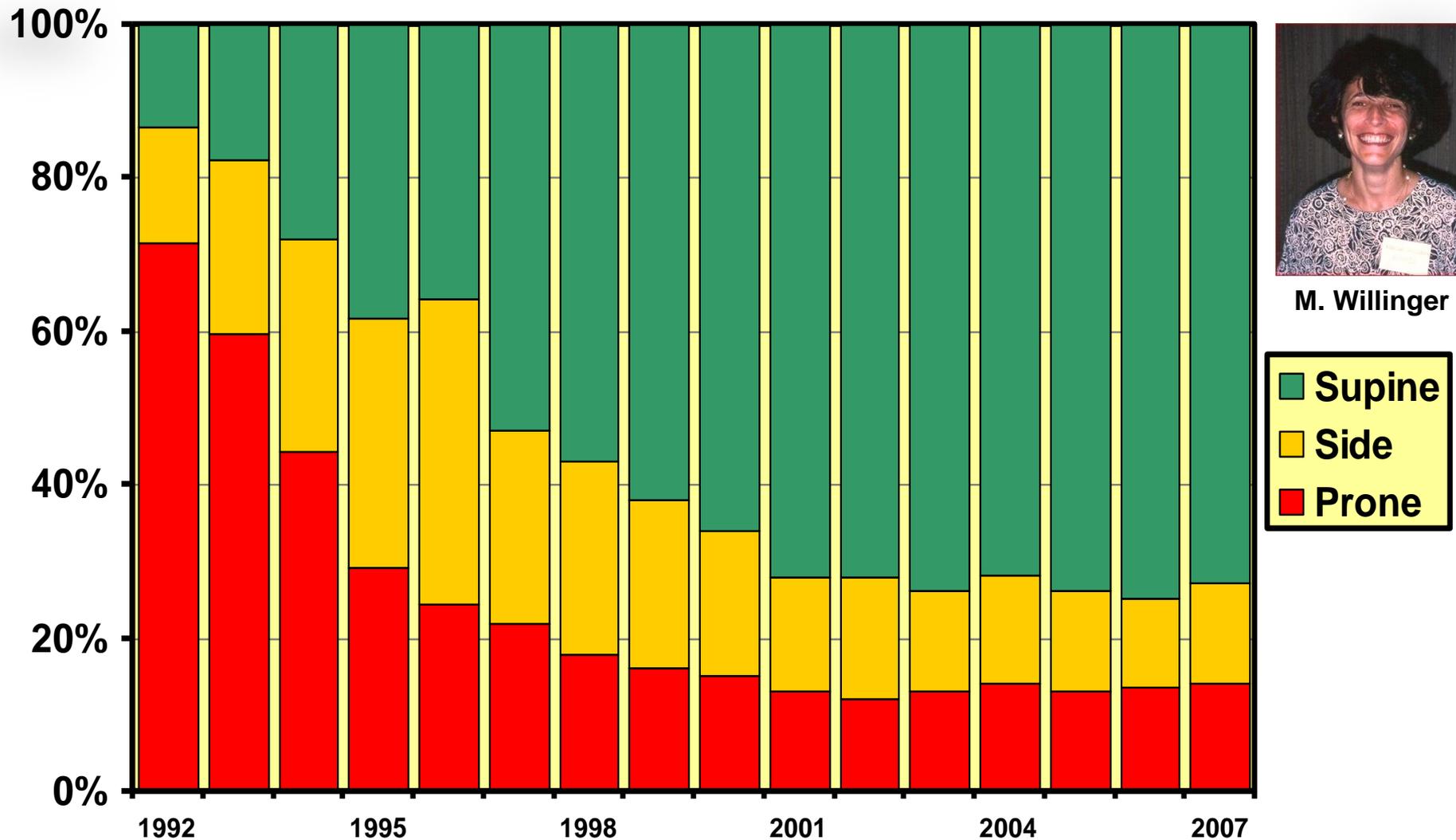
Li, D-K, et al. *Am. J. Epidemiol.*, 157: 446-455, 2003.

Mitchell, E.A., et al. *Arch. Pediatr. Adolesc. Med.*, 153: 1136-1141, 1999.

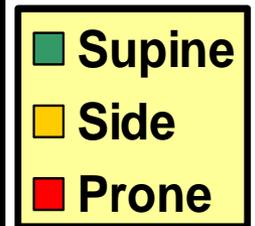
Mitchell, E.A., et al. *Pediatrics*, 100: 835-840, 1997.

Oyen, N., et al. *Pediatrics*, 100: 613-621, 1997.

# National Infant Sleep Position Study (U.S.A.)

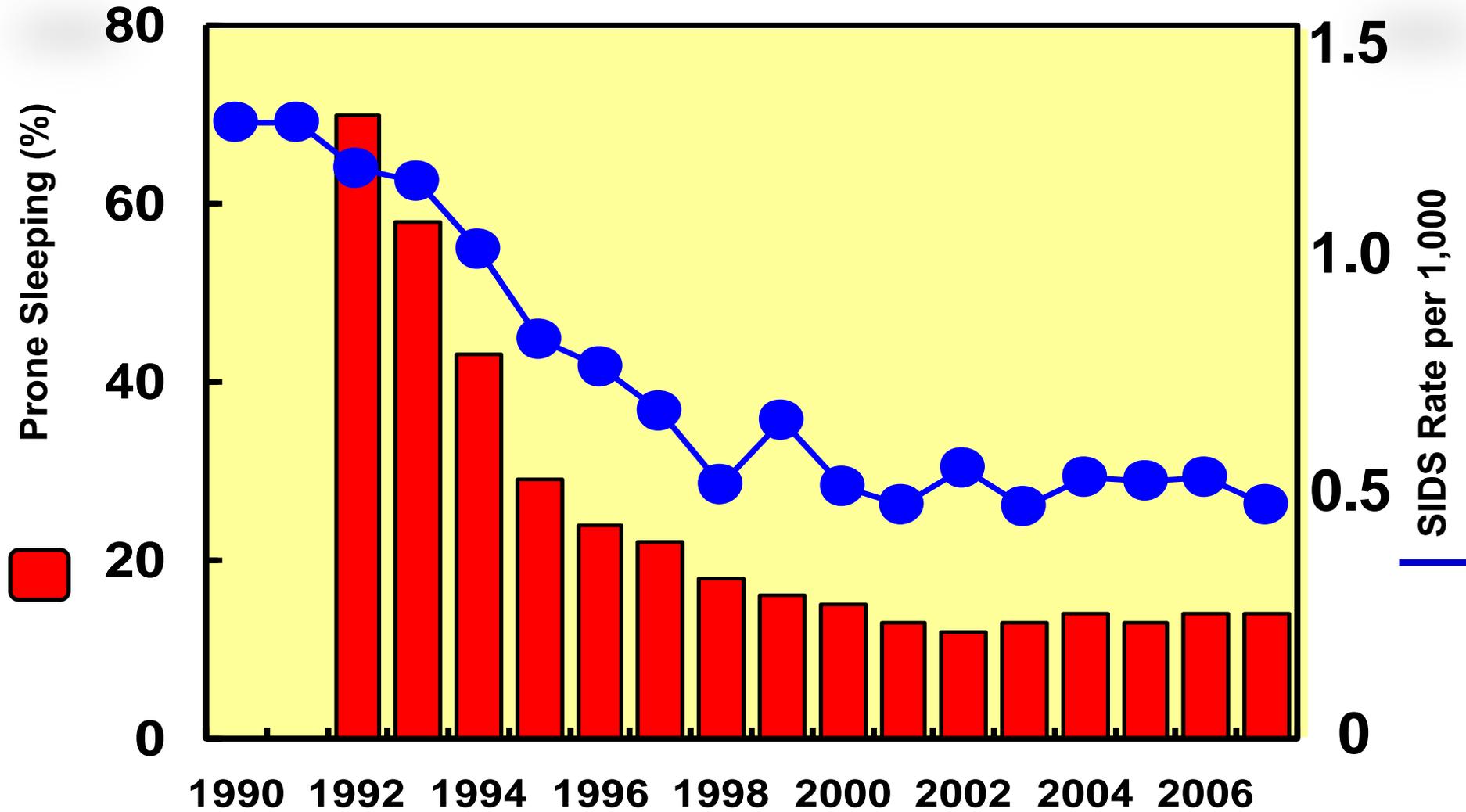


M. Willinger



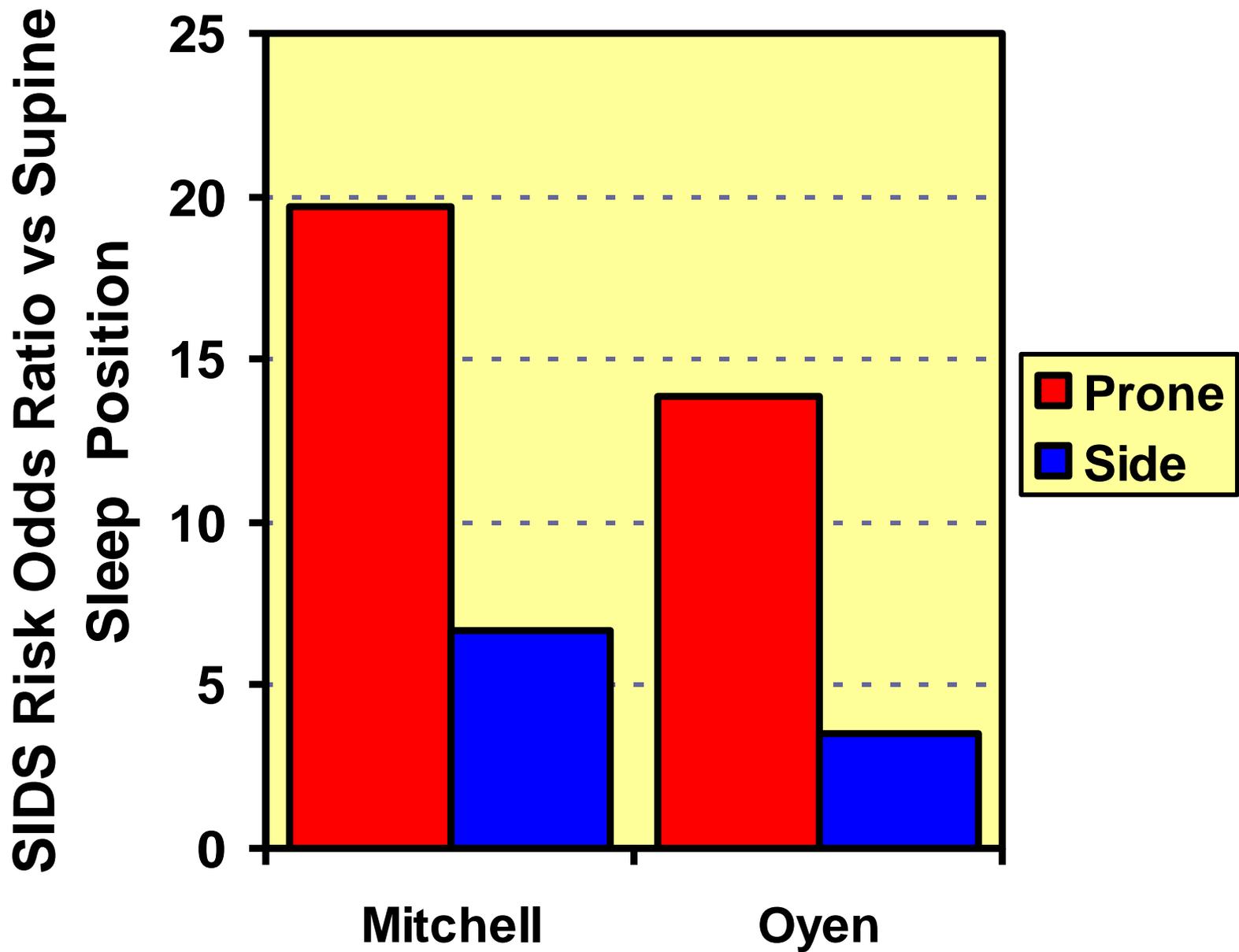
Willinger, M., et al. *J. Amer. Med. Assoc.*, 280: 329-335, 1998.

Colson, E.R., et al. *Arch. Pediatr. Adolesc. Med.*, 163: 1122-1128, 2009.



M. Willinger, et al. *J. Amer. Med. Assoc.*, 280: 329-335, 1998.

Colson, E.R., et al. *Arch. Pediatr. Adolesc. Med.*, 163: 1122-1128, 2009.

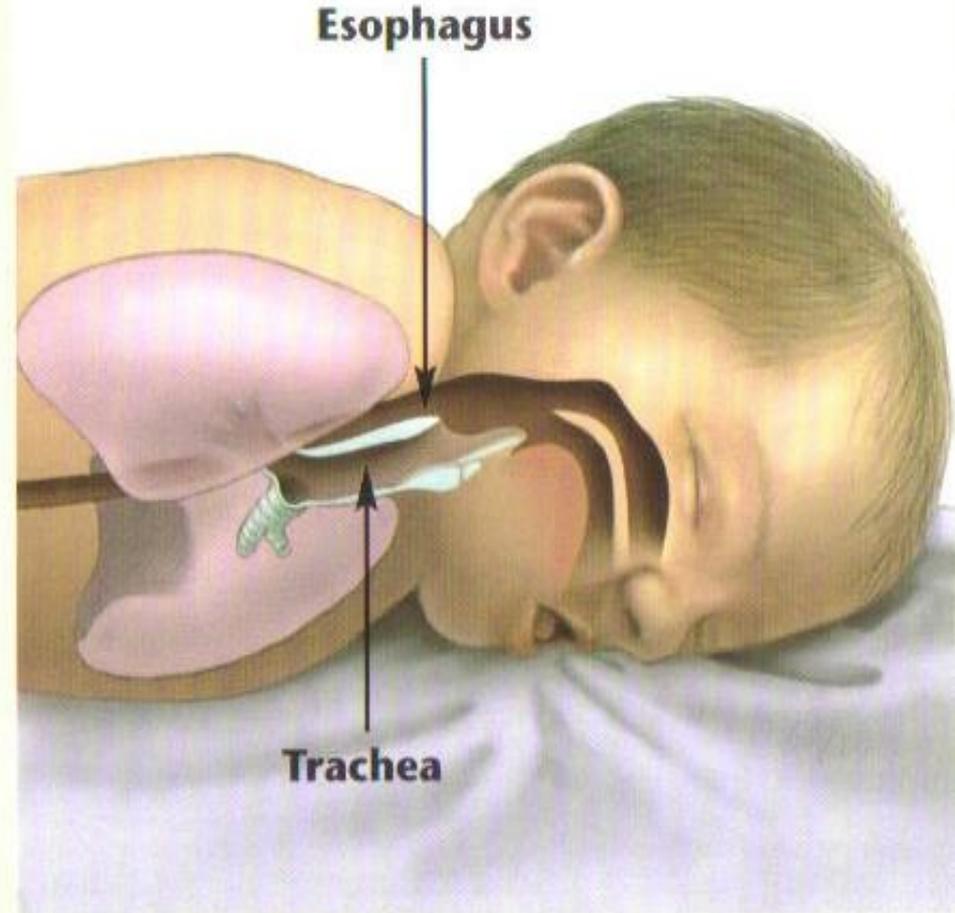
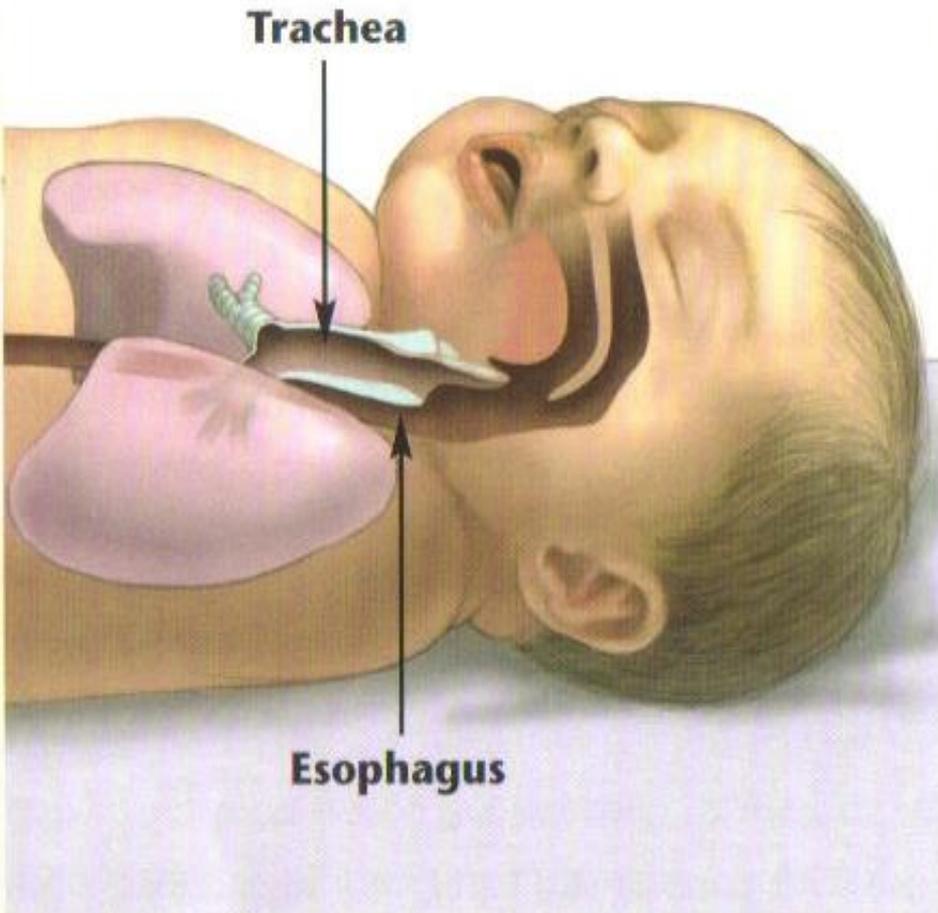


Mitchell, E.A., et al. *Pediatrics*, 100: 835-840, 1997.

Oyen, N., et al. *Pediatrics*, 100: 613-621, 1997.

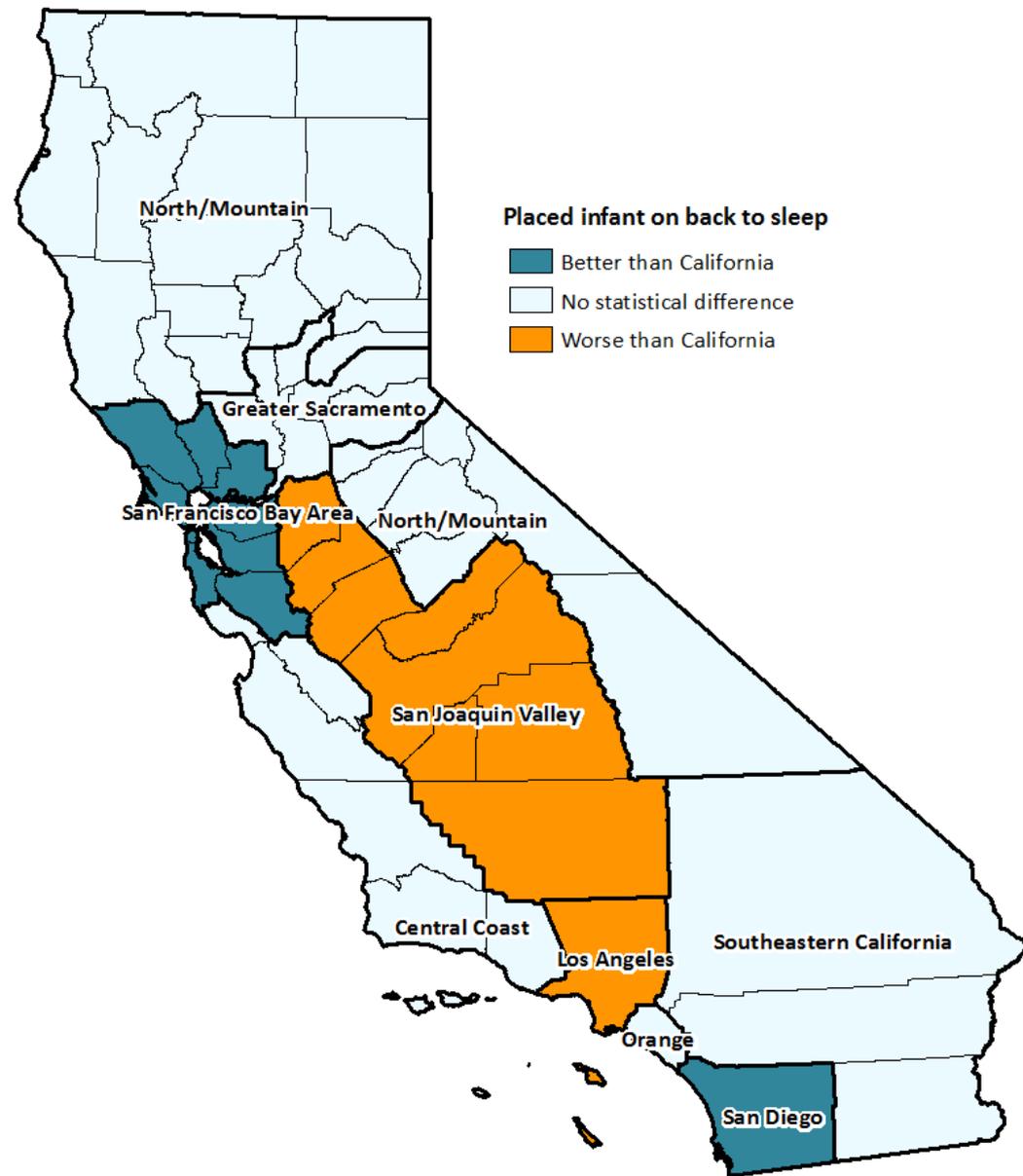
# Supine

# Prone



**SIDS Risk Reduction: Curriculum for Nurses, NICHD, 2006.  
NIH Publication No. 06-6005.**

**California  
Infants  
Placed on  
the Back to  
Sleep:  
76.1%**



Maternal and Infant Health Assessment Survey Prepared by: Maternal, Child and Adolescent Health Program, Center for Family Health, California Department of Public Health

<http://www.cdph.ca.gov/data/surveys/MIHA/MIHAComparisonMaps/CompareRegSleepPos2012.pdf>



# Use a Firm Sleep Surface. Firm Crib Mattress and Fitted Sheet



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**

<http://www.medscape.com/features/slideshow/safe-sleep-principles?>



# Sitting Devices are Not Recommended for Routine Sleep



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**  
<http://www.medscape.com/features/slideshow/safe-sleep-principles?>



# Roomsharing, Without Bedsharing, is Recommended.



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**

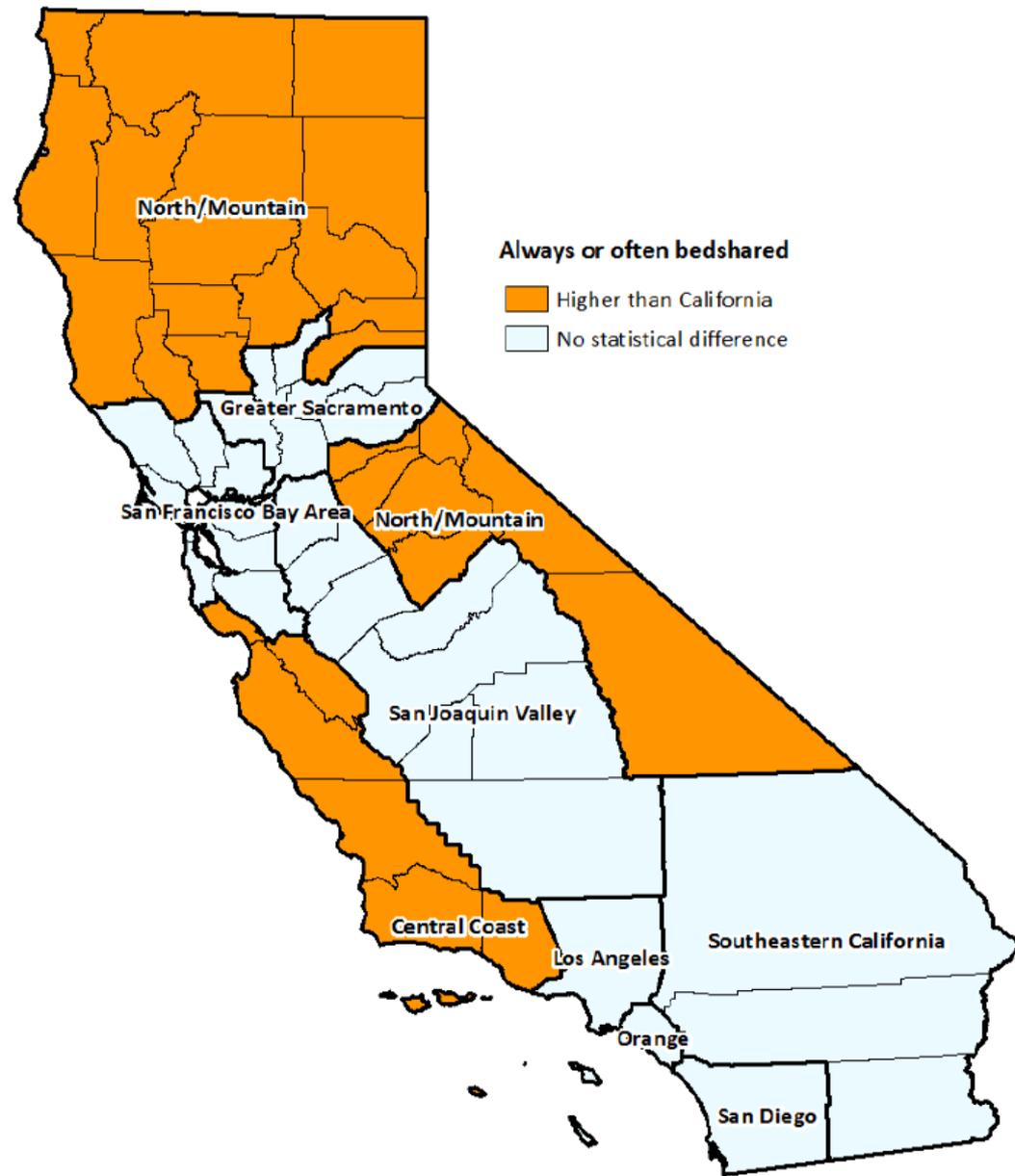
<http://www.medscape.com/features/slideshow/safe-sleep-principles?>

# Early Study of Maternal Overlaying

- In 1892, a Scottish police surgeon, Templeman, first drew attention to the potential role of excessive alcohol consumption and overlaying.
- 258 cases of suffocation in infants.
- More than half of deaths occurred Saturday night.
- Postulated that intoxication impaired arousal responses of parents sleeping with infants, thus increasing the risk of accidental suffocation.

**Templeman, C. *Edinburgh Med. J.*, 38: 322-329, 1892.**

**California  
Infants  
Who  
Always or  
Often  
Bedshare:  
39.3%**



Data Source: Maternal and Infant Health Assessment Survey Prepared by: Maternal, Child and Adolescent Health Program, Center for Family Health, California Department of Public Health

<http://www.cdph.ca.gov/data/surveys/MIHA/MIHAComparisonMaps/CompareRegBedshare2011.pdf>



# Bedsharing, Breathing, and Infant Sleep



- Increased breastfeeding, but not when compared to room-sharing.
- No decrease in apnea.
- No stimulation of breathing.
- Increased arousals (baby wakes mother).
- Decrease in deep sleep.
- No apparent physiological protection.

Richard, C., et al. *Sleep*, 19: 685-690, 214-219, 1996.

McKenna, J.J., et al. *Pediatrics*, 100: 214-219, 1997.

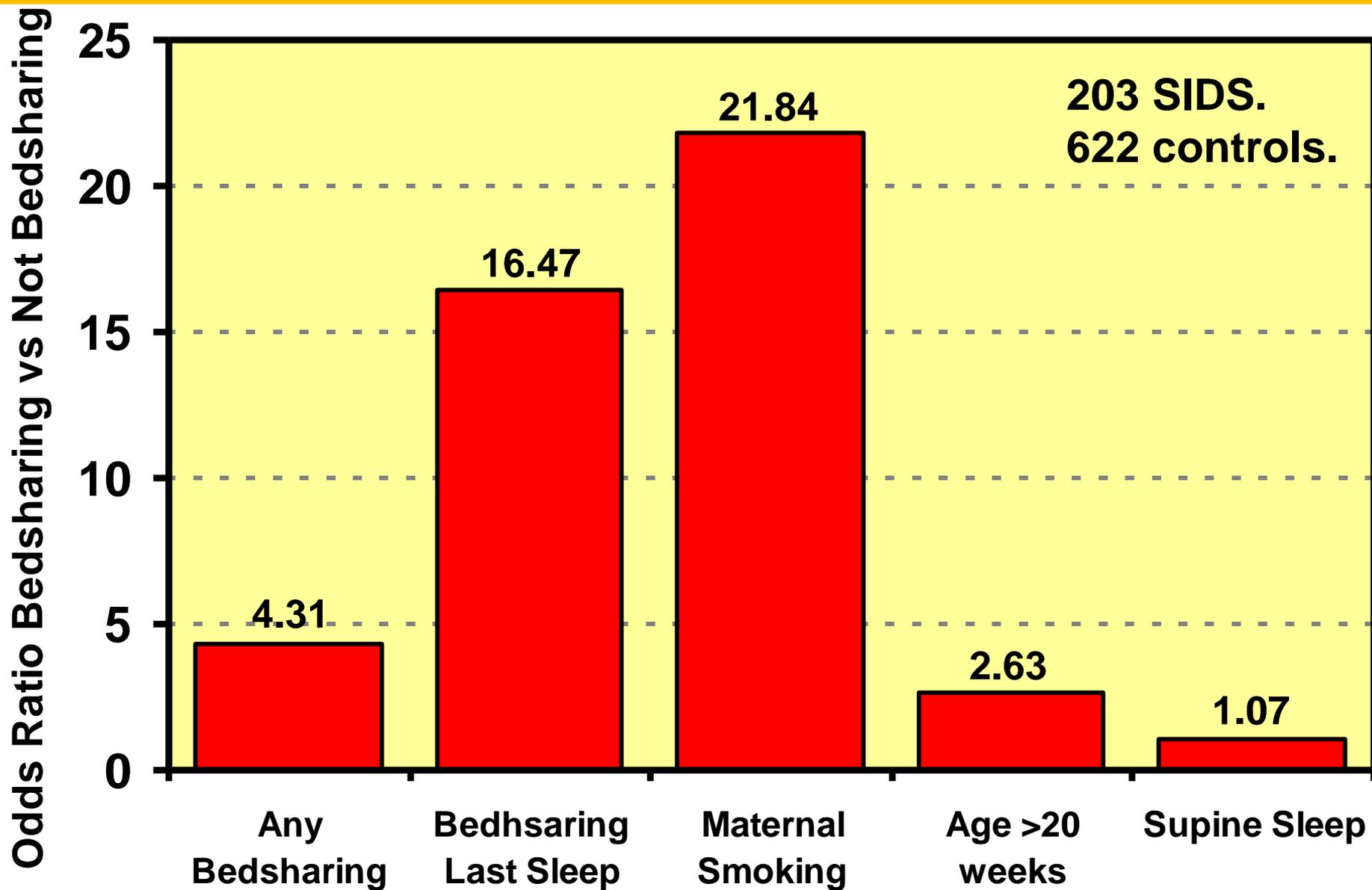
Mosko, S., et al. *Am. J. Physical Anthropol.*, 103: 315-328, 1997.

Richard, C.A., et al. *J. Appl. Physiol.*, 84: 1374-1380, 1998.

McKenna, J.J., and T. McDade. *Paediatr. Respir. Rev.*, 6: 134-152, 2005.

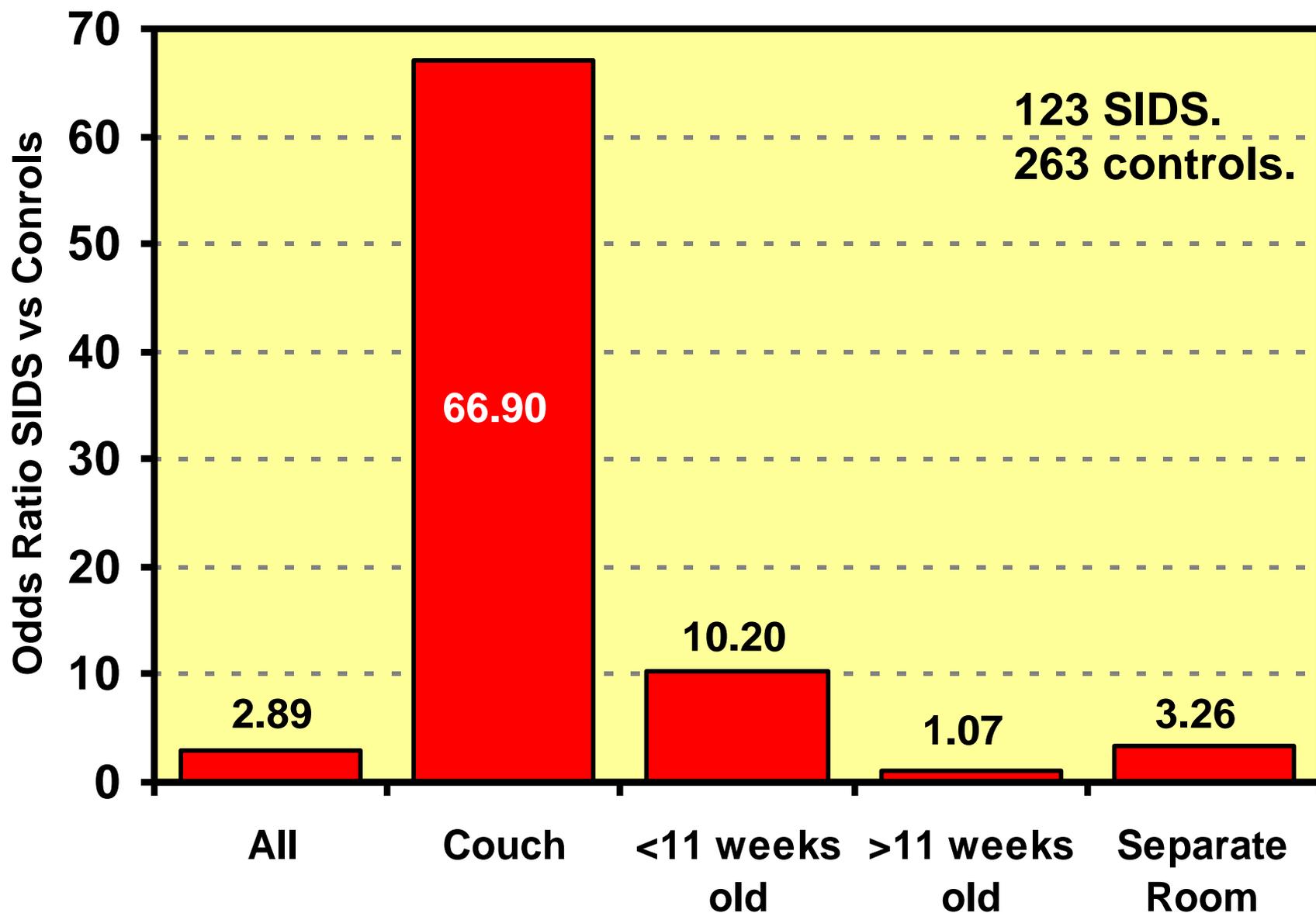
Ball, H.L., et al. *Arch. Dis. Child.*, 91: 1005-1010, 2006.

# Bedsharing and SIDS in Ireland, 1994-1998



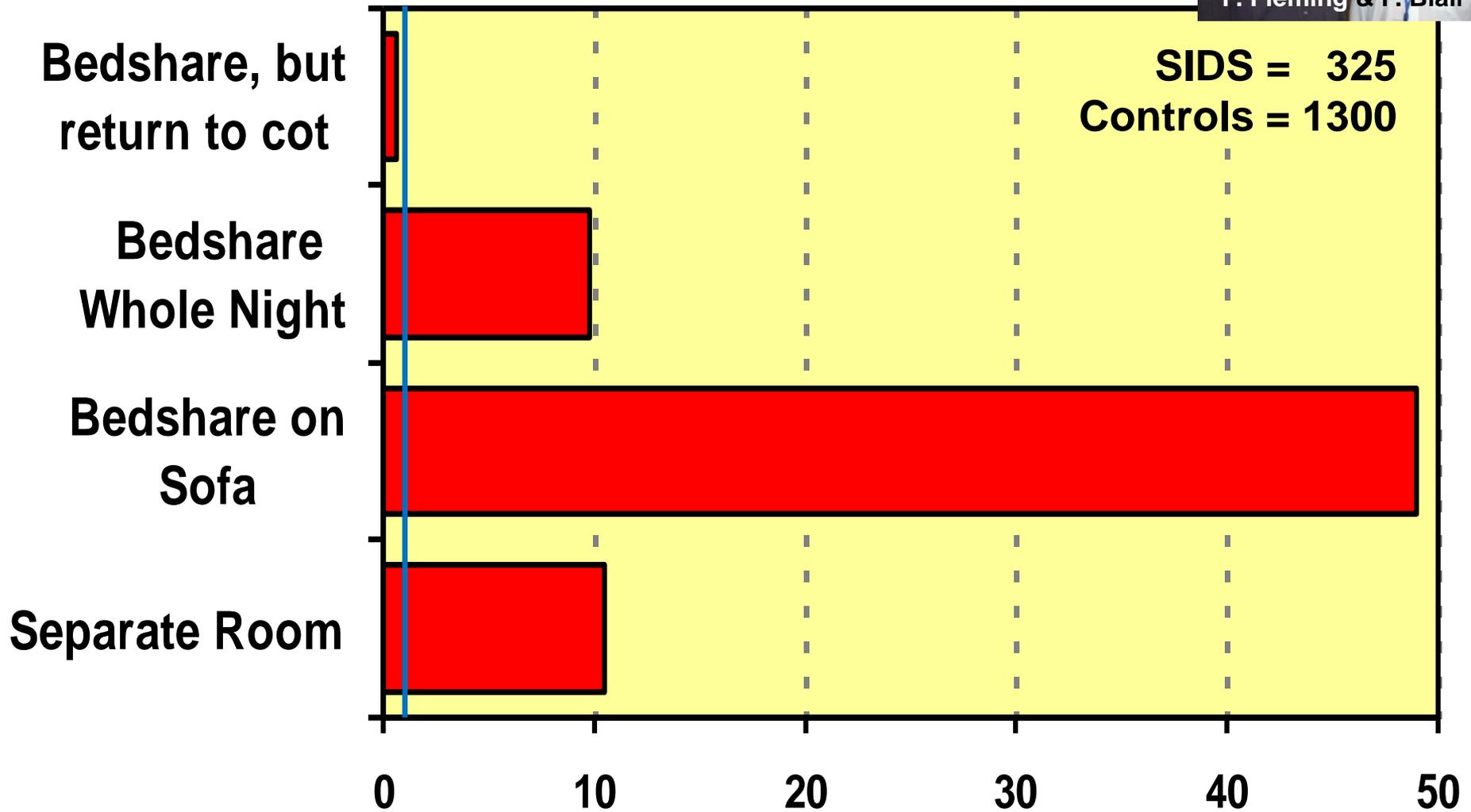
McGarvey, C., et al. *Arch. Dis. Child.*, 88: 1058-1064, 2003.

# Bedsharing and SIDS in Scotland, 1996-2000



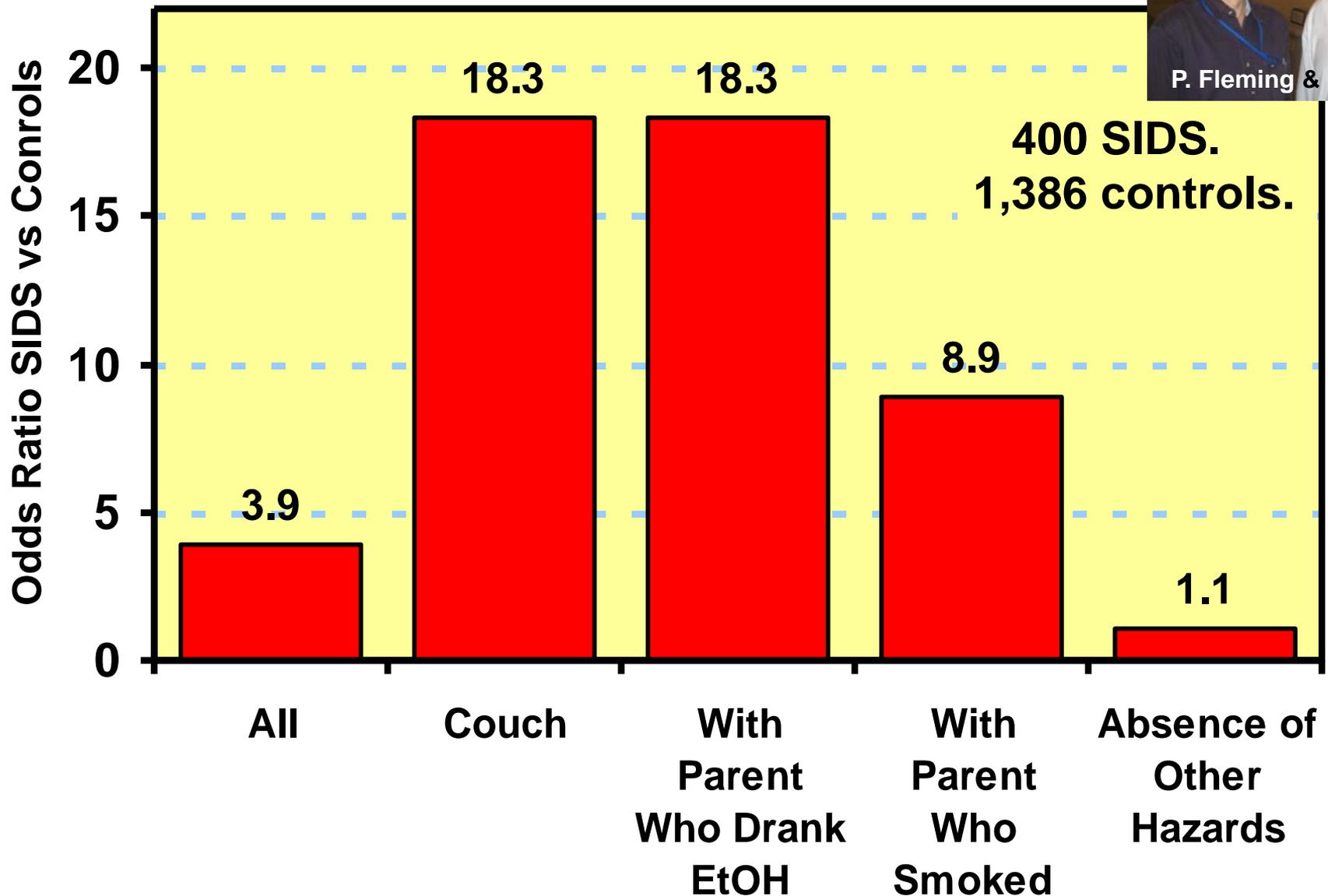
Tappin, D, et al. *J. Pediatr.*, 147: 32-37, 2005.

# Bedsharing and SIDS Risk: CESDI Study (Odds Ratios vs did not sleep with an adult)



Blair, P.S., et al. *Br. Med. J.*, 319: 457-462, 1999.

# Bedsharing and SIDS in the U.K.



Blair, P.S., et al. *PLoS ONE* 9(9): e107799. doi:10.1371, 2014.

# Roomsharing



- **Infant's crib or bassinet should be placed in the parents' bedroom close to the parents' bed.**
- **Infant can be brought to bed for breastfeeding, but then returned to the crib.**
- **Devices promoted to make bedsharing "safe" are not recommended.**



# Bedsharing is *Especially Unsafe with:*



- **Infant <3-months of age.**
- **Parent cigarette smoking.**
- **Parent is excessively tired; such as sleep deprivation (<4-hours sleep the previous night).**
- **Parent depressant medication or alcohol use.**
- **With non-parent or multiple persons.**
- **Soft or unsafe bed.**
- **Duvets, pillows, or soft covers.**
- **Sleeping on a sofa, armchair, or couch.**



# AAP Recommendations



- **Roomsharing, with the infant in a crib in the parents' room next to the adult bed, is safest, and is safer than bedsharing.**
- **Infants brought to bed for breastfeeding should return to a separate crib.**
- **Do not bedshare if parents smoke cigarettes.**
- **Do not bedshare if the parents' arousal is depressed (alcohol, drugs, sleep deprived <4-hours sleep the night before).**
- **Do not sleep with an infant on a sofa or chair.**



# Keep Soft Objects and Loose Bedding Out of the Crib



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**

<http://www.medscape.com/features/slideshow/safe-sleep-principles?>





# Consider Offering a Pacifier at Nap Time and Bedtime



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**



# Avoid Cigarette Smoke Exposure During Pregnancy and After Birth



AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.

BREATHING AREA

**NO SMOKING**

**NO VAPING**





**Avoid Overheating and Head Covering;  
Infants should not feel hot to touch.**



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**

<http://www.medscape.com/features/slideshow/safe-sleep-principles?>



**Infants Should be Immunized  
according to AAP and CDCP Advice.**



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**

<http://healthlevelup.com/vaccinations-and-children/>



# Avoid Alcohol and Illicit Drug Use During Pregnancy and After Birth.



AAP Policy Statement. *Pediatrics*, 138:e20161889, 2016.



# Avoid Use of Commercial Devices Inconsistent with Safe Infant Sleep



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**



Encourage *Tummy Time* when the Infant is Awake and Observed.



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**

<http://www.medscape.com/features/slideshow/safe-sleep-principles?>



# No Evidence to Recommend Swaddling to Reduce the Risk of SIDS



**AAP Policy Statement. *Pediatrics*, 138: e20162938, 2016.**

# Infant Swaddling

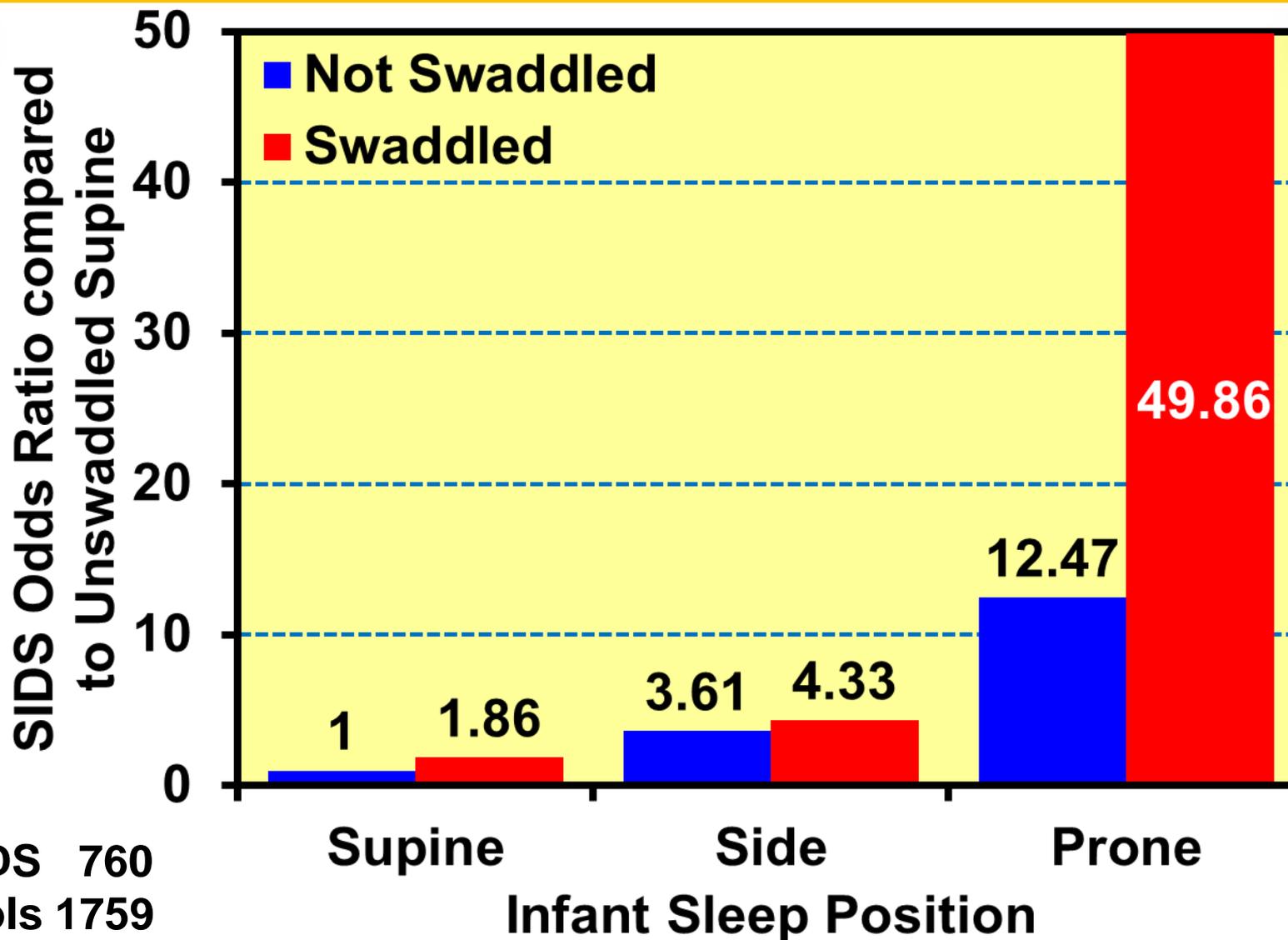


# Infant Swaddling





# Swaddling and SIDS



SIDS 760  
Controls 1759

Pease, A.S., et al. *Pediatrics*, 137: e20153275, 2016.



# Avoid Swaddling if ...



- **Prone sleeping position.**
- **Thick blankets.**
- **Face covered.**
- **For infants older than 3-months.**

**There is a danger when infants begin to roll from supine to prone, the swaddled infant can not regain the supine position.**

**Ponsonby, A.L., et al. *N. Eng. J. Med.*, 329: 377-382, 1993.**

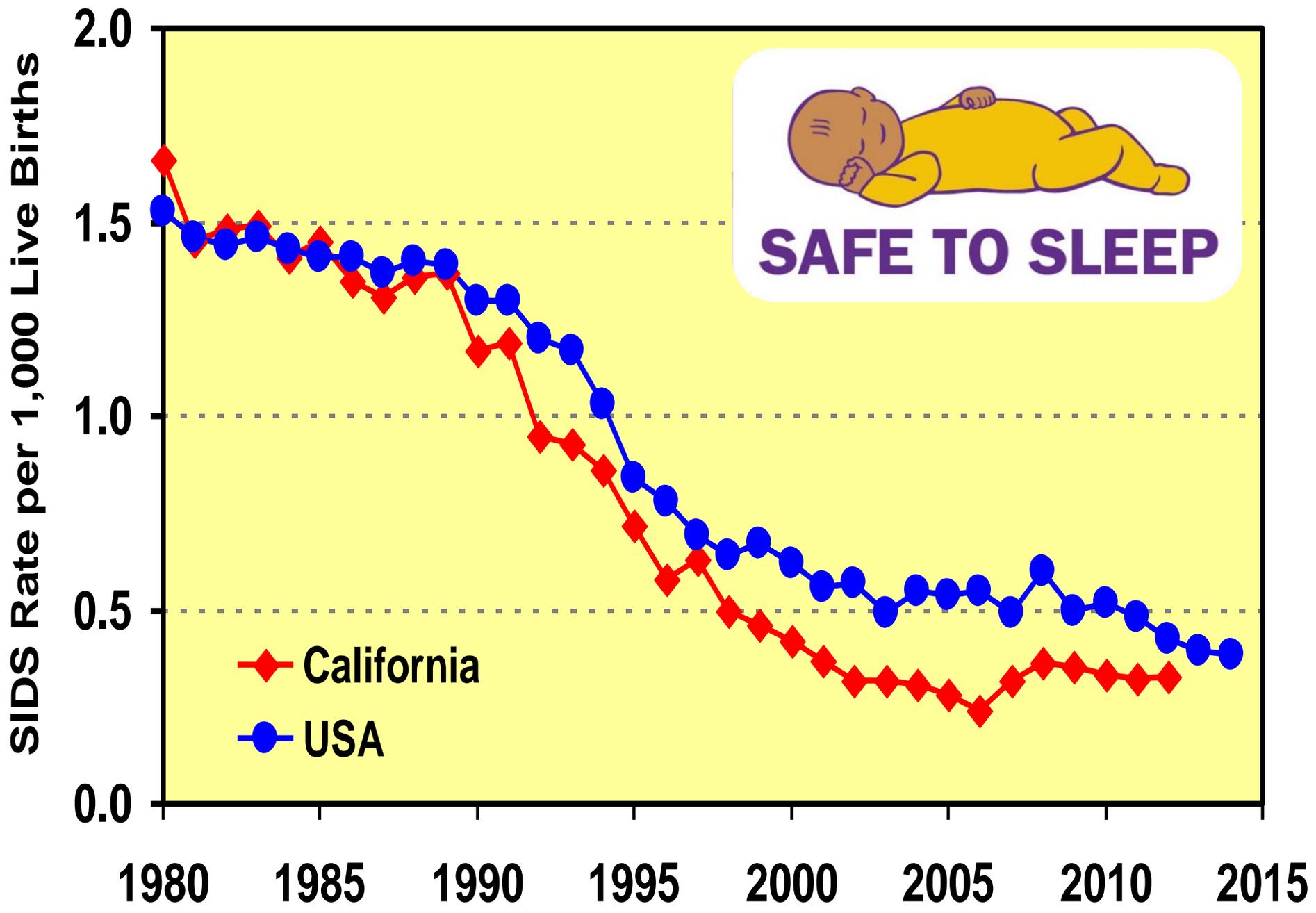
**Wilson, C.A., et al. *J. Paed. Child Health*, 30: 506-512, 1994.**

**L'Hoir, M.P., et al. *Eur. J. Pediatr.*, 157: 681-688, 1998.**

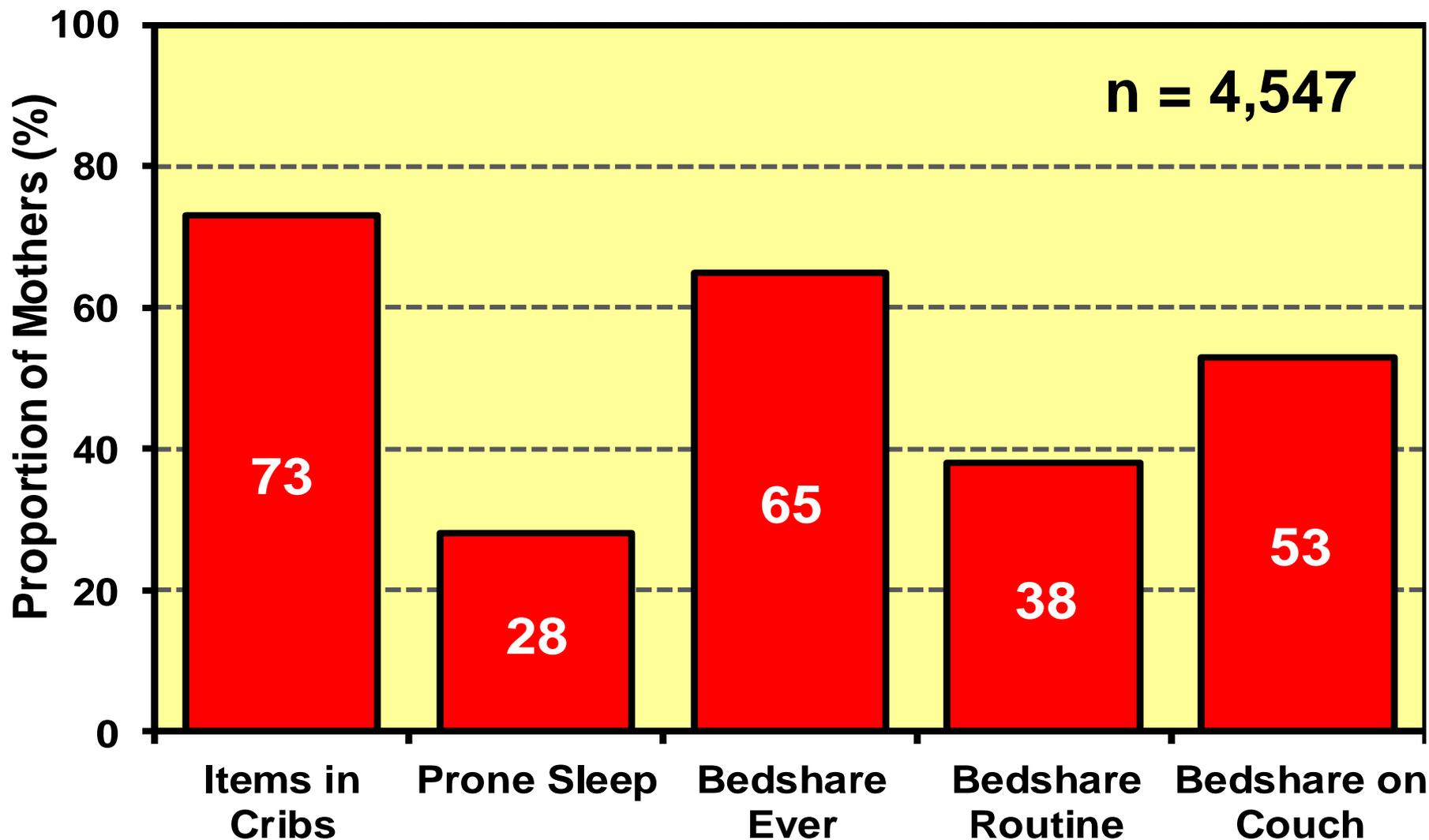
**Van Sleuwen, B.E., et al. *Pediatrics*, 210: e1097-e1106, 2007.**

**Pease, A.S., et al. *Pediatrics*, 137: e20153275, 2016.**

**AAP Policy Statement. *Pediatrics*, 138: e20161889, 2016.**



# Parents Ignore Safe Infant Sleep Recommendations

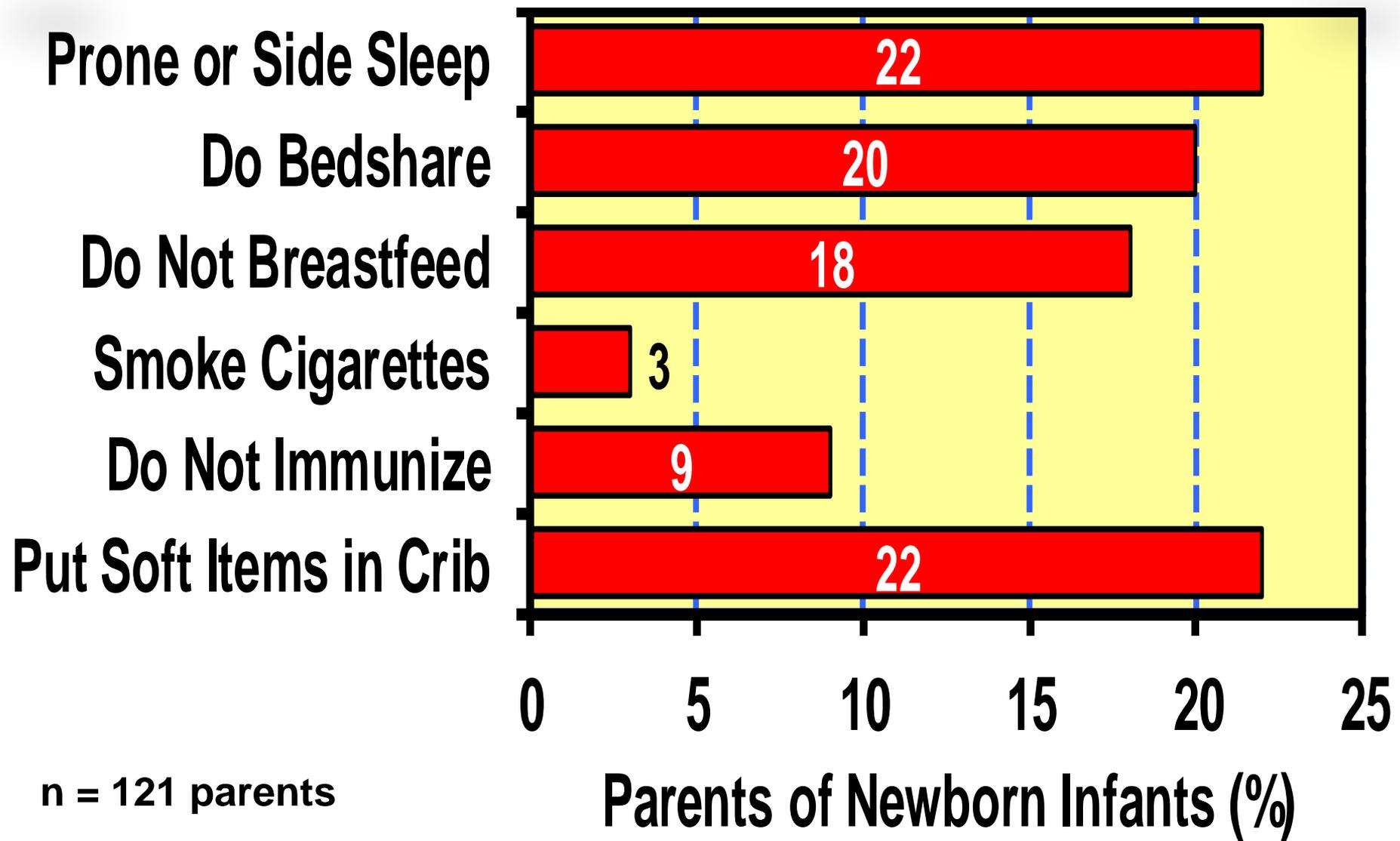


Dreisbach, S. *American Baby Magazine*, March, 2014, issue.

<http://www.parents.com/baby/safety/nursery/how-safe-is-your-babys-sleep/?page=3>



# Many Parents Do Not Follow Safe Infant Sleep Recommendations





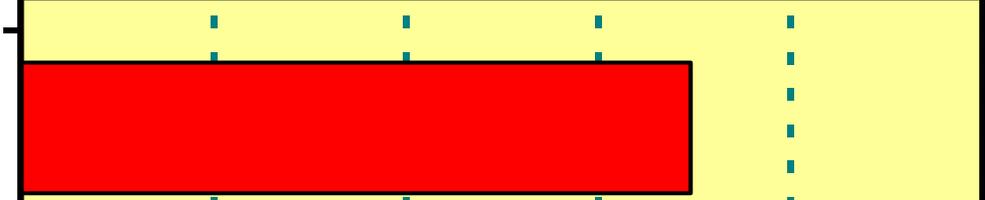
# Primary Care Physicians Do Not Discuss SIDS Risk Reduction



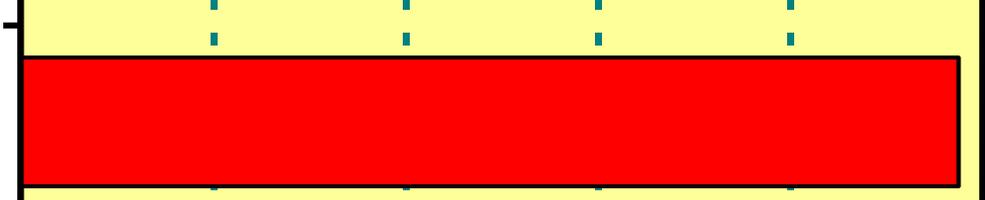
**Behavior Can Reduce SIDS**



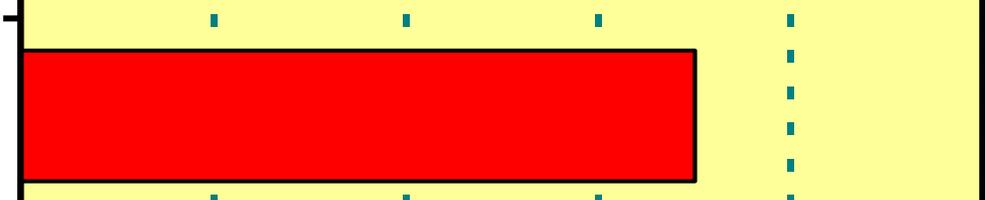
**Knows Back Sleep Safest**



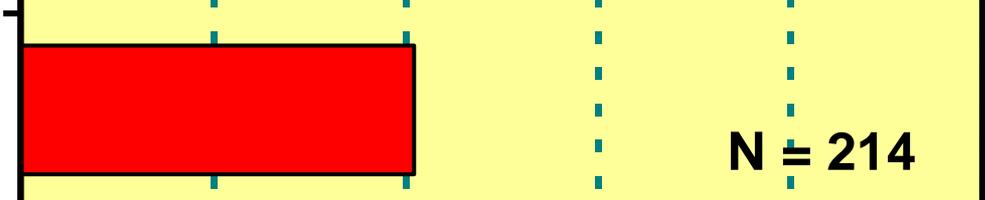
**Should Discuss SIDS Risk**



**Do Discuss SIDS Risk**



**Give Written Material**



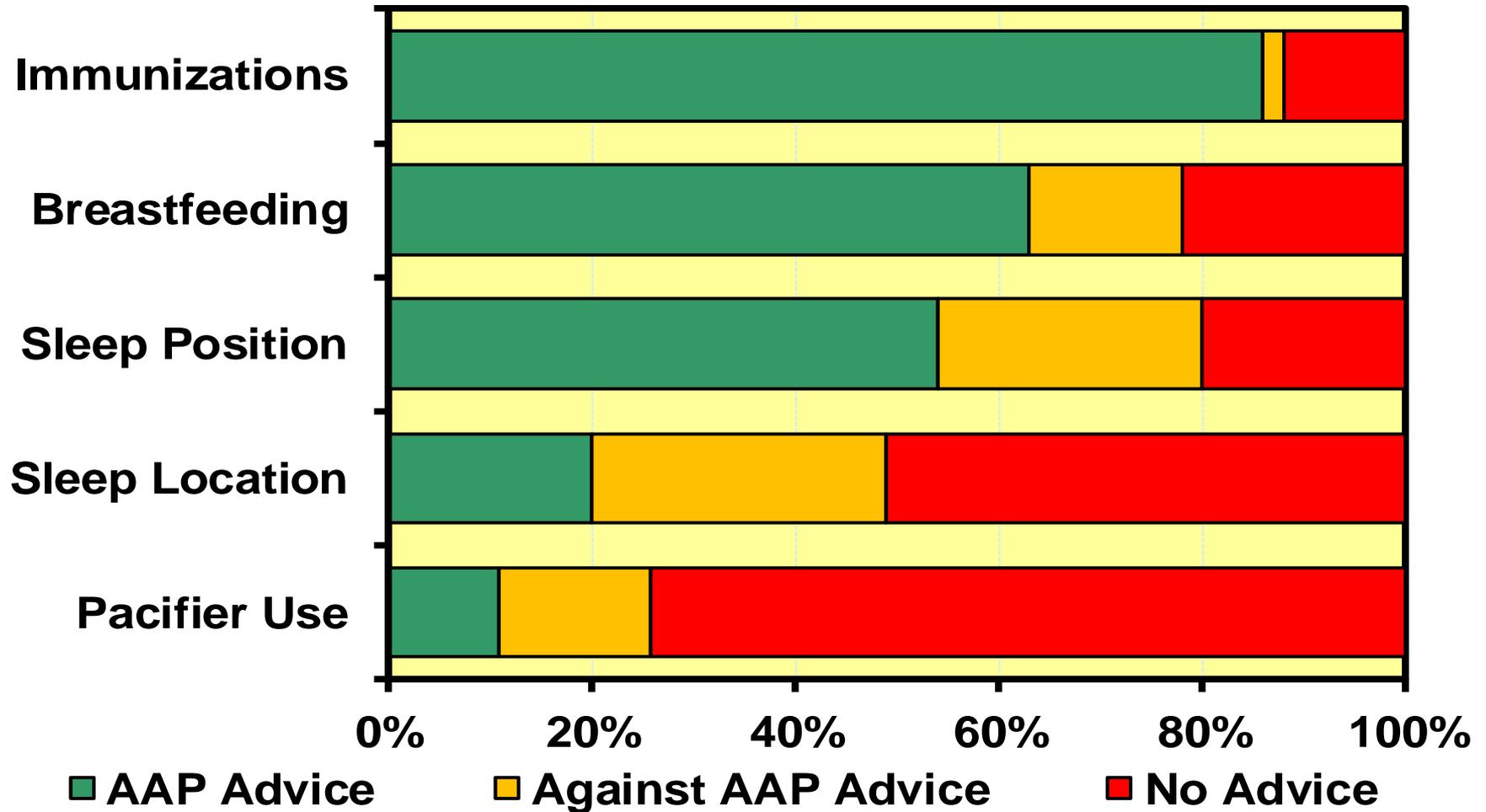
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# Mothers Commonly Receive No Advice on Infant Care Practices



## Advice from Physicians

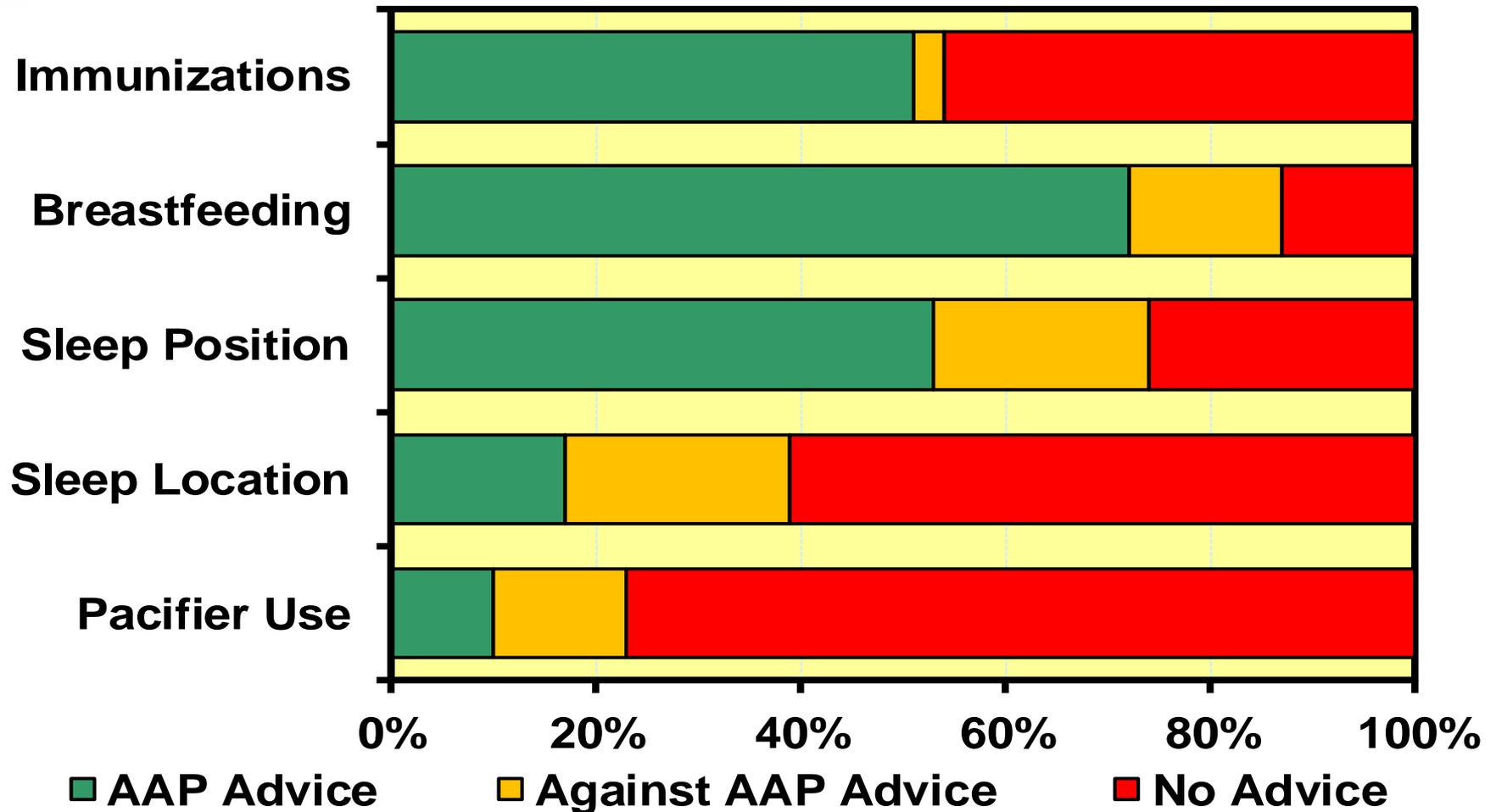




# Mothers Commonly Receive No Advice on Infant Care Practices



## Advice from Nurses



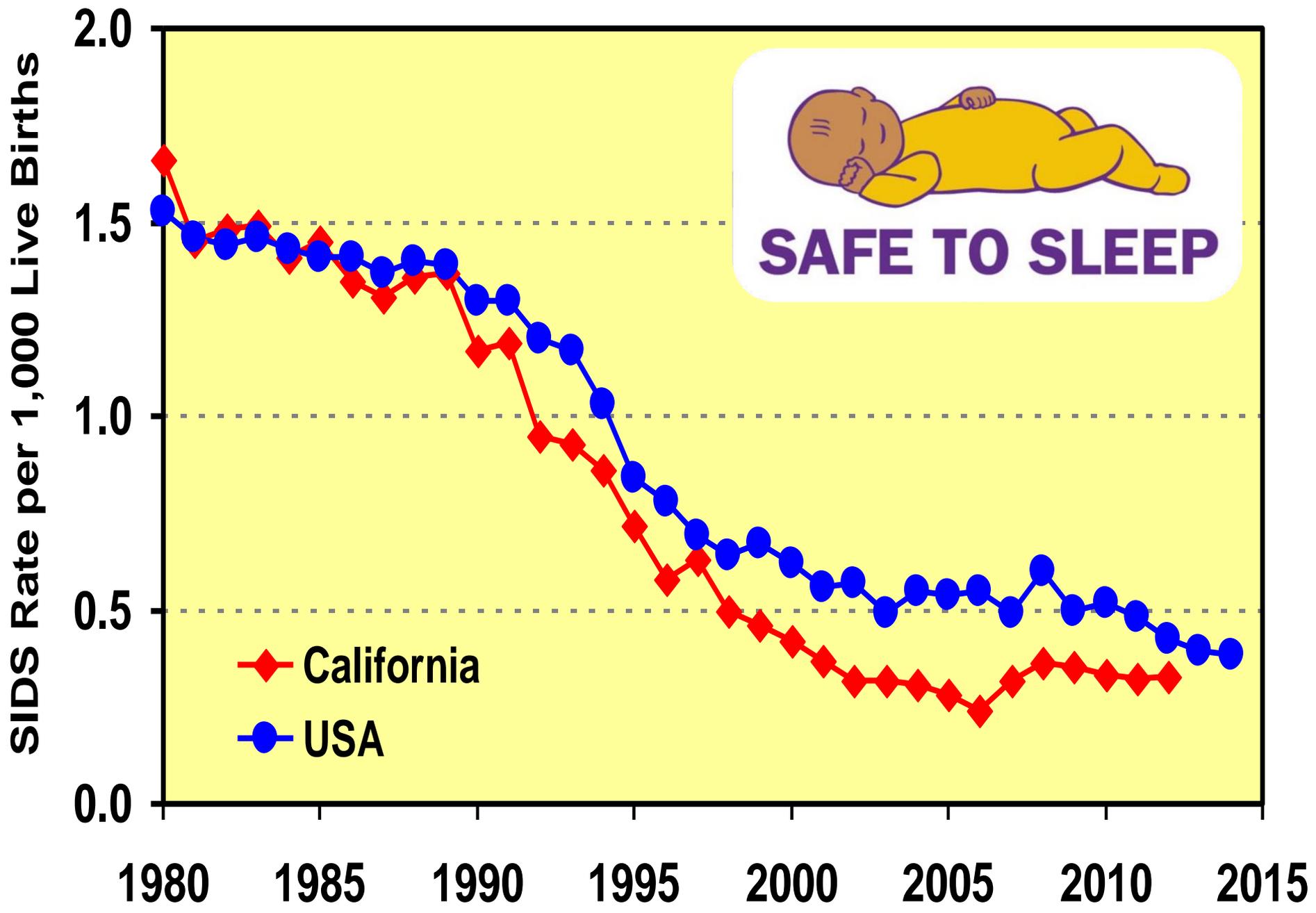


**S**upine

**A**lone

**F**irm mattress

**E**empty crib



# Are We Reducing SIDS or Suffocation?



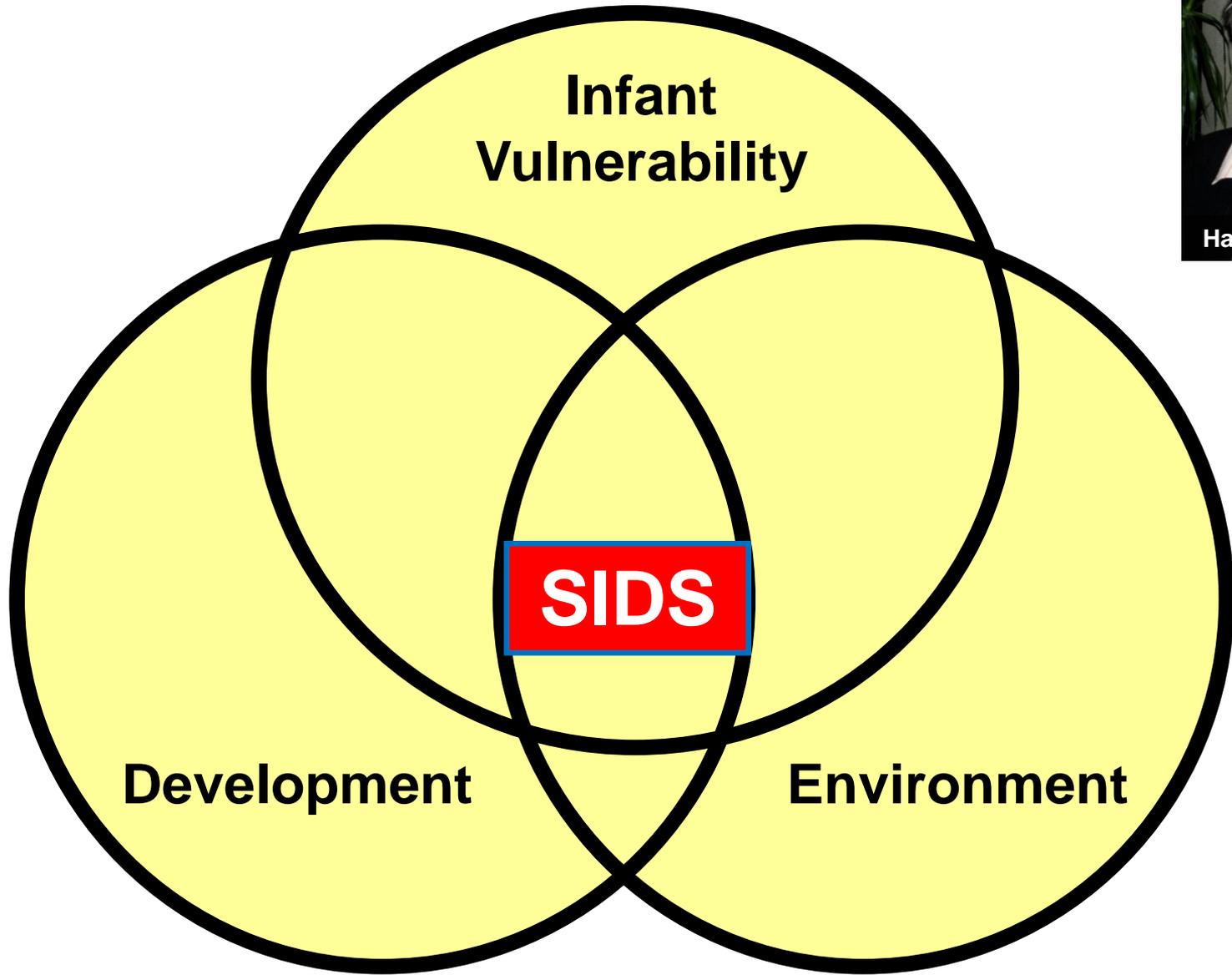
- **Safe infant sleep recommendations create a safer infant sleep environment.**
- **Should reduce accidental infant deaths during sleep.**
- **Triple Risk Hypothesis suggests SIDS is an interaction between age, intrinsic vulnerability, and environment.**
- **The only thing we can affect is the environmental stress.**

# **WARNING**

**The cause of SIDS is not yet known.**

**This information has not been proved to be the cause of SIDS.**

**However, I have attempted to give you some idea about some current directions of SIDS research.**



Filiano, J.J., and H.C. Kinney. *Biol. Neonate*, 65: 194-197, 1994.

# Sudden Infant Death Syndrome



- **Most common cause of sudden infant death between the ages of 1-month and 1-year.**
- **Cause remains unknown.**
- **Can not be predicted in infants prior to death.**
- **Reduction in SIDS in populations through public health intervention.**
- **SIDS has not been eliminated.**



**SAFE TO SLEEP**